# Active surveillance of pests and diseases: a scoping study in vegetables

Euan Laird
Victorian Department of Primary Industries (VICDPI)

Project Number: VG09099

**VG09099**

This report is published by Horticulture Australia Ltd to pass on information concerning horticultural research and development undertaken for the vegetables industry.

The research contained in this report was funded by Horticulture Australia Ltd with the financial support of the vegetables industry.

All expressions of opinion are not to be regarded as expressing the opinion of Horticulture Australia Ltd or any authority of the Australian Government.

The Company and the Australian Government accept no responsibility for any of the opinions or the accuracy of the information contained in this report and readers should rely upon their own enquiries in making decisions concerning their own interests.

ISBN

Published and distributed by:
Horticulture Australia Ltd
Level 7
179 Elizabeth Street
Sydney NSW 2000
Telephone: (02) 8295 2300
Fax: (02) 8295 2399



HAL

*Know-how for Horticulture™*

**HAL Project Code: VGO9099**
**(31/5/2010)**

# SURVEILLANCE OF PEST AND DISEASE: SCOPING STUDY IN VEGETABLES

**Mark Lee**

**Project manager - Biosecurity and Emergencies, Horticulture and Forestry**

**Victorian Department of Primary Industries**

and

**Mark Hincksman**

**Project Officer - Biosecurity and Emergencies, Horticulture**

**Victorian Department of Primary Industries**

State Government Victoria Department of Primary Industries

HAL Know-how for Horticulture™

## HAL Project VGO9099

# SURVEILLANCE OF PEST AND DISEASE: SCOPING STUDY IN VEGETABLES

**Project Leader:**
Mark Lee
Project Manager DPI Vic
PO Box
BALLART, Victoria 3350

Phone: (03) 5336 6605
Fax: (03) 5336 6601
E-mail: mark.lee@dpi.vic.gov.au

**Project Team Members:**
Mark Lee
Mark Hincksman
Ben Rowbottom,
James Kellerman,
Christopher Linehan

Steering Committee

| | |
|---|---|
| • Kim James | Horticulture Australia Limited |
| •Hugh Tobin | AUSVEG |
| •Andrew White | AUSVEG |
| •Sharon Taylor | Plant Health Australia |
| •Bill Trend | Agriculture and Food, WA |
| •Denise Little | Primary Industries and Resources, SA |
| •Jane Moran | Primary Industries, Vic. |
| •Sandra McDougall | Industry and Investment, NSW |
| •Denis Persley | Employment, Economic Development & Innovation |
| •Cherie Gambley | Employment, Economic Development & Innovation |


This report discusses the findings of a joint industry/government steering committee and subject specialist reference group. A list of recommend options has been developed that can be road tested through a pilot project for the Australian Vegetable industry.

This project was funded by Horticulture Australia Limited, the Vegetable R&D Levy and the Victorian Department of Primary. Their support is gratefully acknowledged.

June 2010

## Contents

## Media Summary

The risk of plant pests entering Australia continues to rise and with this comes significant potential costs to Australia's Vegetable sector through lost productivity, loss of markets and increased input and compliance costs. National and state quarantine measures and 'on farm' hygiene practices can reduce the likelihood of an exotic pest incursion. However, some pests will inevitably manage to evade detection at the quarantine stage and will only be discovered once a population establishes. Early detection is critical to minimise the potential spread and economic cost of an incursion. Early detection will depend on a surveillance system that is knowledgeable, provides broad coverage, links to rapid and accurate diagnostics and reporting systems.

This research and development scoping study aims to develop an increased understanding of the detection of biosecurity pests in the Australian vegetable industries and recommend a model for passive surveillance that meets the vegetable industries needs. The report discusses a number of enhanced passive surveillance models that are potential options to detect pest incursions and establishes the case for the recommended models.

The scoping study contains three sections –
- a literature review on applications of passive surveillance that have been implemented in agricultural industries in Australia and around the world,
- a grower consultation document; investigating current pest surveillance practices and the potential for an enhanced passive surveillance program. Information for this report was captured through an interview process
- a discussion paper on different passive surveillance applications that could be applied to enhance the vegetable industry's biosecurity activities.

A specialist joint industry/government steering committee guided then provided an industry and state based perspective on vegetable biosecurity.

The Steering committee have reviewed the literature review, grower consultation document, and discussion paper and are providing recommendations for a future pilot project. These recommendations will guide the development of practical models suitable for the diverse range of situations found in Australia's vegetable industries.

The report recommends:
- Establishing a pilot project based on the current "CropSafe" model from the Victorian grains industries. Some aspects of the "Cropwatch" model can enhance the current CropSafe program and are recommended for inclusion.
- Run the pilot in at least three separate situations. One based on a geographic region and one on a commodity group.
- Working with the existing surveillance activities and existing service providers.

## TECHNICAL SUMMARY

This project focuses on providing the national vegetable industry with a number of options for establishing an effective and efficient passive surveillance models to enhance early detection of pest incursions and improve market access for Australian produce.

The recommendations were informed by:
- a subproject which captured current pest surveillance practices, growers' understanding of biosecurity threats, and determined the potential for an enhanced passive surveillance program.
- a literature review conducted on the implementation of passive surveillances approaches within Australia and around the world with the approach that one of these models may be adopted by the vegetable Industry.
- feedback from the national committee on a discussion paper which highlighted a number of possible passive surveillance models that could address the industry's biosecurity needs.

Feedback from growers was that an Enhanced Passive Surveillance approach must work with and complement existing networks such as existing crop monitoring and IPM programs, and services provided by agronomists and consultants. This is reiterated in the literature review. The literature review found that a basic form of surveillance could be conducted based on existing informal communication networks, by adding a formal recording and reporting structure. It also states that 'there is value in having biosecurity aware farm managers and workers to minimise the risk of outbreaks', and 'in most cases detection limitations are due to a lack of awareness'.

The discussion paper presents a number of models for consideration. Examples such as 'Cropwatch', 'CropSafe' are industry driven programs that could be used as approaches to enhance biosecurity and resulting in benefits to the vegetable industry's production outcomes (reducing input costs, reducing crop losses). These models are sentinel systems – primary and secondary information sources where networks of observers are recruited across the industry to monitor for exotic incursions and to report and provide samples of pests for positive identification.

A national steering committee reviewed information from the literature review, grower consultation document, and discussion paper and provided recommendations for a future pilot project.

Recommendations for future technical work in this area include:
- Enhanced passive surveillance is an under researched aspect of biosecurity and warrants future research. Specific areas of interest include grower adoption of enhanced passive surveillance and industry 'stewardship' in biosecurity.
- This project was able to gather sufficient data on grower attitudes and behaviours to make recommendations in the area of surveillance and biosecurity. However there is a lack of information on the broad drivers and motivators for growers in the horticultural sector. This information would enable better targeting of best practice information to growers.

# PROJECT REPORT

**Background**
The Australian vegetable industry's 2009/2010 strategy identified biosecurity as a key priority. This aligns with the VegVision 2020 plan and the Victorian Governments Biosecurity Strategy for Victoria and four year Agriculture and Fisheries strategy.

**Significance for industry**
Biosecurity is a role for all participants in an industry, however often individual growers are not well placed to develop tools that enable biosecurity measures to be undertaken across a wide area. Growers require assistance from government and their national grower representatives to develop these tools and provide the skills and knowledge for them to implement the systems.

In addition to this the vegetable industry has a unique set of challenges in implementing national surveillance strategies. These include the breadth of crops and pests, the distribution of regional growing areas and their unique characteristics, and the variation in grower's knowledge and preparedness in biosecurity management.

**Aim of the project**
The aim of this project was to investigate options to reduce the impact of exotic pest incursions in the vegetable by introducing enhanced surveillance compatible with industry needs, enabling early detection.

To investigate this the project: conducted a grower consultation; prepared a report on grower attitudes and behaviours; undertook a literature review; and prepared a discussion paper in consultation with a national steering committee to determine the most appropriate surveillance model suited for a national vegetable industry pilot project.

**Summary**
A grower consultation report provided results of investigations into the pest surveillance practices of Eastern Australian vegetable growers and the potential for an enhanced passive surveillance program for the vegetable industry. The study investigated growers understanding of biosecurity, current biosecurity related practices and opinions on models for an Enhanced Passive Surveillance program in the vegetable industry.
The report captured growers' primary concern in relation to biosecurity incursions - preventing commercial damage to their crops by endemic pests. As a result of this concern, growers currently conduct a number of desirable practices in relation to biosecurity. This includes some level of pest surveillance at least once per week and identification of crop problems by relevant experts or laboratories. Some growers also hire skilled staff members or consultants as pest scouts to ensure adequate pest surveillance is conducted. Conversely plant hygiene practices are often considered impractical or too costly for the protection they provide. The benefit growers receive from practices such as pest surveillance, plant hygiene practices and pest surveillance scouts depends on aspects of individual grower's farm context.
In regard to the implementation of an Enhanced Passive Surveillance model in the Vegetable industry the grower survey report recommends:

- That any Enhanced Passive Surveillance model must work with and complement existing networks, and not be seen to override, impose or alter too much, these networks that have desirable practices already occurring. Failure to do this is likely to impact negatively on individual's and industries perception of the model.
- If further quantitative data on the numbers of growers and consultants conducting specific practices, for specific reasons is required a quantitative survey should be conducted based on the findings of this study.
- That questions arising from interviews, be given careful consideration before implementation of an Enhanced Passive Surveillance model.

Some growers' responses to questions over the course of this study raise a few questions that assist this project in developing and initiating an Enhanced Passive Surveillance model for the vegetable industry. The questions posed are:

• How important is proving that Australian vegetable crops are free of exotic pests given the low level of export?

• What is sufficient surveillance to prove Australia, a state or a region is free of exotics?

• What area of crop needs to be covered by an Enhanced Passive Surveillance program for it to be worthwhile?

• How much documentation will be required and who will do this?

• Given the many desirable behaviours of many growers interviewed, including frequent pest surveillance by growers and promptly getting new crop problems identified by experts or laboratories, is an Enhanced Passive Surveillance program needed?

• If pest scouting consultants do not currently cover enough area, which other individuals could be relied on for data and what incentives would the program provide for consultants to cover a larger area or encourage more people to become consultants?

• Given some active surveillance occurs at markets and when growers apply for certain permits to move produce is further surveillance data required?

A literature review on the extension of passive surveillance for horticulture was conducted throughout Australia and world wide. It revealed that limited information on the application of passive surveillance models exists. However, the study determined the strength and coverage of existing surveillance programs that are delivered through consultants in industries such as pome fruit (the Cropwatch program), grapes and citrus (private consultants), the Plantation Health Surveillance scheme for forestry, as well as the grain industry's CropSafe program.

**Results**

The discussion paper presented several passive surveillance models with examples providing context towards recommendations for a pilot program. It presented findings of the grower consultation survey and report, the literature review, and the models discussed in the paper to the national steering committee. Recommendations from the Steering committee have been captured for a future pilot project that the National vegetable industry can implement.

Recommendation to Industry:

- Governments can provide 'Barrier quarantine', movement restrictions and awareness and training that will assist in reducing the risk of exotic incursions. However, government can not provide thorough coverage of all crops to detect incursions that may still occur. Therefore industry must play a role in exotic pest surveillance.
- The enhanced passive surveillance model recommended by this project would provide the vegetable industry with an ideal pathway to play an important role in the detection of exotics.

## MATERIALS AND METHODS

**Steering committee**

A steering committee was set up and contained members of the Australian vegetable industry, and government experts in biosecurity from across Australia. The steering committee's function was to oversee the projects' direction, provide insight into to various vegetable industries and locations, provide growers contacts from different growing regions for the grower consultation paper, and recommend passive surveillance model(s) for a pilot program from the list provided in the discussion paper

A detailed case study of various surveillance programs was undertaken and presented in a discussion paper for the Steering Committee. The discussion paper presented 10 models of various surveillance approaches for the committee, some from existing surveillance programs and other models from surveillance approaches in other industries. Each model description includes strengths, weaknesses, comments and relative costs.

**A survey of vegetable growers**

Vegetable growers were interviewed by specialist DPI practice change staff to determine current practices of farm biosecurity and likely issues and uptake of a passive surveillance pilot project. These grower consultations were captured in a report that provided results of investigations into the pest surveillance practices of Eastern Australian vegetable growers and the potential for an enhanced passive surveillance program for the vegetable industry.

The study investigated growers understanding of biosecurity, current biosecurity related practices and opinions on models for an Enhanced Passive Surveillance program in the vegetable industry. Thirty nine growers were randomly selected for interview from grower lists provided by state departments. Growers represented different growing regions across Victoria, New South Wales and Queensland. Three agronomists who work as IPM consultants or pest scouts were also interviewed. The majority (40) of the interviews were conducted face-to-face, where interviews were recorded manually by interviewers, then analysed using case and cross-case analysis. The cross section of growers had crops grown in either open paddocks, plastic green houses (in ground and hydroponic) and under netting (hydroponic), and had farm management structures including owner operator, family-owned and managed, family-owned with hired manager and corporate ownership with hired management staff.

**Scan of existing surveillance programs**

A literature review was conducted to search for existing surveillance approaches in horticulture through Australia and around the world.

The literature review focused on models of passive surveillance that are being and can be applied to horticulture in Australia. Limited information was found to exist for models of passive surveillance for Horticulture in Australia so the search was widened to other industries both in Australia and worldwide. The review also looked for examples of surveillance models and application from medicine and livestock. A number of models that come from surveillance approaches in aquaculture industries were captured and presented in the discussion paper for the national steering committee.

Resources for this search were: Cab Abstracts, Online DPI Library, data bases (worldwide), and online search engines such as Google. Once these approaches were exhausted, support was provided from staff in the Victorian Knowledge Resource Centre, where most of the information was sourced.

## RESULTS and DISCUSSION

Results from the literature search presented various options of passive surveillance techniques that could be adapted as practices by the National Vegetable Industry. See Appendix 1, page **21**. of the discussion paper 'Surveillance of Pest and Disease: Scoping Study In Vegetables'

Results form the social research project increased understanding of grower's requirements, level of awareness and understanding of biosecurity issues, and grower's expectations of an enhanced surveillance program developed around exotic pests. See the social research paper 'Enhanced passive surveillance and the vegetable industry' for comments from growers.

The findings from the literature review and social research projects were presented in a discussion paper. These findings developed a number of passive surveillance options and were presented to a national steering committee.
The research suggested a number of models or activities could be applied to suit the vegetable industries across Australia. See the recommendations section on page 11.

The committee engagement process helped refine these options into a final recommendation for the committee to accept or adapt. The agreed model is recommended to be the focus of a future pilot program. A major benefit to the industry would be to trial a model that links to existing surveillance structures and enhances the industry's ability to manage exotic pests, therefore reducing likely impacts and costs on production.

## TECHNOLOGY TRANSFER

To ensure adoption of the research undertaken in this project, it is recommended that the National vegetable industry and HAL fund a pilot project that will create an opportunity for the industry and government to test these practices.

This information will also be available to other horticultural industries as a model to enhancing their surveillance approaches. Information from this project could be used in other industries to pilot their own trial, or/and also benefit through the biosecurity networks involved and outcomes produced in the pilot trial.

During this project awareness has been raised about enhanced passive surveillance models and the possibility of a project occurring in the future, through discussion with key stakeholders, the national committee members and growers involved in the social research.

## RECOMMENDATIONS FOR PILOT STUDY

**Models of passive surveillance for Horticulture**

This project recommends that a pilot project, directed by the Nation Vegetable industry, and supported by national and state government, be considered. The recommendations from the discussion paper suggest one or a combination of some of the following models be used. See page **19** of the *Surveillance of Pest and Disease: Scoping Study in Vegetable*'.

The models recommended for a pilot project are:

CropSafe – an agribusiness lead approach

The model involves engaging service providers to the vegetable industry in a network to ensure exotics are detected and they are reported appropriately. The model aims to build on established provider-customer relationships without adding onerous additional requirements.

Currently a CropSafe program is run in Victoria's grain industry is a partnership between, DPI, five of Victoria's largest agribusinesses and a network of private consultants. Experienced agronomists filter endemic or established pests and forward on unknown or suspicious samples. Initially the samples go to experienced DPI crop agronomists, if they are unable to identify the pest it is sent Crop Health Services for formal identification. Each provider has access to a fixed number of DPI funded samples to Crop Health Services – and exotic detections are never charged. This encourages sample submission, whilst allowing them to build skills and knowledge in identifying pests they may not have dealt with in the past.

Under this model the service providers are also provided with additional training in exotics, regular updates of exotic pest threats and summary information of pests recorded across the program – the level of detail these reports provide is agreed to by the participants.

Cropwatch – an industry lead approach

The model for Cropwatch could work in the vegetable industry, but may not be as widely acceptable as the CropSafe model and would therefore reduce the likelihood of detection.

Cropwatch is a division of Fruit Growers Victoria Ltd. It is a fee for service approach that focuses on endemic pests and provides integrated pest management advice to growers as a service to commercial fruit growers within the association. As the service is provided in field this approach would allow for surveillance of exotic pests outside the usual problematic focuses. As with the CropSafe model it would require links to be made to a diagnostic service and biosecurity expertise to ensure currency of knowledge.

The advantage of this approach is it is funded by the grower – those most likely to benefit from the detection of exotics. The fact that the individual grower bears most if not all of the cost of the surveillance could also be the biggest disadvantage of the approach.

## ACKNOWLEDGEMENTS

- **Australian Vegetable Industry – Growers that participated in the Grower survey and other members of the industry who provided valuable information and advice to make this project possible.**

- **National Steering Committee**

- **Ben Rowbottom, James Kellerman, Christopher Linehan. Practice Change Capacity Development. Farm Services Victoria Division Department of Primary Industries**

- the Victorian Knowledge Resource Centre.

We acknowledge the following industry associations for their support in making this work possible:

- Horticulture Australia Limited,
- AusVeg
- Farm Services Victoria, Victorian Department of Primary Industries Vic.

## BIBLIOGRAPHY

The bibliographies can be located in the grower consultation paper 'Enhanced passive surveillance and the vegetable industry,' and the discussion paper 'Surveillance of Pest and Disease: Scoping Study in Vegetables'. This includes an appendix containing tables of papers captured by the literature review.

**APPENDICES**

*Appendix 1 Discussion Paper*
*'Surveillance of Pest and Disease: Scoping Study in Vegetables.'*

*Appendix 2 Findings from interviews with vegetable growers*
*'Enhanced passive surveillance and the vegetable industry'*

# Enhanced Passive Surveillance and the vegetable industry

A Victorian Government Initiative

Victoria The Place To Be

HAL Know-how for Horticulture™

Published by the Victorian Government Department of Primary Industries
Tatura, June 2010.



ISBN 978-1-74264-207-9



**Authors:**
Ben Rowbottom, James Kellerman, Christopher Linehan.
Practice Change Capacity Development
Farm Services Victoria Division
Department of Primary Industries
Private Bag 1
Ferguson Road
TATURA, Victoria

**Acknowledgments:**
The authors would like to thank all farmers who gave up their time to assist us conducting this investigation. We greatly appreciate Cinzia Ambrosio's assistance in conducting interviews. The authors are grateful to Mark Lee, John Whiting, Peter Howden and Marg Watters for providing invaluable feedback, editing and contributions to writing this report.

This project was funded by Horticulture Australia Limited (HAL) and initiated by the Horticulture and Forestry team, Department of Primary Industries (DPI), Victoria.

## Table of contents



## Tables



## Figures

## 1. Introduction

In this report we provide the results of our investigation into the pest surveillance practices of vegetable growers in eastern Australia and the potential for an Enhanced Passive Surveillance program for the vegetable industry. We use the term 'pest' to refer to all forms of pests and diseases (insects, vertebrates, fungi, bacteria, viruses, but not weeds) that may cause damage to vegetable crops unless otherwise specified, for example 'disease' or 'insect pests'.

This study was undertaken as a component project of the Horticulture & Forestry team, Department of Primary Industries (DPI), Victoria called "Active surveillance of pests and diseases: a scoping study in vegetables". This project was funded by Horticulture Australia Limited (HAL) and aligns with an increasing strategic focus on biosecurity by government and industry. The study investigates vegetable growers' understanding of biosecurity and current biosecurity related practices and also their opinions on models for an Enhanced Passive Surveillance program in the vegetable industry.

In this report we briefly give some background to the project, describe the methods used and report our findings from interviews with vegetable growers. We then provide recommendations on the potential of an Enhanced Passive Surveillance program for the vegetable industry.

## 2. Scope

In this report we investigate the current hygiene and pest surveillance practices of vegetable growers in eastern Australia, particularly those relating to exotic pests. We make recommendations on the potential of an Enhance Passive Surveillance program for the vegetable industry. More specifically we will:

- determine growers' current understanding of industry initiatives to deal with, and respond to, exotic pest incursions
- determine the biosecurity issues vegetable growers believe are important in their region
- develop an understanding of the current practices vegetable growers use to reduce the risk of pest infestations
- identify the practices growers are adopting to reduce the risk of biosecurity infestations and the reasons for not adopting other practices
- identify areas of biosecurity that growers see as a priority

- test grower response to potential passive surveillance program models, where they are interested in biosecurity issues.

## 3. Background

The protection of the Australian Vegetable Industry from exotic and endemic biosecurity risks is critical. Farm Services Victoria (FSV), a division of the DPI, is investigating ways to reduce the risk of biosecurity incursions on behalf of HAL. One model that is being investigated is the "CropSafe" model from the Victorian Grains Industry (ORM 2009). This Enhanced Passive Surveillance model uses a cascade of pest identification experts, with the first level being the early notification of potential new exotic pests by growers or consultants (ORM 2009). Critical to the success of this project is that the growers and consultants have sufficient motivation to report any potential issues to the appropriate authorities.

The application of such a model has synergies with the DPI's, Plant Health Australia's and HAL's current strategies and agreements including Vegvision2020 (AVIDG 2006), Emergency Plant Pest Response Deed (EPPRD)(PHA 2010), the Biosecurity Strategy for Victoria (DPI 2009), the Future Farming Strategy (DPI 2008b) and the Better Services to Farmers strategy (BSTF) (DPI 2008a). In particular this project aligns with strategic themes regarding the strengthening of the DPI's focus on developing partnerships, working with industry, improving biosecurity responsiveness and gathering evidence to support policies.

Under 'The WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement)', Article 6.3 (WTO 2010):

> *"Exporting Members claiming that areas within their territories are pest- or disease-free areas or areas of low pest or disease prevalence shall provide the necessary evidence thereof in order to objectively demonstrate to the importing Member that such areas are, and are likely to remain, pest or disease-free areas or areas of low pest or disease prevalence, respectively. For this purpose, reasonable access shall be given, upon request, to the importing Member for inspection, testing and other relevant procedures (WTO 2010)."*

Recently there has been a global trend towards showing greater evidence for claims regarding pest presence or absence when applying phytosanitary measures (ORM 2009). In particular there is more pressure to prove a country has searched for a pest before they can claim pest free status; that is the pest is 'known not to occur'. In the past if a pest had not been reported then a country could claim pest free status; that is the pest is 'not known to occur.' In response to this trend, and a decline in state government networks for animal and plant pest and disease surveillance, the DPI piloted an Enhanced Passive Surveillance program named "CropSafe" in the grains industry (ORM 2009). Under the "CropSafe" model, grains industry agronomists were recruited to create a network

of field agronomists who could identify common pests and pass unidentified samples through a tiered system of experts and laboratories for timely diagnosis. The program also aimed to log data that could contribute to a 'known not to occur' assurance for pest free zones, by providing 'negative data', that is data samples showing no occurrence of exotic pests (ORM 2009).

Evaluation of the "CropSafe" Enhanced Passive Surveillance model for the grains industry in Victoria concluded that in principle the model shows potential to be expanded to other Australian states and industry sectors (ORM 2009). The report also cautions that before transferring the model to other plant industries, significant research into grower culture, advisory structures, and industry co-ordination should be conducted (ORM 2009). This research should investigate if the "CropSafe" model would be useful and what factors will be critical for successful implementation of the model in the vegetable industry.

Therefore in this study we will investigate the behaviour of vegetable growers in response to biosecurity issues to give insights into the likely success of Enhanced Passive Surveillance techniques in the Australian Vegetable Industry.

## 4. A brief review of adoption literature relating to pest surveillance and plant hygiene practices in the vegetable industry

This section contains a brief review of published literature regarding pest surveillance in the vegetable industry. Large bodies of literature exist in regard to Integrated Pest Management (IPM) and biosecurity which discuss surveillance and hygiene practices, to some extent. Less literature appears to focus specifically on plant hygiene and pest surveillance. In particular, there is little literature on passive and enhanced passive surveillance and on the adoption of surveillance and hygiene practices in the Australian Vegetable Industry.

While biosecurity literature discusses many issues that relate to the adoption of plant hygiene and pest surveillance practices, the literature does not focus specifically on these two issues. Biosecurity literature does explore economic issues in regards to:

- costs and risks associated with different pests and biosecurity policies – for example Hennessy (2008) and Cook and Proctor (2007)
- features of effective biosecurity policy – for example Jay *et al.* (2003) and Meyerson and Reaser (2002)
- current challenges to biosecurity – for example Eagling (2007) and Thompson *et al.* (2003).

Many authors in the biosecurity literature emphasise early detection as a key part of successfully preventing the spread of, or eradication of invasive pests (Meyerson and Reaser 2002; Simberloff

2009; Vander Zanden *et al.* 2010). Others literature focuses on improving technology for detecting pests, to enable earlier, more accurate or more precise detection of pests (Hatfield and Pinter 1993; Yuee *et al.* 2009). This literature does not place much emphasis on conducting surveillance for this desirable early detection. Some studies discuss the need for active surveillance to enable early detection, for example Vander Zanden *et al.* (2010), but few studies investigate the adoption of passive surveillance practices or how to enhance passive surviellance to enable early dection of pests.

The majority of the literature on passive surveillance came from either studies of animal pests in the developing world (Muhammad *et al.* 2006) or from the field of healthcare, in relation to human diseases and not from literature more closely related to the Australian Vegetable Industry.

In the health care literature (Vogt *et al.* 1983) discusses the limitations of passive surveillance when compared to active surveillance on reported rates for human diseases. Vogt *et al.* (1983) then argue for increased active surveillance because of the limitations of passive surveillance. Conversely Ogden *et al.* (2006) utilised passive surveillance data to study the spread of disease carrying ticks in Canada and thus demonstrated the usefulness of passive surveillance.

Muhammad *et al.* (2006) demonstrated the rates of camel disease in Pakistan based on passive surveillance data, again demonstrating that passive surveillance can provide useful information on disease spread and frequency.

Successful IPM programs require regular monitoring (surveillance) of crops (Schellhorn *et al.* 2009). A considerable number of studies exist on the adoption of IPM in vegetable and other horticultural crops (for example Fernandez-Cornejo *et al.* 1994; Horne *et al.* 2008; Kaine and Bewsell 2008), with some reports suggesting IPM adoption has been slow (Fernandez-Cornejo *et al.* 1994). Both Horne *et al.* (2008) and Kaine and Bewsell (2008) provide detailed reviews of IPM adoption by farmers. Kaine and Bewsell (2008) reviewed the literature and found inconsistency in the variables influencing adoption across industries and countries. Kaine and Bewsell (2008) then suggest a farm context[1] based approach to determining factors that influence adoption. Their research, revealed an influence of 'pest pressure' on IPM adoption. This finding is somewhat similar to Horne *et al.* (2008) who suggests that, in the absence of a crisis involving the failure of existing pest control practices (due to pest pressure or chemical resistance), farmers are unlikely to risk adopting IPM.

Murdoch *et al.* (2007) investigated the response of farmers and other industry agents to grape *Phylloxera*, Queensland fruit fly (QFF) and potato cyst nematode (PCN) biosecurity regulations.

[1] The farm context is the combination of the biophysical, human and financial resources and the mix of management practices available to the grower that influence the benefits to be had from an innovation (Kaine 2008).

They explored issues around a number of hygiene practices including traffic control and washing of machinery, vehicles and crates. They found growers do not discuss the management of one pest or disease in isolation to the management other pests or diseases. Murdoch *et al.* (2007) also discussed how an individual's different farm context influences the practices they adopt to limit pest and disease incursions.

Similar results where found by Ambrosio *et al.* (2010) in relation to the voluntary adoption of hygiene practices by grape growers in Phylloxera Infested Zones (PIZs). They showed how growers adopted a level of hygiene practice relative to the risk of disease incursion, where the risk of disease incursion related to the vineyard (farm) context of the grower.

In this literature review we have briefly discussed literature that relates to plant hygiene and passive surveillance in the Australian Vegetable Industry. We found:

- biosecurity literature discussing various aspects of biosecurity related to pest surveillance
- studies on passive surveillance in animals in the developing world
- studies on surveillance for human diseases
- studies on the adoption of IPM
- studies on biosecurity regulations and plant hygiene practice in other industries.

We did not find any studies specifically looking at the level of adoption of plant hygiene practices and passive surveillance by Australian vegetable growers, nor did we find studies exploring the factors effecting the voluntary adoption of these two practices in the Australian Vegetable Industry. This gap in literature based knowledge will be partially filled by this study.

## 5. Methods

This investigation used qualitative research techniques to explore the pest surveillance practices, understanding of biosecurity and perceptions of exotic pest threats of vegetable growers in Victoria, New South Wales and Queensland. The qualitative techniques used in this study are based on the assumption that decisions regarding the adoption of farm practices or innovations are high involvement decisions (Kaine 2008). High involvement decisions are decisions that are important to the individual because these decisions are functionally, financially, or socially risky (Kaine 2008). Therefore growers are likely to have used complex decision making (Assael 1998) to make decisions regarding the adoption of farm practices, such as plant hygiene and pest surveillance practices. Through appropriate use of qualitative interviewing techniques it will be possible to determine which benefits growers were seeking when adopting practices (Kaine 2008).

The farm context is the combination of the biophysical, human and financial resources and the mix of management practices available to the grower that influence the benefits to be had from an innovation (Kaine 2008). It is farm context that determines the benefits an innovation can provide. Hence Kaine (2008) suggests that farmers can be categorised into groups or market segments based on the benefits they are seeking from an innovation because of similarities and differences in their farm contexts.

In this study three groups practices or product classes (Hill *et al.* 2009), are explored in detail; hygiene practices, pest surveillance practices and use of pest surveillance scouts. It is important to note that segments are innovation or practice specific, therefore a grower may be in different segments for each of the different practices. For example a grower could be in a different segment for hygiene practices than for pest surveillance practices. While there may be some logical correlations between different segments for different practices, these should not be assumed. Also growers may fall into different benefit segments for practices concerning pests versus diseases. For example a grower may not follow hygiene practices for insect pest control but will for fungal disease control depending on the grower's farm context.

In total 39 growers were interviewed. A breakdown of the locations of interviewee's properties is provided in Table 1. Farms areas ranged from 1.21 hectares (3 acres) to 809.37 hectares (2000 acres) (Table 1). Three agronomists who work as IPM consultant pest scouts were also interviewed to provide further information on the practices of growers who use pest scouts. Thus a total of 42 interviews were conducted. The majority (40) of the interviews were conducted face-to-face by two interviewers; two interviews were conducted over telephone due to time conflicts in grower's and interviewer's schedules. Interviews were recorded manually by interviewers, then analysed using case and cross-case analysis (Patton 1990).

A list of crops grown by the growers interviewed and the regions they grew these crops in is provided in Table 2. Crops were grown in open paddocks, plastic green houses (in ground and hydroponic) and under netting (hydroponic). Farms had various management structures including owner operator, family-owned and managed, family-owned with hired manager and corporate ownership with hired management staff. Farms usually employed a number of labourers as full-time, part-time or casual arrangements depending on the labour needs of the business.

**Table 1. Location of interviewee's properties**

| State | Farm size | Growing Region | Face to Face | Telephone | Region Total | State Total |
|---|---|---|---|---|---|---|
| Victoria | (1.21ha – 809.37ha) | Cranbourne | 8 | 2 | 10 | |
| | | Lara | 5 | 0 | 5 | |
| | | Werribee | 4 | 0 | 4 | **19** |
| Queensland | (12.14ha – 360ha) | Gatton | 5 | 0 | 5 | |
| | | Stanthorpe | 4 | 0 | 4 | |
| | | Wyreema | 1 | 0 | 1 | **10** |
| New South Wales (Sydney basin) | (1.21ha – 60ha) | Peats Ridge | 1 | 0 | 1 | |
| | | Rossmore/ Leppington | 5 | 0 | 5 | |
| | | Central Sydney | 1 | 0 | 1 | |
| | | Werombi/ Theresa Park | 3 | 0 | 3 | 10 |
| **Total Growers** | | | | | | **39** |
| Consultants | | | | | | 3 |
| **Total Interviews** | | | | | | **42** |

**Table 2. Crops grown by interviewees**

| Crop | Regions | Crop | Regions |
|---|---|---|---|
| **brassicas** | | **tomatoes** | |
| broccoli | All, except Lara | cherry | Lara, Sydney basin |
| cabbage | Cranbourne | heirloom | Lara, Sydney basin |
| cauliflower | All, except Lara | roma | Lara, Sydney basin |
| mustard | Cranbourne | standard | Lara, Sydney basin |
| **lettuces** | | **herbs** | |
| baby cos | All, except Lara | basil | Lara |
| baby leaf | Cranbourne | parsley | Cranbourne |
| cos | All, except Lara | coriander | Sydney basin |
| iceberg | All, except Lara | mint | Sydney basin |
| Shanghai | Cranbourne | **beetroots** | Sydney basin |
| **other salad mixes** | | **celery** | All, except Lara |
| endive | Cranbourne | **cucumbers** | All, except Lara |
| rocket | Cranbourne | **kohl rabi** | Cranbourne |
| **Asian** | | **leaks** | Cranbourne |
| baby wombok | Cranbourne | **onions** | Gatton |
| bok choy | All, except Lara | **potatoes** | Cranbourne, |
| choi sum | Sydney basin | **pumpkins** | Sydney basin |
| long mellon | Lara | **shallots** | Sydney basin |
| pak choy | All, except Lara | **silver beet** | Cranbourne |
| soft mellon | Lara | **snow peas** | Sydney basin |
| **carrots** | | **spring Onions** | Cranbourne |
| carrots | Cranbourne | | |
| Dutch carrots | Cranbourne | | |

We used convergent interviewing (Dick 1998) and laddering (Grunert and Grunert 1995) to identify similar and contrasting patterns in the reasoning underlying growers' pest surveillance practices and their interest in biosecurity and exotic pests. Convergent interviewing is unstructured in terms

of content but structured in process; it starts with broad questions aimed to keep the interviewee talking (Dick 1998). Laddering is a process of asking continually more focused questions, used to systematically explore common themes within and between interviews (Grunert and Grunert 1995). The entire process is continued until no new themes emerge from subsequent interviews, hence convergence (Dick 1998). Purposive and snowball sampling techniques were used to identify interviewees (Patton 1990). Horticultural industry staffs from the DPI Victoria, the Department of Industry and Investment, NSW and the Department of Employment, Economic Development and Innovation, Queensland were asked to identify growers in different farm contexts (for example crops, farm size, business structure and soil type). Some additional growers and consultants for interviewing were identified by interviewees. The growing regions were chosen because they were considered to include all key vegetable crops that related to funder's priorities for this project.

Convergence in the benefits growers was seeking from pest surveillance and biosecurity was achieved at approximately 20 interviews. At this stage initial market segments were developed for revision and confirmation in later interviews.

## 5.1. Limitation of these methods

Qualitative interview data for this study was obtained using non-random sampling techniques. Therefore we cannot say the results of this study are statistically representative of the general population of Australian vegetable growers. Assumptions regarding the exact proportions of growers with characteristics identified in this report should not be made; this includes proportions of growers within market segment or conducting a particular behaviour.

By combining purposive and snowballing sampling (Patton 1990) with convergent interview techniques (Dick 1998), we can confidently determine some characteristics of the population of interviewed growers. The sampling techniques are designed to maximise variation in the sample by deliberately seeking interviewees with different backgrounds and farm contexts. As interviews were continued until no new themes emerged, it can be assumed that more interviews would not have revealed additional information about the population. Therefore results from this study can be assumed to provide a good representation of the views of interviewed growers' on pest surveillance, biosecurity and exotic pests within the areas surveyed.

A quantitative research study would be required to provide population proportions for characteristics described in the results section (section 6) of this report.

## 6. Results

Many growers we interviewed were conducting a number of practices that would be considered desirable as part of an Enhanced Passive Surveillance program. The reasoning of these growers for conducting these practices suggests their biosecurity priorities varied from that of government (the DPI and other relevant departments). While government is greatly concerned with the potential arrival of exotic pests, spread of pests between states and keeping export markets open, we found growers are primarily concerned with managing pests that cause commercial damage to the crops they grow. Commercial damage to crops caused by pests and diseases has a great impact on growers and their business and therefore actions to prevent commercial damage to crops are very important to growers.

We also found that growers are frequently conducting pest surveillance in their crops (at least once per week). This frequency of surveillance is due to the short growing times of some vegetable crops (as short as six weeks in peak growing season), low tolerance of damage by produce buyers and speed at which pests can cause commercial damage to crops. Many growers also reported using an IPM consultant, agronomist, chemical reseller or laboratory to identify the cause of unusual crop damage, unhealthy looking plants, or production loss. The time taken from when growers identified a new problem occurring to when the problem was diagnosed was usually reported to be within ten days (at best same day, at worst 14 days).

Growers find many plant hygiene practices to be impractical, too costly or time consuming for the amount of pest and disease protection they provide.

The following sections outline findings from interviews with growers and provide answers to key questions outlined in the scope section (section 2) of this report. All names used in the results section of this report are fictitious aliases and not the individual's real name. This is done to protect the confidentiality of individuals involved in this study. No characteristics about individuals should be assumed from the name provided.

### 6.1. Determine growers' current understanding of industry initiatives to deal with and respond to exotic pest incursions

When discussing biosecurity and industry initiatives to deal with and respond to exotic pest incursions, growers generally mentioned:

- the existence of quarantine measures conducted by the Australian Quarantine Inspection Service (AQIS)

- state government interstate biosecurity controls requiring inspections and certificates to move produce interstate, to limit the spread of pests
- a number of information sources that provide adequate information regarding how to deal with imminent exotic incursions
- reliance on state and federal quarantine and biosecurity controls to be effective because it is not practical for growers to be concerned about all potential exotic threats.

As one New South Wales grower stated when discussing exotic pests:

> *"Not my problem. As long as quarantine does their job, I can do mine. They protect, I grow food."*

Some of the growers we interviewed held the opinion that international and interstate controls were often more about trade barriers artificially preventing them entering a market, rather than controlling the spread of pests. To justify this opinion, many growers suggested that interstate controls along the eastern seaboard were not particularly effective and only slowed the spread of pests.

Bill, a Queensland grower, spoke about interstate trade regulations for lettuce aphid and white blister:

> *"Better everyone has it [lettuce aphid]. Interstate regulations just prolong it [how long a pest or disease takes to get here], gave Queensland more time to be prepared. We put in protocols when it [lettuce aphid] hit New Zealand though. I had New Zealand guys on farm, so learnt what to do. Confidor® is a quick and cheap insurance. We all knew it [lettuce aphid] was gonna get here, same with white blister."*

Growers discussed getting information about imminent exotic pest incursions such as lettuce aphid, western flower thrips, and white blister through a number of information sources. Growers said they received information about these exotic pests through industry newsletters, industry groups, private consultants, chemical resellers, local primary industry government departments, local media (radio, newspapers), family members, neighbours and other growers.

Most growers we interviewed believed they had appropriate warning about imminent invasions of exotic pests such as western flower thrips, lettuce aphid and white blister. In the case of lettuce aphid some growers had been on industry trips to New Zealand, Tasmania and the United States of America (USA) prior to outbreaks in their local area to learn about the impacts and control of the pest. Hence current methods of communication about imminent threats appear to be working.

For example this grower from Queensland visited the USA to learn about lettuce aphid before it arrived in Australia:

> *"I've never seen a lettuce aphid, I treat seedlings with Confidor®. I went to the U.S. [United States] before New Zealand got it. I saw how they [the U.S. vegetable farmers] manage it. Came back thinking there's no issue, no problem, can control it."*

Julian a Victorian grower learnt about lettuce aphid through his IPM consultant who had visited New Zealand:

> *"John [IPM consultant] said, "Don't panic. Got to treat it like any other pest. It [lettuce aphid] crawls to heart [of the lettuce]. If see it [lettuce aphid] treat with right pesticide, don't hurt your beneficials. We're the only ones here [in this area] not to Confidor® drench. It's easy, IPM easy. I'm happy to just monitor it [lettuce aphid]."*

## 6.2. Determine the biosecurity issues growers believe are important in their region

From our interviews it is apparent that how growers define and prioritise biosecurity is different from the definitions and biosecurity priorities of government (the DPI and other relevant departments). Growers' main biosecurity concerns are about the private benefits obtained from managing pests that cause commercial damage to the crops they grow. Government priorities are with the public benefits obtained from stopping the potential arrival of exotics pests, stopping the spread of pests between states and keeping export markets open.

A list of pests reported by growers and the crops and regions these were reported in is provided in Table 3. It is worth noting that growers rarely reported pests by scientific name, multiple common names where used by growers for the same pest and an individual grower may use multiple common names for the same pest. Growers also seemed to not group pests and diseases together. Interviewers had to ask specifically about 'pests' and then 'diseases' to get growers to discuss both.

When discussing exotic pests most growers spoke about pests in other states or regions that they do not currently have on their property and not what may be officially listed as an exotic pest or disease. The pests growers reported as being 'exotics' are listed in Table 4. Most growers could not cite any official exotic pest, not currently in Australia, that they were concerned about. The only pests not currently thought to be in Australia cited as a biosecurity concern were citrus canker, celery mosaic virus and yellow curly leaf spindle virus.

**Table 3. Pests reported by growers**

| Pest reported by Growers | Scientific Name | Pest or disease | Growing Regions[2] | Crops cited to be affected by pest[3] |
|---|---|---|---|---|
| black spot | (probably early blight or target spot) *Alternaria solani* | disease | Sydney Basin | tomatoes, long melon |
| *Botrytis* | *Botrytis cinerea* | disease | Sydney Basin | tomatoes, long melon |
| brown wilt | Possibly *Fusarium, Rhizoctonia* or *Verticillium* | disease | Sydney Basin | snow peas, tomatoes |
| *Septoria* | *Septoria* | disease | QLD | brassica, lettuce, celery |
| club root (club rot) | *Plasmodiophora brassicae* | disease | All | brassica, lettuce |
| downy mildew | *Peronospora parasitica* | disease | All | brassica, lettuce |
| powdery mildew | *Leveillula tauica* | disease | All | brassica, lettuce, tomatoes |
| *Pythium* | *Pythium spp.* | disease | All | brassica, lettuce, tomatoes |
| *Schlerotinia* (schlero) | *Sclerotinia sclerotiorum* | disease | ALL | brassica, lettuce, tomatoes |
| white blister (blister) | *Albugo candida* | disease | Werribee, Gatton, Stanthorpe | brassica, lettuce |
| white rot/root | *Sclerotium cepivorum* | disease | QLD | onions |
| aphids | *aphididae,* various species | insect | All | brassica, lettuce |
| Bogong moths | *Agrotis spp.* | insect | QLD | brassica, lettuce |
| budworms (native budworm) | *Helicoverpa punctigera* | insect | VIC, QLD | brassica, lettuce |
| butterflies | species not available | insect | Lara | Chinese broccoli |
| cluster caterpillars (cluster) | *Spodoptera litura* | insect | All | brassica, lettuce |
| diamond back moths (*Plutella*) | *Plutella xylostella* | insect | All | brassica, lettuce |
| flea beetles | *Chaetocnema sp.* or Nisotra sp. | insect | Stanthorpe | lettuce |
| grubs | Various species | insect | All | brassica, lettuce |
| heliothis (heli's, a*rmigera*) | *Helicoverpa armigera* | insect | All | brassica, lettuce |
| lettuce aphids | *Nasonovia ribisnigri (Mosley)* | insect | Werribee, Cranbourne, QLD | brassica, lettuce |
| mites | *Various species* | insect | All | brassica, lettuce, celery, basil, tomatoes |
| Rutherglen bugs | *Nysius vinitor* | insect | All | brassica, lettuce |
| thrips | Various species | insect | All | brassica, lettuce |
| two spotted mites | *Tetranychus urticae* | insect | Cranbourne | lettuce, Leaks |
| western flower thrips | *Frankliniella occidentalis* | insect | Werribee, Cranbourne, NSW | brassica, lettuce, tomatoes |
| white cabbage moths/ butterflies | *Pieris rapae* | insect | Lara | chinese broccoli |
| white flies | Possibly *Aleurodicus disperses* or *Trialeurodes vaporariorum* | insect | QLD, Lara | brassica, lettuce, celery |
| deer | *Cervidae,* species not available | vertebrate | Sydney Basin | brassica, lettuce |
| ducks | *Anatidae,* various species | vertebrate | All | brassica, lettuce |
| kangaroos | *Macropus,* species not available | vertebrate | Sydney Basin | brassica, lettuce |
| rabbits | *Oryctolagus cuniculus* | vertebrate | Cranbourne, Gatton, Stanthorpe | brassica, lettuce |
| tomato mosaic virus | *Tobamovirus* | virus | All | brassica, lettuce |
| tomato spotted wilt virus | Part of the *Tospovirus* group | virus | Lara | tomatoes |
| nematodes | various species | | Sydney Basin | tomatoes |

[2] Growing Regions are based on the location of growers and may not perfectly reflect actual pest distribution.
[3] 'Crops cited to be affected by pest are based on grower reports and may not perfectly reflect crops actually affected.

**Table 4. Pests reported as exotic by growers**

| Pest reported by Growers | Scientific Name | Pest or disease | Growing Regions[4] | Crop cited to be affected or likely to affected[5] |
|---|---|---|---|---|
| citrus canker | *Xanthomonas axonopodis pathovar citri* | disease | VIC | none currently |
| white blister | *Albugo candida* | disease | All | brassica - broccoli |
| fire ants | *Solenopsis invicta* | insect | QLD | none currently |
| lettuce aphids | *Nasonovia ribisnigri (Mosley)* | insect | All | brassica, lettuce |
| Queensland fruit flies | *Bactrocera tryoni* | insect | VIC, QLD | was mentioned but growers weren't actually effected |
| silverleaf white flies | *Bemisia tabaci* | insect | NSW | tomatoes |
| western flower thrips | *Frankliniella occidentalis* | insect | All | brassica, lettuce, tomatoes |
| celery mosaic virus | *Potyvirus* | virus | Cranbourne | celery |
| yellow curly leaf spindle virus | *Begomovirus* | virus | Sydney basin | snow peas, tomatoes |

## 6.3. Develop an understanding of the current practices vegetable growers use to reduce the risk of pest infestations

Grower practices are currently focused on reducing the risk of pest damage that is commercially harmful, as opposed to reducing the risk of pest infestations. To limit the risk of damage by pest infestations growers use a number of practices that all rely on some level of pest surveillance. These practices are integrated pest management (IPM), chemical spraying and crop rotations. All growers we interviewed conducted pest surveillance as part of their pest control practices. The benefits received from pest surveillance practices where different for growers in different farm contexts. Many growers employed an IPM consultant, agronomist, chemical reseller or employee as a pest scout. Very few growers we interviewed relied on on-farm hygiene practices to limit the risk of pest infestations as many growers found these practices to be ineffective or impractical in their farm context.

In the following sections of this report we will discuss in detail the adoption of hygiene practices, pest surveillance practices and pest surveillance scouting. This discussion will be based on market segments for adoption of these practices by growers. As discussed in the methods section (section 5) segments are practice specific, a grower may be in different segments for each of the different practices; while there may be some apparent correlations between different segments for different practices these should not be assumed.

[4] Growing Regions are based on the location of growers and may not perfectly reflect actual pest distribution.
[5] Crops cited to be affected by pest are based on grower reports and may not perfectly reflect crops actually affected.

### 6.3.1. Adoption of hygiene practices of growers

In our interviews we found two segments of growers who use plant hygiene practices to prevent the spread of disease that cause damage to their crops. Theses growers believed that the benefit of these practices outweighed the costs, given their farm context. Theses growers use hygiene practices either because they grow a crop that is prone to an uncontrollable soil borne disease or because they have larger businesses with farms in multiple growing regions (for example Werribee, Cranbourne and Goulburn Valley) and transport produce from a farm in one region to a packing facility on a farm in another region. All other growers thought that hygiene practices such as vehicle washing, foot baths and traffic control are impractical and/or ineffective.

A summary of the benefit segments for growers who adopt hygiene practice is provided in Figure 1. These segments will be discussed in detail in the following sections.

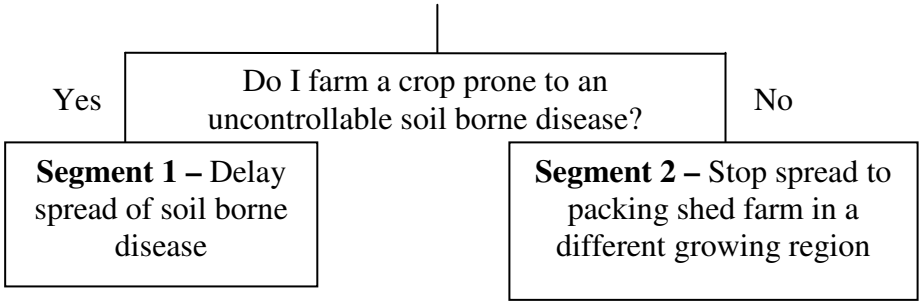


**Figure 1. Adoption of hygiene practices**

#### 6.3.1.1. Hygiene practices Segment One: Delay spread of soil borne disease

Growers in hygiene practices Segment One (Figure 1) grow a crop that is prone to an uncontrollable soil borne disease – for example white rot in onions. These growers sought to delay the spread of the disease by using hygiene practices, in particular cleaning vehicles and machinery. These growers typically brushed or pressure washed machinery before entering the "clean" (disease free) crop site. Interestingly these growers still acknowledge that they probably could improve their cleaning practices.

Growers explained that these soil borne diseases do not spread through the air like other pests (e.g. insects and fungal spores), therefore using hygiene practices could quite effectively limit the spread of these diseases. These growers also explained that current control measures for these diseases are ineffective; therefore their only option is to stop these diseases infecting a growing site, if they desired to continue growing these crops.

James from Gatton in Queensland is an example of a Segment One onion grower:

> *"We have 180 acres, (72 hectares) and grow lettuce, silver beet, cabbage, honey dew melon, onions and grain in winter. We lease the onion ground, because of white rot and not enough water here. It's more economical to pay lease [on another block of land], than grow onions here [on this original farm]. We brought [this] farm 8 years ago, it was clean, now it's dirty [has white rot] and can't grow onions. We try to keep leased ground clean [white rot free]; there is no real control that works. It's bloody hard, we try to wash things down, but you miss bits, the tractors get washed before they go to leased ground, bins too."*

#### 6.3.1.2. Hygiene practices Segment Two: Stop spread to packing shed farm in a different growing region

Hygiene practices Segment Two (Figure 1) consists of large, more likely to be corporate growers that own multiple farms in different growing regions (e.g. Werribee, Cranbourne and Goulburn Valley) and transport produce from these farms back to a packing facility on the main or original farm. This is primarily to stop potential incursions onto crops grown on the land surrounding the packing facility. These growers are careful to ensure machinery, packing crates and produce is pest and soil free before moving them from regional farms back to the packing shed on a property in another region. Packing sheds are typically located on original, larger farms or farms in growing regions closer to market access.

Theo is a farm manager from Segment Two. He manages a large family owned vegetable growing business, based in Cranbourne, Victoria but with properties in other regions as well:

> *"…produce comes back here for packing. We use the same trucks to transport between farms. We wash the crates that produce is harvested into. We also make sure visiting contractors' vehicles and machinery is cleaned. You can't be sure other properties haven't got something [pest or disease]. We have wash pads on all of our properties and hope to have a commercial crate washer soon."*

Growers who own multiple farms within one growing region did not follow hygiene practices because the practices were ineffective or impractical within a region, for most pests, with the exception of growers in Segment One. Growers with farms in multiple growing regions that did not transport product to a packing shed in another region did not see hygiene practices as necessary, effective or practical.

#### 6.3.1.3. Further detail on growers who have not adopted hygiene practices

It is important to note that many farmers we interviewed were not in the segments described above and did not undertake hygiene practices, for a variety of reasons related to their farm context. These growers may prefer visitors to contact the farm manager before entering crops and use crop rotations to reduce pest and disease pressure where the ratio of land area to cropped area permits. Otherwise these growers suggested that all hygiene practices such as vehicle washing, foot baths

and traffic control are impractical and/or ineffective. Below are some statements that summarise the viewpoints of these growers.

One grower made this statement about practices aimed at preventing the spread of pests to their farm:

> *"What are we going to do? Build a wall and flap our arms around! We just hope customs and the like are doing their job properly…we just hope!"*

Many growers also thought that most hygiene practices were too time consuming to be practical. As this grower with four farms in the same growing region explained:

> *"We would be paying five people to clean full time, we can do 30 trips a day, it's just not practical. We do spread weeds and no doubt spread disease."*

This grower with multiple farms in the same growing region also thought many hygiene practices were impractical:

> *"I have five different locations [in this region], it's [good hygiene/ quarantine] almost impossible. Can wash equipment but you don't know what's on the road. You'd just spend too much time washing. Besides I have to transport to this packing shed anyway [on main part of farm]. Just wouldn't work with business, it's a logistical nightmare. I'd like to but you've got to look at what you're actually capable of.*

### 6.3.2. Adoption of pest surveillance by growers

Pest surveillance is used by growers as a part of their pest control practices (IPM, chemical spraying and crop rotations) to limit commercial damage to their crops. Growers sought different benefits from pest surveillance depending on what pest control practices they were using in their crop/s (see Figure 2). The benefit received from pest surveillance was independent of whether surveillance was conducted by the farm manager or a pest scout that was either an internal employee or an external consultant.

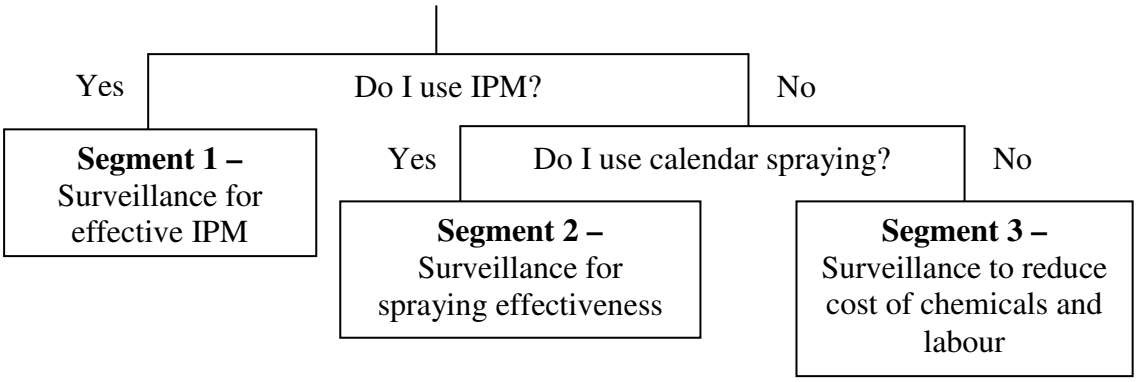


**Figure 2. Adoption of pest surveillance**

#### 6.3.2.1. Pest surveillance Segment One: Surveillance for effective IPM

Growers in the first pest surveillance segment (Figure 2) were using pest surveillance to ensure their IPM program worked effectively. We found growers who used IPM rely on regular, detailed pest surveillance to ensure IPM will effectively control pests that cause commercial damage to their crops. Growers using IPM conduct detailed pest surveillance at least once per week or hire a pest scout to do the task for them (see section 6.3.3). This detailed pest surveillance was in addition to surveillance conducted as part of other crop management activities.

Pest surveillance by growers using IPM aimed to identify the presence or absence and population density of both pests and beneficial species. The surveillance usually included a quick visual assessment of the entire crop for damage often from a motor vehicle or farm machine, by walking through the crop looking for pests, pest damage, pest eggs or spores, during post harvest inspections and sometimes using pest traps. Growers may conduct this pest surveillance entirely on their own, use an IPM consultant in conjunction with conducting their own pest surveillance, or rely predominantly on an IPM consultant to conduct pest surveillance. Decisions on how to approach current pest levels were based on an assessment of pests and beneficial populations, weather forecasts and crop development. If weather forecasts were for conditions favouring a specific pest, in particular diseases (for example Powdery Mildew), chemicals may be used to provide some preventative effect.

If an unidentified pest or plant damage is noticed by these growers they first consult with an IPM consultant and information sources such as industry newsletters. If the pest is not identified via these means, samples will be sent to a laboratory, usually at a state government department for identification.

Frankie is an example of a grower managing a large business that conducts pest surveillance for effective IPM, in conjunction with the use of an IPM consultant.

> *"I scout once a week, guy from CRT scouts as well. Target what is there [pests] and not take out other crops…selective. I go to each paddock Monday or Friday, other guy goes Thursday or Friday. I'm not an expert at trying to find eggs; it's not cut and dry. You need to have a feel for it. If the weather is hot you always end up spraying more."*

James is a smaller owner operator from Victoria who relies on an IPM consultant to conduct pest surveillance.

> *"I use Mark Cowan [IPM consultant]. I get a note every Tuesday. I don't do anything unless he tells me to. I've used Mark Cowan since 1999. Before that I did that [pest surveillance] myself. I had an outbreak and phoned Mark. There's no need to Know*

*[do pest surveillance] he does it. I occasionally have a look. I think he's saved me a lot of money and I haven't used S7s [Schedule 7 poisons[6]] in 11 years."*

#### 6.3.2.2. Pest surveillance Segment Two: Surveillance for spraying effectiveness

Segment Two (Figure 2) growers conducted pest surveillance primarily to check that calendar sprays of pest control chemicals were working. Calendar spraying of pest control chemicals was considered effective on these growers' properties. Many of these growers grew leafy vegetables, in which any pest damage is seen as unacceptable at market. Pest surveillance by these growers may be more ad-hoc than growers in Segment One.

Pest surveillance by growers in this segment involves checking for crop damage, presence of pests (dead or alive), eggs and spores while conducting other management activities such as irrigation, fertilising, spraying and harvesting. These growers follow a chemical spray program that is based on time of year, time since last spraying, type of chemical used, instructions from chemical resellers, weather forecasts and their own experience. This spray program does not rely on pest surveillance to determine when to spray. Pest surveillance is only perceived to be necessary to check if the chemical spray program is still effective. If weather conditions are favourable to specific pests, in particular diseases (for example Powdery Mildew), these growers are likely to use chemicals for a preventative effect.

If a grower in Segment Two notices that chemical sprays are not working as effectively as desired, unidentified crop damage or an unidentified pest, they will change chemicals, consult information sources such as industry newsletters, and contact a chemical reseller or agronomist. If the pest is not identified via these means, samples will be sent to a laboratory usually at a state government department, for identification.

Stephen grows hydroponic leafy Asian vegetables for the Sydney market and is an example of a Segment Two grower:

*"Spray it [pest and diseases], just 'nuke' it, use soft chemicals Success™, Belt®, Confidor®, Movento®. Walk around and check once per week. Pickers are my biggest eyes. If they see an aphid they tell me straight away. It's hard to be IPM with current pests, I believe in the concepts but if I get a hole in one leaf I'm *#@$*#!"*

Hamish is a Cranbourne grower of brassicas, Asian vegetables and Dutch carrots, who is in Segment Two:

*"We have a spray schedule that we try to stick to. Missed one spray (once) and the whole crop was stuffed, just had holes in the ground. I walk into middle of the patch, it's a good example of the whole plot; if there's a lot in the middle they're everywhere."*

[6] "Schedule 7s *are substances with a high potential for causing harm at low exposure and which require special precautions in manufacture handling or use. These poisons should be available only to specialised or authorised officers who have the skills necessary to handle them safely"* (DoR 2010).

#### 6.3.2.3. Pest surveillance Segment Three: Surveillance to reduce cost of chemicals and labour

Segment Three (Figure 2) growers use pest surveillance to reduce the cost of pest control chemicals and the labour time of spraying pests. While these growers rely on chemical sprays to control pests they limit spray use by only spraying if pests are detected. These growers do not claim to be using IPM. Pest surveillance by these growers involves quick visual assessment of the entire crop for damage usually from a motor vehicle or farm machine, by walking through the crop looking for pests, pest damage, pest eggs or spores, and during post harvest inspections. These growers may spray after observing one to a few pests, eggs or spores; or they may not spray until pest, egg or spore numbers reach a critical density at which commercial damage is likely to occur. These growers also incorporate crop development and weather forecasts into their decisions to apply chemicals. If weather conditions are favourable to specific pests, in particular diseases such as Powdery Mildew, these growers are also likely to use chemicals for a preventative effect.

Siang from Lara, Victoria spoke on behalf of her non-English speaking tomato and basil growing father:

> *"Every week dad checks and changes chemical every time. If no mites no spray, at first sign of mites spray, only spray when stuff [pests]. Chemicals cost a lot and might get resistance."*

Mario a hydroponic cherry tomato and cucumber grower from the Sydney Basin discussed using pest surveillance to reduce chemical costs:

> *"You must monitor and understand pest and diseases. I learnt this from older growers. Expectations are higher in community now, used to spray shine or rain once per week. First understand chemicals and then cost. Why do it [spray chemicals] if you don't have to do it?"*

Henry also conducts pest surveillance to limit the use of insecticides, but regularly sprays for fungal disease in his green housed tomatoes and cucumbers:

> *"Good hygiene and spray protection against diseases is important. I keep farm as clean as possible clear grass, debris and sick plants. Every week when there [pests are present], spray. insects less [of a problem than diseases], nice weather here not much rain, too hot. insects, I look for which ones, waste of time [spraying] if don't see insects, but disease so quick, when you cut [pick] fruit, you make a wound and disease can get in.*

### 6.3.3. Adoption of pest surveillance scouts

Many growers we interviewed were using an external consultant or had hired an internal employee as a pest scout. External consultants conducting pest surveillance may be an IPM consultant, independent agronomist or a chemical reseller agronomist. Internal pest surveillance employees were usually university or TAFE level graduates from courses in agriculture or horticulture, with

varying levels of experience at pest scouting and employed on an ongoing, fulltime basis (not casuals). An outline of the segments of growers using consultants or employees for pest surveillance is provided in Figure 3. The first segment of growers (Figure 3) consisted of growers who have had a pest get out of control, causing extensive commercial damage to crops. The second segment of growers (Figure 3) consisted of growers who faced a novel situation such as a new pest in a current crop or managing pests in a novel crop to the grower. Growers in both Segments Three and Four do not have enough time to conduct adequate pest surveillance themselves due to the size of their business or other commitments and therefore use consultants or an employee as a pest scout for time saving reasons. Growers in Segment Three (Figure 3) manage farms that are large enough support and can economically justify having an internal employee as a pest scout. Growers in Segment Four (Figure 3) manage farms that are not large enough to support or justify having an internal employee and the grower does not have time to conduct adequate pest surveillance and therefore will employ one or more external consultants as pest surveillance scouts.

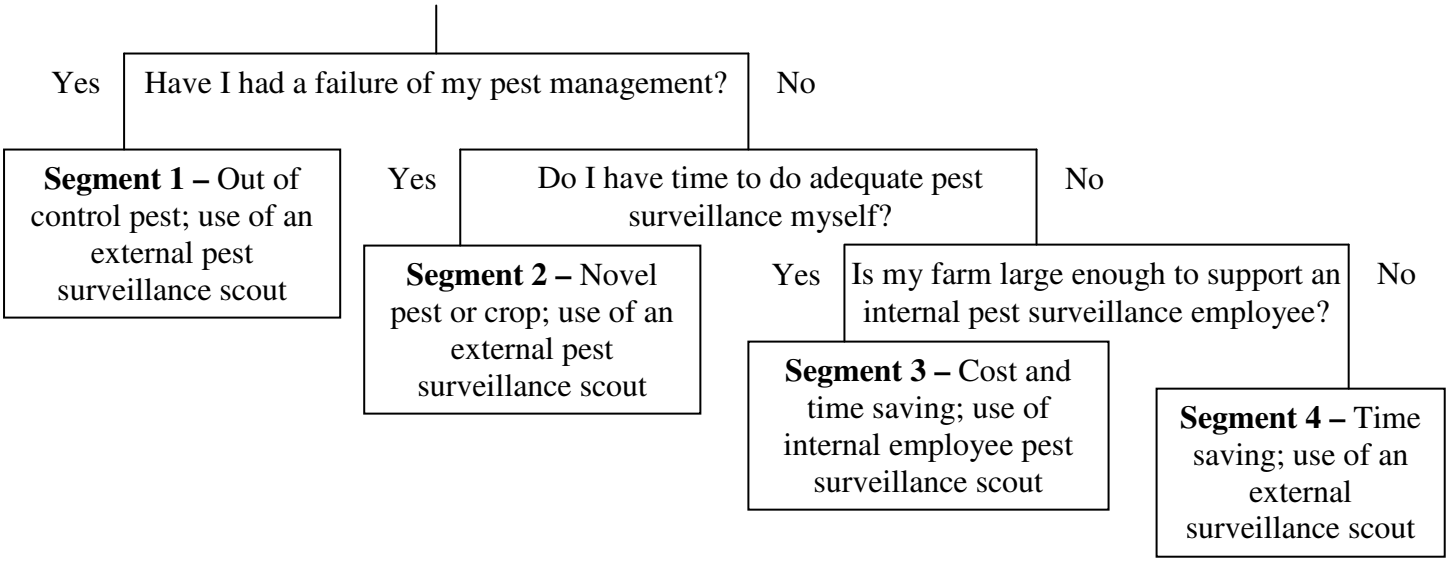


**Figure 3. Adoption of a dedicated pest surveillance consultant**

#### 6.3.3.1. Pest surveillance scouts Segment One: Out of control pest; use of an external pest surveillance scout

Growers in Segment One (Figure 3) adopted an external surveillance consultant as a pest scout after they have had failure of their pest management system, with one or more pests getting out of control and causing crop damage. This loss of control may have been due to chemical resistance, seasonal conditions or pest pressure. These growers bring in an external pest surveillance consultant for the benefit of controlling uncontrolled pests, as they believe they no longer have the skills, knowledge or experience to bring the pest back under control on their own. Typically these

growers continue using the pest surveillance consultant after the pest has been brought back under control to reduce the risk of the pest occurring again.

Guido is an example of a Segment One grower who has used a pest surveillance consultant to control an out of control pest:

> *"In the mid 90's we were wiped out by diamond back moth, so we got an IPM consultant in then. We now employ an independent bug checker, two days a week in the summer. We are not quite big enough to employ our own full time agronomist."*

#### 6.3.3.2. Pest surveillance scouts Segment Two: Novel pest or crop; use of an external pest surveillance scout

Growers in Segment Two (Figure 3) adopted an external pest surveillance consultant when either a novel pest or crop entered into their farm system. These growers do not have experience in controlling pests in a novel crop or the novel pest in their current crops; therefore they bring in an external pest surveillance consultant. Typically these growers continue using the pest surveillance consultant to reduce the risk of pest problems once experience has been gained with the novel pest or crop.

Euan is a grower who is inexperienced at growing lettuce:

> *"I'm new to lettuce and find new problems, so I talk to Elders to figure it out. They come and check the crops on a Wednesday, but if I have a problem in-between I can call. Greg from Elders will be here within 24hrs."*

#### 6.3.3.3. Pest surveillance scouts Segment Three: Cost and time saving; use of internal employee pest surveillance scout

Segment Three (Figure 3) growers do not believe they have enough time themselves to do adequate pest surveillance to ensure pests do not cause commercial damage to their crops. Segment Three growers businesses are large enough to support an internal employee whose role is predominately dedicated to pest surveillance and control, although the role may include some other tasks. Growers with businesses large enough to employ an internal pest scout had previously employed an external consultant, usually for multiple days of the week. Employing an internal pest scout become more economical. Growers tend to keep using the consultants as pest scouts, in a limited way, as a secondary means of pest surveillance to reduce the overall risk of commercial pest damage to crops. These large growers were typically conducting little or no pest surveillance themselves.

Peter manages a very large Victorian salad mix growing company with multiple farms:

> *"We have our own agronomist for soil health, pest management and plant nutrition and use our seed supply company's agronomist for 3 to 4 hours per week. The sprayers and harvesters also watch the crop and we have bug traps which are sent to [the] DPI for identification."*

Fox is a farm manager for a Queensland business with two farms one 360 acres the other 160 acres:

> *"We have three agronomists. We employ our own independent agronomist Jack, a consultant and one part time. Depending on time of year, [pest] surveillance twice per week in summer. We choose not to use a chemical reseller, and only spray when we want to spray."*

#### 6.3.3.4. Pest surveillance scouts Segment Four: Time saving; use of an external surveillance scout

Segment Four (Figure 3) also do not believe they have enough time to do adequate pest surveillance to ensure pests do not cause commercial damage to crops. This may be because the grower's business has become too large for an owner operator or because they have commitments outside the business. These growers use a pest surveillance consultant as a pest scout to limit the time they have to spend themselves on pest surveillance. These growers will still do some pest surveillance themselves to ensure they agree with the external consultant's assessment and may vary pest control measures from those recommend by the external consultant based on their own surveillance.

Cinzia is an example of a Segment Four grower:

> *"Scouts come twice a week, Tuesday and Friday, one from an independent company and one a reseller. Had scouts for 3 years, time was becoming an issue, I couldn't get around it all properly and I missed [spraying] one crop, lost the lot."*

John also uses a pest scout for similar reasons:

> *"No time to give it full protection. Chris [pest scout] has a better trained eye. I do look around a bit and do the boom spraying. He [pest scout] also does other people [other growers' surveillance] so can give me an insight into what's in the area, if heliophis around, he tells me."*

## 6.4. Identify the practices growers are adopting to reduce the risk of biosecurity infestations and the reasons for not adopting others

The practices growers used to limit the risk of biosecurity infestations are essentially the same practices they use to limit the risk of pest incursions already discussed in section 6.3 of this report. In addition to practices already discussed, many growers interviewed partake in activities to keep themselves informed on current industry issues through industry publications, industry workshops, industry tours, private consultants or their relevant state department. Therefore growers felt they had appropriate warning about imminent invasions of exotic pests such as western flower thrips, lettuce aphid and white blister. For further information see section 6.1 of this report.

## 6.5. Identify areas of biosecurity that growers see as a priority

Different growers identified different areas as priorities for biosecurity as they define it, and these priorities appear to be independent of the pest surveillance and plant hygiene practices they had adopted. Having a crop that is more likely to be affected by a biosecurity outbreak, for example celery by celery Mosaic virus, may affect which particular biosecurity areas growers see as a priority.

Some growers suggested that international quarantine (as conducted by AQIS) was important to themselves, industry and Australia for a number of reasons.

Some growers believed quarantine was important because there was little they could do to limit the spread of a pest once it is in Australia. Growers cited the spread of western flower thrips, white blister and lettuce aphid as examples of how pests can get into and spread within Australia. However some growers also felt that these new pests had not been as disastrous as expected because controls have been available.

Few growers we interviewed exported vegetables, although many had at some stage in the past. Some growers therefore suggested that is was not important to them to keep Australia's pest free status, particularly given some recent exotic pest incursions had been controllable. However other growers suggested it was very important to keep Australia's pest free status because they may like to export in the future or because it was "*just good for the industry*".

Other growers suggested international quarantine was important to keep pests out of Australia to keep pest related costs as low as possible. Some growers suggested that because of the high production costs (particularly labour) in Australia compared to some other countries, the only way for them to compete in Australian markets was to be more technically advanced and require less inputs such as chemicals. Other growers suggested that although exotics can often be eventually controlled, they lost large amounts of crop and it is an extra cost to control extra pests, therefore it is important to them to keep pests out.

A number of growers we interviewed believed that stopping interstate, and to a lesser extent international, phytosanitary biosecurity regulations from being nothing more than trade barriers was important. Some growers thought that due to the apparently ineffective nature of interstate regulations, the regulations were a waste of time. Other growers felt that, if nothing else, regulations slowed the spread long enough to learn how to control pests before an incursion occurred on their property.

Some growers suggested that the importation of vegetables for consumption in Australia from overseas was a large biosecurity risk. These growers felt that many of the countries that export to

Australia did not have pest control or quality assurance standards as good as Australia. Growers also suggested that international markets were not a level playing field in relation to phytosanitary regulations and other trade policies.

Other growers suggested that seeds and seedlings were an area of particular priority in the spread of diseases. These growers often suggested that one of the more likely sources of the arrival of new diseases is from seedlings they had bought. From interviews it seems a lot of seed is sourced from overseas and due to the nature of seeds and diseases it is difficult to ensure the seed is clean. Therefore some growers saw importation of new seed stock as an important biosecurity issue.

Another biosecurity priority area suggested by growers was in controlling fruit marketer or wholesaler and retailer behaviour. Some growers discussed examples of wholesalers grouping produce with different levels of quality assurance (chemical, pest and disease related) into single consignments and then using the highest quality assurance grade certificate from one grower across the whole consignment. Other growers discussed how they had got into trouble after some of their produce that was authorised for sale in one market zone was purchased at a wholesale market and exported to a zone that the produce was not authorised for distribution to.

Many growers also suggested that when supply is high, buyers use pest presence, damage and lack of certification certificates to reject produce or negotiate prices down. However when supply is low buyers will accept produce without certification certificates just to fill a gap in the market and growers suggested this could result in the spread of pests and diseases.

In this section we have identified a number of areas that some growers suggest are biosecurity priorities for themselves. These priorities seem to relate at some level to a growers farm context, for example crops grown, pests affecting them and markets they sell product too. The authors suggest that any program relating to biosecurity and pest control should match with these grower priorities.

## 6.6. For growers interested in biosecurity issues, test their response to potential passive surveillance program models

When we tested growers for their response to potential Enhanced Passive Surveillance program models, growers were first asked if they had heard of the “CropSafe” program. Most growers interviewed had not heard of this program. Growers who claimed they had heard of the “CropSafe” program usually had little or no knowledge of the program; they could not describe it in any detail or stated they had only heard of it.

After the concepts behind the "CropSafe" model were explained to growers they were asked to comment on their views on how such a model would work with their business and the vegetable industry in their area. Grower response to this question varied widely.

Below are some themes in grower responses to the "CropSafe" model for Enhanced Passive Surveillance as applied to the vegetable industry:

- The model would work fine because it documents what happens anyway.
- Because similar processes occur at the moment, there is no need to implement such a model.
- Because few growers export there is little need for such a program.
- There may not be enough consultants to cover enough area.
- They would rather the government just did it.
- Providing there is not too much paper work, it would be alright.

Another point to note is that some growers were suspicious of the fact that staff from a government department was asking questions about biosecurity. Some of these growers expressed concerns to interviewers that there must be some big or important new threat that 'we' the interviewers as agents of government were not, or were not allowed, to tell them about. Others were concerned about what new controls or regulations government might be about to force on them.

Interestingly the IPM consultants interviewed had some similar view points to growers. The following additional viewpoints from consultants may be important to the implementation of a "CropSafe" model in the vegetable industry.

1. Finding a pest insect in a crop is much simpler than proving there is not a pest insect in a crop. To prove something is not present you need a valid, representative sample of the entire crop. To prove a pest is present you only have to find one and this does not require as extensive sampling of crops.
2. The consultants we interviewed claimed they were working at close to their maximum capacity and if the program required significantly more paper work, more detail in pest inspections or visiting more clients they would not be as motivated to participate in the program.

## 7. Questions raised from interviews

Some growers' responses to questions over the course of this study raise a few questions that may assist the DPI or others to decide if and how to develop and initiate an Enhanced Passive Surveillance model for the vegetable industry. These questions are outlined below:

- How important is proving that Australian vegetable crops are free of exotic pests given the low level of export?
- What is sufficient surveillance to prove Australia, a state or a region is free of exotics?
- What area of crop needs to be covered by an Enhanced Passive Surveillance program for it to be worthwhile?
- How much documentation will be required and who will do this?
- Given the many desirable behaviours of many growers interviewed, including frequent pest surveillance by growers and promptly getting new crop problems identified by experts or laboratories, is an Enhanced Passive Surveillance program needed?
- If pest scouting consultants do not currently cover enough area, which other individuals could be relied on for data and what incentives would the program provide for consultants to cover a larger area or encourage more people to become consultants?
- Given some active surveillance occurs at markets and when growers apply for certain permits to move produce is further surveillance data required?

## 8. Summary of Findings and Key Points

In this report we have provided background to this study and results from our interviews with growers in regards to current hygiene and pest surveillance practices to reduce the risk of pest and exotic pest incursions. We have also provided some information from our interview data on growers' views and understandings of biosecurity threats, exotic pests, biosecurity initiatives and a potential Enhanced Passive Surveillance model. In this section we provide a summary of findings and some key points that will along with other data, assist with the development and implementation of any proposed Enhanced Passive Surveillance model for the vegetable industry.

The primary concern of growers in relation to biosecurity incursions is with preventing commercial damage to their crops by pests and diseases. Therefore growers are conducting a number of desirable practices in relation to biosecurity including some level of pest surveillance at least once per week and getting crop problems identified by relevant experts or laboratories. Some growers

also hire skilled staff members or consultants as pest scouts to ensure adequate pest surveillance is conducted. This is not to suggest that the quality of grower, expert and laboratory pest surveillance screening is adequate to limit the risk of exotic pest incursions to desired levels. Individuals (growers, experts and laboratories) are currently conducting a level of pest surveillance deemed appropriate given their context.

In contrast to pest surveillance practices, plant hygiene practices are often considered impractical or too costly for the protection they provide. The benefits growers receive from practices such as pest surveillance, plant hygiene practices and pest surveillance scouts depends on aspects of an individual grower's farm context.

In regard to the implementation of an Enhanced Passive Surveillance model in the Vegetable Industry we recommend:

- Targeting any Enhanced Passive Surveillance program towards grower priorities, such as limited commercial damage to crops or preventing trade barriers between regions.
- Careful consideration of the questions arising from our interviews, outlined in Section 7 of this report, is given before implementation of an Enhanced Passive Surveillance model.
- Implementation of any Enhanced Passive Surveillance model must work with and complement desirable practices already occurring, and not be seen to override, impose or alter the practices too much. Failure to do this is likely to impact negatively on an individual's and industry's perception of the model.
- Conducting a quantitative survey based on the findings of this study, if further data on the numbers of growers and consultants conducting specific practices is required.

## 9. References

Ambrosio, C, Rowbottom, B and Linehan, C 2010, 'Attitudes towards on-farm hygiene practices by grape growers in Phylloxera Infested Zones (PIZs)', Department of Primary Industries, Tatura, Victoria.

Assael H 1998, Consumer Behaviour and Marketing Action, South Western College Publishing, Ohio.

AVIDG, Australian Vegetable Industry Development Group 2006, 'Vegvision 2020'.

Cook, D and Proctor, W 2007, 'Assessing the threat of exotic plant pests', *Ecological Economics*, vol. 63, pp. 594-604.

Dick, B. (1998). 'Convergent Interviewing: a Technique for Qualitative Data Collection [Online]'. Available from: http://www.scu.edu.au/schools/gcm/ar/arp/iview.html [Accessed 21/05/2010].

DoR, Department of Resouces – Primary Industry 2010, 'Schedule 7 and Restricted Chemical Products [Online]'. Available from: http://www.nt.gov.au/d/Primary_Industry/index.cfm?newscat1=Chemical%20Services&newscat2=&header=Schedule%207%20and%20Restricted%20Chemical%20Products [Accessed 07/04/2010].

DPI, Department of Primary Industries 2008a, 'Better Services To Farmers - delivered by DPI/Farm Services Victoria, November 2008', Department of Primary Industries, Melbourne.

DPI, Department of Primary Industries 2008b, 'Future Farming - Productive, Competitive and Sustainable'. Department of Primary Industries, Melbourne, pp. 1-50.

DPI, Department of Primary Industries 2009, 'Biosecurity Strategy for Victoria, May 2009', Biosecurity Victoria, Department of Primary Industries, Melbourne.

Eagling, D 2007, 'Australian trade in agricultural food products - the challenge for plant pathologists', *Australasian Plant Pathology*, vol. 36, pp. 539-542.

Fernandez-Cornejo, J, Beach, ED and Huang, W-Y 1994, 'The adoption of IPM techniques by vegetable growers in Florida, Michigan and Texas', *Journal of Agricultural and Applied Economics*, vol. 26, no. 1, pp. 158-172.

Grunert, K and Grunert, S 1995, 'Measuring subjective meaning structures by the laddering method: Theoretical considerations and methodological problems', *International Journal of Research in Marketing*, vol. 12, pp. 209-225.

Hatfield, JL and Pinter, PJ 1993, 'Remote sensing for crop protection', *Crop Protection*, vol. 12, no. 6, pp. 403-413.

Hennessy, DA 2008, 'Biosecurity incentives, network effects, and entry of a rapidly spreading pest', *Ecological Economics*, vol. 68.

Horne, PA, Page, J and Nicholson, C 2008, 'When will integrated pest management strategies be adopted? Example of the development and implemenation of integrated pest management strategies in cropping systems in Victoria', *Australian Journal of Experimental Agriculture*, vol. 48, pp. 1601-1607.

Jay, M, Morad, M and Bell, A 2003, 'Biosecuirty, a policy dilemma for New Zealand', *Land Use Policy*, vol. 20, pp. 121-129.

Kaine, G 2008, 'The Adoption of Agricultural Innovations'. School of Marketing and Management. University of new England, Armidale, NSW, vol. Doctor of Philosophy, pp. 315.

Kaine, G and Bewsell, D 2008, 'Adoption of Integrated Pest Management by apple growers: the role of context', *International Journal of Pest Management*, vol. 54, no. 3, pp. 11.

Meyerson, LA and Reaser, J, K. 2002, 'Biosecurity: Moving toward a Comprehensive Approach', *BioScience*, vol. 52, no. 7, pp. 593-600.

Muhammad, G, Jabbar, A, Iqbal, Z, Athar, M and Saqib, M 2006, 'A preliminary passive surveillance of clinical diseases of cart pulling camels in Faisalabad metropolis (Pakistan)', *Preventive Veterinary Medicine*, vol. 76, pp. 273-279.

Murdoch, H, Lourey, R, Kaine, G and Linehan, C 2007, 'Understanding behavioural responses to biosecurity interventions', Victorian Government Department of Primary Industries, Tatura.

Ogden, NH, Trudel, L, Artsob, H, Barker, IK, Beauchamp, G, Charron, DF, Drebot, MA, Galloway, TD, O'Handley, R, Thompson, RA and Lindsay, LR 2006, '*Ixodes scapularis* Ticks Collected by Passive Surveillance in Canada: Analysis of Geographic Distribution and Infection with Lyme Borreliosis Agent *Borrelia burgdorferi*', *Journal of Medical Entomology*, vol. 43, no. 3, pp. 600-609.

ORM 2009, 'Evaluation of the Enhanced Passive Surveillance System 'CropSafe'. Undertaken for Department of Primary Industries, Farm Services Victoria, "Enhancing Victoria's Plant Biosecurity Capability" project'.

Patton, MQ 1990, Qualitative interviewing: a technique for qualitative data collection, Sage Publications, USA.

PHA, Plant Health Australia 2010, 'Government and Plant Industry Cost Sharing Deed in respect of Emergency Plant Pest Responses, March 24, 2010', Phillips Fox, Canberra. Available from: http://www.planthealthaustralia.com.au/index.cfm?objectid=5BC64DD2-AE21-601E-BF29DC6AA453AFF8 [Accessed 31/05/2010].

Schellhorn, NA, Nyoike, TW and Liburd, OE 2009, 'IPM Programs In Vegetable Crops in Australia and USA" Current Status and Emerging Trends [Online]', in R Peshin and AK Dhawan (eds), *Integrated Pest Management: Innovation-Development Process*, vol. Volume 1, Springer, Google Books, pp. 575-689. Available from: http://books.google.com.au/books?id=xjhr2M1H_9IC&pg=PA575&lpg=PA575&dq=IPM+Programs+in+vegetables+crops+in+australia+and+usa&source=bl&ots=J8_DOAH8oq&sig=qGpa5h_NBAG3e19H0YfJXT8kfAs&hl=en&ei=763nS--JJougkQWHh-3oBg&sa=X&oi=book_result&ct=result&resnum=2&ved=0CA8Q6AEwAQ#v=onepage&q=IPM%20Programs%20in%20vegetables%20crops%20in%20australia%20and%20usa&f=false [Accessed 07/04/2010].

Simberloff, D 2009, 'We Can eliminate invasions or live with them. Successful management projects', *Biological Invasions*, vol. 11, pp. 149-157.

Thompson, RCA, Owen, IL, Puana, I, Banks, D, Davis, TME and Reid, SA 2003, 'Parasites and biosecurity - the example of Australia', *TRENDS in Parasitology*, vol. 19, no. 9, pp. 410-416.

Vander Zanden, MJ, Hansen, GJA, Higgins, S, N. and Kornis, Ms 2010, 'A pound of prevention, plus a pound of cure: Early detection and eradication of invasives species in the Laurentian Great Lakes', *Journal of Great Lakes Research*, vol. 36, pp. 199-205.

Vogt, RL, LaRue, D, Klaucke, DN and Jillson, DA 1983, 'Comparision of Active and Passive Surveillance Systems of Primary Care Providers for Hepatitis, Measles, Rubella, and Salmonellois in Vermont', *American Journal of Public Health*, vol. 73, no. 7, pp. 795-797.

WTO, World Trade Organisation 2010, 'The WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement)'. Available from: http://www.wto.org/english/tratop_e/sps_e/spsagr_e.htm [Accessed 21/05/2010].

Yuee, L, Zhang, J, Richards, MA, Pham, BL, Roe, P and Clarke, AR 2009, 'Towards continuous surveillance of fruit flies using sensor networks and machine vision' Paper presented at: *Proceedings of the 5th International Conference on Wireless Communications, Networking and Mobile Computing*, 24-26 September 2009.