Horticulture impact assessment program 2020-21 to 2022-23 (MT21015)

Annex 5: Impact assessment of the project *Improving biosecurity preparedness of the Australian citrus industry* (CT17001)

Delivery partner:

Ag Econ

Report author/s:

George Revell

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Level 7
141 Walker Street
North Sydney NSW 2060

Telephone: (02) 8295 2300

www.horticulture.com.au

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What the report is about

This report presents the results of an impact assessment of a Horticulture Innovation Australia Limited (Hort Innovation) investment in *CT17001 Improving biosecurity preparedness of the Australian citrus industry*. The project was funded by Hort Innovation over the period September 2017 to 30 June 2021.

Methodology

The investment was first analysed qualitatively within a logical framework that included activities and outputs, outcomes, and impacts. Actual and/or potential impacts then were categorised into a triple bottom line framework. Principal impacts identified were then considered for valuation in monetary terms (quantitative assessment). Past and future cash flows were expressed in 2020-21 dollar terms and were discounted to the year 2020-21 using a real (inflation-adjusted), risk free, pre-tax discount rate of 5% to estimate the investment criteria and a 5% reinvestment rate to estimate the modified internal rate of return (MIRR).

Results/key findings

The Hort Innovation investment in project CT17001 provided improved industry surveillance capacity relating to key exotic pests, particularly Huanglongbing (HLB) and its psyllid vectors, and citrus canker.

This was achieved through the appointment of a National Citrus Surveillance Coordinator, supporting the collection and collation of surveillance data, communicating information to industry stakeholders, identifying pest control options, and establishing the HLB Taskforce.

From these outputs, CT17001 was assessed to have supported a range of impacts relating to reduced biosecurity risk. These were quantified where possible based on available data:

Quantified

- A reduced HLB and citrus canker risk, supporting reduced impacts in the event of a pest incursion:
  - [Economic] Avoided orchard revenue losses, including from the death or removal of infected trees.
  - [Economic] Avoided orchard cost increases from additional management practices including removing and replanting affected trees, and increased ongoing pest-management costs.

Additional economic, social and environmental outcomes were identified but could be valued due to a lack of data. These have the potential to provide additional industry impact above what has been identified.

Investment criteria

Total funding from all sources for the project was $1.4 million (2021 equivalent value). The investment produced estimated total expected benefits of $17.0 million (2021 equivalent value). This gave a net present value of $15.6 million, an estimated benefit-cost ratio of 11.90 to 1, an internal rate of return of 69% and a modified internal rate of return of 12%.

Sensitivity testing showed that changes in fourteen key underlying variables resulted in a benefit cost ratio (BCR) ranging from 5.6 to 18.2.

Conclusions

Effective biosecurity risk management requires sustained investment to manage the risk of an incursion happening. The impact of CT17001 was valued in the context of its contribution to long-term risk management, and modelled as a reduced risk profile faced by the citrus industry over the four years of project funding (2018 to 2021).

The extent to which coordination (through CT17001) improves the effectiveness of existing surveillance investments and resources is difficult to estimate. While this could be done on a cost share basis it is also possible that coordination has a multiplier affect greater than its simple cost share.

Keywords

Impact assessment, cost-benefit analysis, citrus, risk, biosecurity, surveillance, Huanglongbing (HLB), citrus canker

Introduction

Evaluating the impacts of levy investments is important to demonstrate to levy payers, Government and other industry stakeholders the economic, social and environmental outcomes of investment for industry, as well as being an important step to inform the ongoing investment agenda.

The importance of ex-post evaluation was recognised through the Horticulture Innovation Australia Limited (Hort Innovation) independent review of performance completed in 2017, and was incorporated into the Organisational Evaluation Framework.

Reflecting its commitment to continuous improvement in the delivery of levy funded research, development and extension (RD&E), Hort Innovation required a series of impact assessments to be carried out annually on a representative sample of investments of its RD&E portfolio. The assessments were required to meet the following Hort Innovation evaluation reporting requirements:

- Reporting against the Hort Innovation's Strategic Plan and the Evaluation Framework associated with Hort Innovation's Statutory Funding Agreement with the Commonwealth Government.
- Reporting against strategic priorities set out in the Strategic Investment Plan for each Hort Innovation industry fund.
- Annual Reporting to Hort Innovation stakeholders.
- Reporting to the Council of Rural Research and Development Corporations (CRRDC).

As part of its commitment to meeting these reporting requirements, Ag Econ was commissioned to deliver the *Horticulture Impact Assessment Program 2020-21 to 2022-23 (MT21015)*. This program consisted of an annual impact assessment of 15 randomly selected Hort Innovation RD&E investments (projects) each year.

Project *CT17001 Improving biosecurity preparedness of the Australian citrus industry* was randomly selected as one of the 15 investments in the 2020-21 sample. This report presents the analysis and findings of the project impact assessment.

General method

The 2020-21 population was defined as an RD&E investment where a final deliverable had been submitted in the 2020-21 financial year. This generated an initial population of 175 Hort Innovation investments, worth an estimated $101.14 million (nominal Hort Innovation investment). The population was then stratified according to the Hort Innovation RD&E research portfolios and five, pre-defined project size classes. Projects in the Frontiers Fund, and those of less than $80,000 Hort Innovation investment being removed from the sample. From the remaining eligible population of 59 projects, with a combined value of $39.51 million, a random sample of 15 projects was selected worth a total of $9.7 million (nominal Hort Innovation investment), equal to 25% of the eligible RD&E population (in nominal terms).

The impact assessment followed general evaluation guidelines that are now well entrenched within the Australian primary industry research sector including Research and Development Corporations, Cooperative Research Centres, State Departments of Agriculture, and some universities. The approach included both qualitative and quantitative descriptions that are in accord with the impact assessment guidelines of the CRRDC (CRRDC, 2018).

The evaluation process involved reviewing project contracts, milestones, and other documents; interviewing relevant Hort Innovation staff, project delivery partners, and growers and other industry stakeholders where appropriate; and collating additional industry and economic data where necessary. Through this process, the project activities, outputs, outcomes, and impacts were identified and briefly described; and the principal economic, environmental, and social impacts were summarised in a triple bottom line framework.

Some, but not all, of the impacts identified were valued in monetary terms. Where impact valuation was exercised, the impact assessment uses cost-benefit analysis as its principal tool. The decision not to value certain impacts was due either to a shortage of necessary evidence/data, a high degree of uncertainty surrounding the potential impact, or the likely low relative significance of the impact compared to those that were valued. The impacts valued are therefore deemed to represent the principal benefits delivered by the project. However, as not all impacts were valued, the investment criteria reported for individual investments potentially represent an underestimate of the performance of that investment.

Background and rationale

Industry background

The Australian citrus industry, including oranges, mandarins, lemons and grapefruit, has approximately 1500 growers (Hort Innovation 2022a), with a five year average production of 747 thousand tonnes (to year ending June 2021), and a nominal production value of $873 million. An average 38% of combined production went to the domestic fresh market, 33% to exports, and 29% to processing. In 2021 New South Wales accounted for 36% of citrus production, South Australia accounted for 24%, Queensland 18%, Victoria 17%, and Western Australia 3% (Hort Innovation 2022b).

Producers in the citrus industry pay levies to the Department of Agriculture, Fisheries and Forestry (DAFF), who is responsible for the collection, administration and disbursement of levies and charges on behalf of Australian agricultural industries. Levy is payable on citrus that are produced in Australia and either sold by the producer or used by the producer in the production of other goods. Hort Innovation manages the citrus levy funds which are directed to R&D and marketing.

Rationale

The citrus industry levy investments are guided by a Strategic Investment Plan (SIP). The Citrus SIP 2017-21 (under which CT17001 was delivered) identified the 'relative freedom from pests and diseases in some areas' as a major opportunity for the industry, while 'ensuring there is no loss of markets due to biosecurity or MRL breaches' was identified as a major challenge.

Building upon the outcomes of earlier levy-funded project CT12022 *Protecting Australia's citrus industry from biosecurity threats*, CT17001 was established in 2018 to improve the industry's ability to respond to exotic pests, raise industry awareness about the importance of exotic citrus pests, and develop a nationally coordinated program for targeted surveillance activities.

Alignment with the Citrus Strategic Investment Plan 2017-2021

CT17001 was closely aligned to Outcome 2 of the Citrus 2017-21 SIP: *Growers and the industry reduce biosecurity, phytosanitary and agrichemical related risks*, and particularly Strategy 1: *Safeguard the Australian citrus industry from future biosecurity and phytosanitary risks throughout the value chain*.

Alignment with national priorities

The Australian Government's National RD&E priorities (2015a) and Science and Research Priorities (2015b) are reproduced in Table 1. The CT17001 project outcomes and related impacts contribute to RD&E Priority 2, and to Science and Research Priority 1.

Table 1. National Agricultural Innovation Priorities and Science and Research Priorities

Australian Government	
National RD&E Priorities (2015a)	**Science and Research Priorities (2015b)**
1. Advanced technology 2. Biosecurity 3. Soil, water and managing natural resources 4. Adoption of R&D.	1. Food 2. Soil and Water 3. Transport 4. Cybersecurity 5. Energy and Resources 6. Manufacturing 7. Environmental Change 8. Health.

Project details

Summary

Table 2. Project details

Project code	CT17001
Title	*Improving biosecurity preparedness of the Australian citrus industry*
Research organization	Plant Health Australia (PHA)
Project leader	Sharyn Taylor
Funding period	September 2017 to June 2021

Logical framework

A logical framework is shown in Table 3 to highlight the connection between the project activities, outputs, outcomes, and impact.

Table 3. Project logical framework

<table>
<tr><td>Activities</td><td>
Building upon the outcomes of earlier levy-funded project Protecting Australia’s citrus industry from biosecurity threats (CT12022), CT17001 undertook a range of activities to improve the industries coordination and capacity with regards to minimizing the risk of exotic pests.
The investment focused on five key activity areas: surveillance, industry awareness, capacity building, preparedness, and governance.
The investment had a particular focus on Huanglongbing (HLB) and its psyllid vectors, and citrus canker, with a reduced focus on citrus variegated chlorosis (Xylella).
</td></tr>
<tr><td>Outputs</td><td>
Key outputs delivered under the five focus areas were:

Surveillance: Data relating to exotic pests from commercial, urban, and peri-urban locations were collected through the Korea, China, Thailand (KCT) Surveillance Program and the Asian Citrus Psyllid Trapping Program (established in 2019 to trap and survey for Asian citrus psyllid). This is now embedded in the industry surveillance program as a result of CT17001.
Increased awareness: Communication materials and biosecurity presentations about exotic citrus pests were shared with growers to increase awareness and support surveillance activities.
Capacity building: A National Citrus Surveillance Coordinator was appointed who was responsible for working with growers, researchers, industry bodies and the Australian and state government agencies to coordinate citrus surveillance and biosecurity activities across the country. The First Detectors Network (FDN, a volunteer network created under Protecting Australia’s citrus industry from biosecurity threats (CT12022)) was also reviewed and maintained.
Preparedness: Pesticide control options for high priority exotic pests were identified.
Governance: The HLB Taskforce was established and then merged with the Citrus Pest and Disease Prevention Committee in 2020, with four to five meetings held per year to help guide activities in the biosecurity program.

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<tr><td>Outcomes</td><td>
Decreased exotic pest risk faced by the citrus industry through:

Increased surveillance capacity improving the likelihood of early detection of exotic pest incursions.
Increased industry capacity to slow the rate of spread in the event of an incursion.
Increased chance of containment or eradication as a result of early detection and response.

Supporting ongoing improvements in industry biosecurity surveillance coordination and related R&D.
</td></tr>
<tr><td>Impacts</td><td>
A reduced HLB, citrus canker, and Xylella risk supporting reduced impacts in the event of a pest incursion:

[Economic] Reduced orchard and nursery revenue losses, including from plant death, reduced plant productivity, and decreased marketable yield from reduced quality.
[Economic] Reduced orchard and nursery cost increases from additional management practices including removing and replanting affected trees, and increased ongoing pest-

</td></tr>
</table>

	management costs, increased costs of supply-chain regulation and compliance, and increased regional and national costs of containment and eradication. ○ [Economic] Reduced international and domestic market access issues from movement bans imposed on the affected areas. ○ [Social] Reduced reduction in the supply of fresh and affordable domestic horticultural produce, supporting fruit consumption with associated health and wellbeing benefits. ○ [Social] Reduced loss of industry spillovers from a reduced citrus industry, supporting a sustainable and important source of employment and economic stimulant to local communities. ○ [Environmental] Reduced environmental impacts from increases in chemical use to manage the spread of exotic pests. • [Economic] Increased confidence to invest in and trade with Australian citrus growers due to the presence of well established and effective biosecurity risk management coordination.

Project costs

Nominal investment

Table 4. Project nominal investment

Year end 30 June	Hort Innovation ($)	PHA ($)	Total ($)
2018	163,600	104,262	267,862
2019	164,627	104,917	269,544
2020	163,600	104,262	267,862
2021	224,950	143,360	368,310
Total	716,777	456,800	1,173,577

Program management costs

R&D costs should also include the administrative and overhead costs associated with managing and supporting the project. The Hort Innovation overhead and administrative costs were calculated for each project funding year based on the data presented in the *Statement of Comprehensive Income* in the *Hort Innovation Annual Report* for the relevant year. Where the overhead and administrative costs were equal to the total expenses, less the research and development and marketing expenses. The overhead and administrative costs were then calculated as a proportion of combined project expenses (RD&E and marketing), averaging 16.1% for the CT17001 funding period (2018-2021). This figure was then applied to the nominal Hort Innovation investment shown in Table 4.

Real Investment costs

For purposes of the investment analysis, the investment costs of all parties were expressed in 2020-21 dollar terms using the Implicit Price Deflator for Gross Domestic Product (ABS, 2022).

Extension costs

No additional costs of extension were included as the project included extensive industry engagement as part of the project activities and outputs.

Project impacts

Analyses were undertaken for total benefits that included future expected benefits. A degree of conservatism was used when quantifying impacts, particularly when some uncertainty was involved. Sensitivity analyses were undertaken for those variables where there was greatest uncertainty or for those that were identified as key drivers of the investment criteria.

Impacts valued

Due to the reduced focus on Xylella, the impact analysis focused on HLB and its psyllid vectors, and citrus canker.

The impact(s) valued were:

- A reduced HLB and citrus canker risk, supporting reduced impacts in the event of a pest incursion:
  - [Economic] Avoided orchard revenue losses, including from the death or removal of infected trees.
  - [Economic] Avoided orchard cost increases from additional management practices including removing and replanting affected trees, and increased ongoing pest-management costs.

Valuation method

Risk is measured as a combination of probability and consequences. In the event of a pest incursion, the consequences (lost revenue and increased costs) would occur over a period of time depending on the rate of pest spread. For every year of potential incursion, these consequences are weighted by the probability of incursion giving the annual value of risk faced by the industry. Surveillance coordination does not reduce the probability of a biosecurity incursion, but by allowing a faster response capacity, it reduces the likely consequences.

For HLB, the reduced consequences were modelled based on the USA experience from 2005, with early detection from effective surveillance supporting a slower spread (compared to what would occur without effective surveillance) resulting in delayed costs associated with the disease, including removal and replanting of infected trees resulting in lost revenue, and higher ongoing orchard management costs (such as pesticides for HLB vectors, nutritional management, and surveillance). It is possible that the delay could give the industry time to further reduce the risk such as through improved control techniques, generating additional value in delaying HLB spread, but given the uncertainties related to this scenario it was not included in the analysis.

For citrus canker, the reduced consequences were modelled based on the Northern Territory experience 2018-2021 compared to the Queensland experience (1994-1999), with earlier detection from effective surveillance supporting a smaller containment and eradication area resulting in a reduced costs associated with the disease including removal and replanting of infected trees resulting in lost revenue. In contrast to HLB, there are no ongoing costs after replanting as citrus canker will have been eradicated.

Neither HLB nor its vectors were detected during this project period. While canker was detected in the Northern Territory in 2018, this was before the appointment of the biosecurity coordinator, who thereafter had minimal involvement in containment and eradication (Citrus Australia pers comm 2022). Despite HLB, its vectors, nor canker being detected under the period of CT17001 surveillance coordination activities, to assign no value to the reduced industry biosecurity risk profile during this period would misrepresent the nature of long-term risk-management. Effective biosecurity risk management requires sustained investment to manage the risk of an incursion happening in any one of those years. To attribute benefit to only one period of this longer-term investment that happens to overlap with an incursion would significantly undervalue the costs relative to the benefits, and misrepresent the true impact of biosecurity risk management. As such, the impact of CT17001 was valued in the context of its contribution to long-term risk management, and modelled as a reduced risk faced by the citrus industry over the four years of project funding (2018 to 2021).

Impacts not valued

Not all of the impacts identified in Table 4 could be valued in the assessment, particularly where there was a lack of data to quantify the identified impact. Identified impacts not valued included:

- A reduced HLB and canker risk supporting reduced impacts in the event of a pest incursion:
  - [Economic] Avoided nursery revenue losses and cost increases.
  - [Economic] Avoided orchard revenue losses relating to reduced plant productivity, or decreased marketable yield from reduced quality.
  - [Economic] Avoided orchard and nursery costs from increased costs of supply-chain regulation and compliance, and increased regional and national costs of containment and eradication.
  - [Economic] Avoided international and domestic market access issues from movement bans imposed on the affected areas.
  - [Social] Avoided decrease in the supply of fresh and affordable domestic horticultural produce, supporting fruit consumption with associated health and wellbeing benefits.
  - [Social] Avoided loss of industry spillovers from a reduced citrus industry, supporting a sustainable and important source of employment and economic stimulant to local communities.
  - [Environmental] Avoided environmental impacts from increased chemical use to manage the spread of exotic pests.

- [Economic, social, environmental] A reduced Xylella risk faced by the citrus industry supporting reduced impacts as above.
- [Economic] Increased confidence to invest in and trade with Australian citrus growers due to the presence of well-established and effective biosecurity risk management coordination.

Public versus private impacts

The impacts identified from the investment are predominantly private impacts accruing to citrus growers. However, some public benefits also have been produced in the form of capacity built and spillovers to regional communities from reduced industry risk supporting more sustainable citrus businesses.

Distribution of private impacts

The private impacts will have been distributed between growers, processor/packers, wholesalers, exporters, and retailers. The share of impact realised by each link in the supply chain will depend on both short- and long-term supply and demand elasticities in the citrus markets. In addition, while the analysis quantified private benefits accruing to citrus growers. Additional spillover private impacts would be generated in the wider economy. Changes in farm input costs (increase or decrease) would result in spillover changes (increase or decrease) in income for businesses providing those goods and services.

Impacts on other Australian industries

The research focussed on citrus-specific exotic pests with limited implications for other industries.

Impacts overseas

The research focussed solely on reduced exotic pest risk to Australian citrus stakeholders. However, given the industry's high level of exports (33%), a reduced industry risk profile would have flow on benefits for Australia's trade partners depending on Australia's export market concentration and relative market share.

Data and assumptions

A summary of the key impact data and assumptions is provided in Table 5.

Table 5. Summary of data and assumptions for impact valuation

Variable	Assumption	Source / comment
	Background data	
Discount rate	5% (± 50%)	CRRDC Guidelines (2018)
Industry production (t)	746,812 (± 3%)	Australian Hort Stats Handbook (Hort Innovation 2022b) 5-year average and standard deviation.
Planted area (ha)	28,000	Citrus Australia 2022.
Yield (t/ha)	27 (± 3%)	Calculation from above.
	HLB probability and spread data	
Annual probability of HLB incursion (with and without effective surveillance)	13% (± 92%)	The probability of HLB incursion has variously been estimated as a less than 1% chance of incursion in a given year (Hafi et al 2015) and a 25% chance (Chudleigh 2021). PHA do not have an estimate of the current risk of HLB incursion but estimated the risk to be lower than that of canker (PHA, pers comm 2022). From this, a midpoint of the previous estimates was applied (12.5% equal to a likely incursion in 39 years when incorporated into a binomial distribution) Tested at 1% and 25%.
Likely rate of HLB spread with effective surveillance (% of maximum area)	100% spread by 34 years	Sigmoidal curve constructed based off USDA reports of 30% HLB spread by 8 years (USDA 2016), and 75% spread by 17 years from first identification (USDA 2021).
Likely rate of HLB	100% spread by 28 years (+	Assumption based off reported 100% HLB infection taking

spread without effective surveillance (% of maximum area)	2 years, -9 years)	8 years without management (Bove 2006). It is further assumed that in the absence of CT17001 there would not be uncontrolled spread but rather some less effective surveillance measures would result in spread somewhere between uncontrolled (8 years) and controlled (35 years based on USA data as above). The faster (without CT17001) spread was taken as 25% of the gap between the controlled and uncontrolled spread, tested for sensitivity at 12.5% and 37.5%.
Maximum citrus area impacted by HLB (with and without effective surveillance)	88% (± 14%)	It is difficult to eradicate HLB because efforts focus on symptomatic trees and symptoms might not be seen for 3–4 years (NSW DPI UNK). Despite a comprehensive surveillance and control program the USDA reports approximately 75% of citrus production in Florida has been impacted (USDA 2021), with continued spread, and a risk that the entire USA production will be affected (USDA 2016). Based on the USA experience, 75% spread taken as a lower bound, with 100% as the upper, and 88% midpoint.
Citrus Canker probability and spread data		
Annual probability of canker incursion (with and without effective surveillance)	30% (± 50%)	The probability of incursion for citrus canker was based on the 14 year period between the Queensland incursion (detected 2004) and the Northern Territory incursion (detected 2018). Using a binomial distribution, probable incursion (>99%) withing 14 years equates to an approximate 30% chance of incursion in any given year (tested 15% and 45%).
Likely rate of canker spread with and without effective surveillance (% of maximum area)	100% spread by 28 years (+ 2 years, -9 years)	Citrus canker can spread quickly over long distances (DAFF 2021). No rate of spread data was identified for canker so spread was based on HLB as above.
Maximum citrus area impacted by canker (without effective surveillance)	13% (± 96%)	Experience in Queensland 1994 to 1999 showed that without early detection and containment, an entire growing region can be at risk. The maximum impact area without effective surveillance is assumed to equate to half a single citrus growing regions ranging from 1% of national production to 53% (ABS, 2022b), with an average regional area of 27%.
Maximum citrus area impacted by canker (with effective surveillance)	1% (± 50%)	Assumption based on the experience in the Northern Territory (2018 to 2021) containment and eradication was possible with early detection and strong control measures. Infected plants were in domestic settings (not commercial); however, there remains a risk that commercial plantations could be infected.
HLB and canker consequences data		
Yield loss	100% years 1-3 Reducing to 0% by year 11	Citrus Budget Spreadsheets (NSW DPI 2018) annual yield of new plantings relative to maximum, using averaged figures for mandarin, navel and valencia citrus varieties.
Average citrus farmgate price ($/kg)	$1.23 (± 5%)	Australian Hort Stats Handbook (Hort Innovation 2022) 5-year average and standard deviation. Adjusted to 2021 values using the implicit price deflator (ABS, 2022)
Average citrus gross margin (without disease) (% of revenue)	31% (± 43%)	Citrus Budget Handbook (NSW DPI 2018) average gross margin across all varieties and regions.
Average citrus gross	20% (± 82%)	Citrus Budget Handbook (NSW DPI 2018) average gross

margin (with HLB) (% of revenue)		margin across all varieties and regions, adjusted for a 34% cost increase reflecting HLB in Florida (Barkley, P. and Beattie, A. (2013)).
Tree removal cost ($/ha)	$11,030 (± 3%)	Citrus Budget Spreadsheets (NSW DPI 2018) average and standard deviation of mandarin, navel and Valencia varieties. Adjusted to 2021 values using the implicit price deflator (ABS, 2022)
Tree replanting cost ($/ha)	$10,318 (± 18%)	
Outcome attribution and R&D counterfactual		
Attribution of outcome (effective surveillance) to CT17001 coordination	10% (± 50%)	Assumption. While full cost data for surveillance activities could not be identified, surveillance coordination is assumed to make up only a small proportion of the underlying surveillance resources and investment contributed by growers, researchers, industry bodies and the Australian and state government agencies. However at the same time, coordination improves the effectiveness of these underlying resources to provide a more robust foundation for early detection and response.
Attribution of outcome (canker containment and eradication)	75% (± 50%)	Assumption. While full cost data for all resources required for surveillance, containment, and eradication could not be identified, discussion with stakeholders indicates that surveillance and eradication (both accounted for in this analysis) would make up the majority of the total costs, with some additional costs in awareness and auditing to achieve containment.
R&D counterfactual (surveillance coordinator))	75% (± 33%)	Assumption. Discussions with industry stakeholders indicated that it is very difficult for industry wide citrus biosecurity coordination without Hort Innovation providing support through levy funds.

Results

All costs and benefits were discounted to 2020-21 using a real discount rate of 5%. A reinvestment rate of 5% was used for estimating the Modified Internal Rate of Return (MIRR). The base analysis used the best available estimates for each variable, notwithstanding a level of uncertainty for many of the estimates. All analyses ran for the length of the project investment period plus 30 years from the last year of investment (2020-21) as per the CRRDC Impact Assessment Guidelines (CRRDC, 2018).

Investment criteria

Table 6 shows the impact metrics estimated for different periods of benefit for the total investment, and Table 7 shows the impact metrics for the Hort Innovation investment with benefits attributed at 65% of the total, reflecting the Hort Innovation share of investment.

Table 6. Impact metrics for the total investment in project CT17001

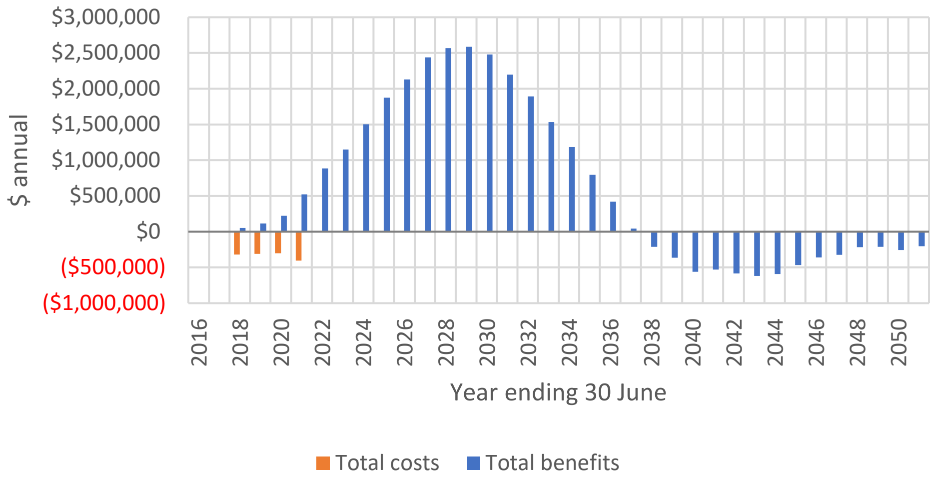
Impact metric	Years after last year of investment						
	0	5	10	15	20	25	30
PVC ($m)	1.43	1.43	1.43	1.43	1.43	1.43	1.43
PVB ($m)	0.94	7.34	15.68	18.87	18.22	17.36	17.05
NPV ($m)	-0.49	5.90	14.25	17.44	16.79	15.93	15.62
BCR	0.66	5.12	10.95	13.17	12.72	12.12	11.90
IRR	Negative	65%	69%	69%	69%	69%	69%
MIRR	Negative	41%	34%	27%	18%	13%	12%

Table 7. Impact metrics for the Hort Innovation investment in project CT17001

Impact metric	Years after last year of investment						
	0	5	10	15	20	25	30
PVC ($m)	0.92	0.92	0.92	0.92	0.92	0.92	0.92
PVB ($m)	0.61	4.74	10.12	12.18	11.77	11.21	11.01
NPV ($m)	-0.32	3.81	9.20	11.26	10.84	10.28	10.08
BCR	0.66	5.12	10.95	13.17	12.72	12.12	11.90
IRR	Negative	65%	69%	69%	69%	69%	69%
MIRR	Negative	41%	34%	27%	18%	13%	12%

Figure 1 shows the annual undiscounted benefit and cost cash flows for the total investment of CT17001. Cash flows are shown for the duration of the investment plus 30 years from the last year of investment.

Figure 3. Annual cash flow of undiscounted total benefits and total investment costs



Sensitivity analysis

A sensitivity analysis was carried out on key variables identified in the analysis where a data range was identified, or there was a level of uncertainty around the data. Data ranges and sources are described in Table 5, where a range was not identified in available data sources, sensitivity was tested at plus and minus 50% of the baseline value. Results from the sensitivity testing are presented in Table 8.

Table 8. Impact BCR sensitivity to changes in key underlying variables

Variable		Low	Baseline	High
Discount rate (%)	Variable range	2.5%	5.0%	7.5%
	BCR range	13.83	11.90	10.19
Industry production (t)	Variable range	720,846	746,812	772,779
	BCR range	11.57	11.90	12.23
Annual probability of HLB incursion (%)	Variable range	1%	13%	25%
	BCR range	6.25	11.90	15.72
Annual probability of canker incursion (%)	Variable range	15%	30%	45%
	BCR range	9.76	11.90	13.10
With project rate of spread (years to max)	Variable range	30	28	24
	BCR range	8.33	11.90	15.32

Maximum area of HLB spread (with and without effective surveillance)	Variable range	75%	88%	100%
	BCR range	11.01	11.90	12.79
Maximum area of canker spread (without effective surveillance)	Variable range	1%	13%	26%
	BCR range	6.44	11.90	17.37
Maximum area of canker spread (with effective surveillance)	Variable range	0.5%	1.0%	1.5%
	BCR range	12.24	11.90	11.58
Average citrus farmgate price $/t	Variable range	1.16	1.23	1.29
	BCR range	11.41	11.90	12.39
Average citrus GM (without disease) (% of revenue)	Variable range	18%	31%	45%
	BCR range	5.60	11.90	18.20
Average citrus GM (with HLB) (% of revenue)	Variable range	4%	20%	36%
	BCR range	16.19	11.90	7.62
Tree removal cost ($/ha)	Variable range	10,655	11,030	11,405
	BCR range	11.86	11.90	11.94
Tree replanting cost ($/ha)	Variable range	8,419	10,318	12,216
	BCR range	11.69	11.90	12.12
Attribution of outcome (more effective surveillance) to CT17001 coordination	Variable range	0.05	0.10	0.15
	BCR range	5.95	11.90	17.85
Attribution of outcome (canker containment and eradication)	Variable range	0.5	0.75	1.00
	BCR range	10.01	11.90	13.80
R&D counterfactual	Variable range	0.50	0.75	1.00
	BCR range	7.94	11.90	15.87

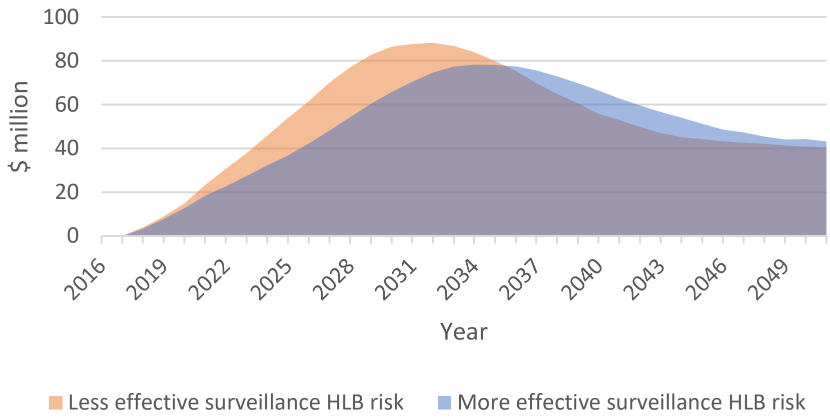
Discussion and conclusions

The analysis showed that the quantified benefits were greater than the investment cost for CT17001, with a BCR 11.9:1. The results reflect the benefit of improved industry surveillance capacity and preparedness as a result of coordination provided through the project, with the end impact being a reduction in biosecurity risk faced by the citrus industry.

Risk is measured as a combination of probability and consequences. In the event of a pest incursion, the consequences (lost revenue and increased costs) would occur over a period of time depending on the rate of pest spread. For every year of potential incursion, these consequences are weighted by the probability of incursion giving the annual value of risk faced by the industry. Surveillance coordination does not reduce the probability of a biosecurity incursion, but by allowing a faster response capacity, it reduces the likely consequences.

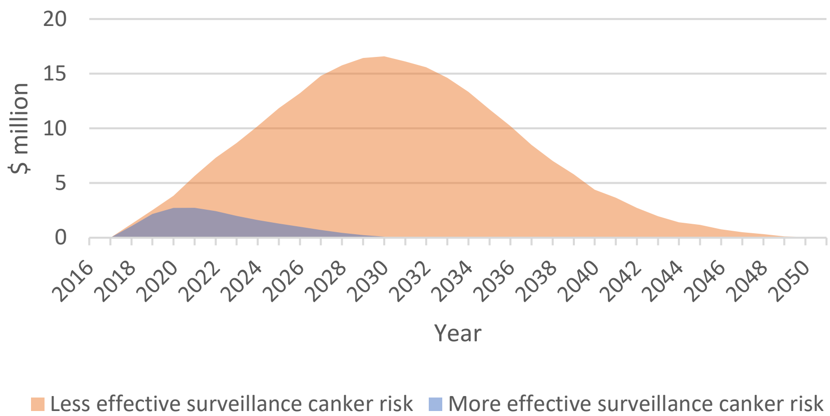
The reduced HLB risk accounted for 52% of the total benefit. Improved surveillance (with CT17001) increased the likelihood that the spread of the HLB and its vectors could be slowed down, resulting in a flatter risk profile (Figure 2). In comparison, with less effective surveillance, the industry faced a faster spread and sharper narrower risk. As a result, with CT17001 the value of the risk was lower in earlier years, but higher in later years, which generated the negative benefits in Figure 1. While the total nominal value of the risk was the same, there was a benefit in delaying the risk due to the time value of money. It is possible that a delayed spread of HLB could also give the industry time to further reduce the risk such as through improved control techniques. This would generate additional value in delaying HLB spread, but given the uncertainties related to this scenario it was not included in the analysis. Of note, not all of the change in risk shown in Figure 2 was attributed to CT17001 given the contribution of other resources (see Outcome Attribution in Table 5).

Figure 2. Annual nominal value of HLB risk with and without effective surveillance



The reduced canker risk accounted for 48% of the total benefit. Improved surveillance (with CT17001) increased the likelihood of early detection of canker, thereby increasing the chance that the pest could be contained and eradicated in a smaller area, with corresponding lower containment and eradication costs. The value of the risk faced by the industry in the event of a smaller or larger containment area are shown in Figure 3. Of note, not all of the change in risk shown in Figure 3 was attributed to CT17001 given the contribution of other resources (see Outcome Attribution in Table 5).

Figure 3. Annual nominal value of citrus canker risk with and without effective surveillance



Sensitivity testing showed that changes in fourteen key underlying variables resulted in a BCR ranging from 5.6 to 18.2. The results were most sensitive to the tested ranges of the following variables:

- Without disease gross margin. The value of lost production from removing and replanting trees, as well as the increased ongoing orchard costs of managing the disease (for HLB) will depend on the specific farm dynamics and underlying gross margin. There was a wide range in citrus gross margins identified indicating a potentially wide variation economic cost to the industry.
- Attribution of outcome (effective surveillance) to coordination provided by CT17001. The extent to which coordination (through CT17001) improves the effectiveness of existing surveillance resources is difficult to estimate. While this could be done on a cost share basis, data of underlying surveillance resources contributed by growers, researchers, industry bodies and Australian and state government agencies was not able to be identified. At this same time, it is possible that coordination has a multiplier affect greater than its simple cost share. This is particularly true in relation to the volunteer (unfunded) FDN. This surveillance network is located in urban and peri-urban areas where an incursion is more likely to begin (as occurred in the Northern Territory in 2018 to 2021). Without coordination of the volunteer FDN, there is a risk that this network ceases to function (as happened prior to CT17001 before it was revitalised as part of the project (Hort Innovation pers comm)). Having a functioning FDN (through the biosecurity coordinator) significantly increases the overall surveillance capacity.
- Baseline probability of HLB incursion. As risk is made up of probability x impact, the probability of incursion effectively provides a weighting to each years potential consequences. There were a wide range of estimates

identified for the probability of HLB incursion in a given year, ranging from 1% (Hafi et al 2015) to 25% chance (Chudleigh 2021).

- Maximum area of canker spread (without effective surveillance). This was based on potential spread throughout half of a growing region, as a result of less effective surveillance resulting in later detection and a larger containment area. With a large variation in the size of Australia's citrus growing regions from less than 1% (e.g. North West New South Wales) to 53% in the Murray River region of New South Wales, Victoria and South Australia, there is a wide variation in the risk profile (probability x consequences) for each region.

A lack of underlying data meant that there were economic, social and environmental impacts identified but not quantified which had the potential to provide additional impact to the citrus industry. These included changes in the biosecurity risk faced by nurseries, the risk of increased supply chain regulation and compliance, the risk of a decrease in citrus produce having flow on community impacts including a loss of jobs, and the environmental risk from increased chemical use to manage disease and vector spread.

The analysis quantified private benefits (avoided risk) accruing to citrus growers. Additional spillover impacts would be generated in the wider economy. A loss of production associated with HLB and canker incursions would result in a subsequent loss of income for both upstream and downstream supply chain participants.

The CRRDC Guidelines focusses on first round impacts, which calculates shifts in the supply and demand curves with no price effect. When considering these second-round price effects, a biosecurity incursion would result in decreased industry supply, and thereby increase prices. By supporting reduced biosecurity consequences, CT17001 would effectively support higher industry production in the event of an incursion, thereby supporting lower prices than would otherwise occur, and effectively shifting some of the benefit between producers and consumers. The extent to which this would occur would depend on the slope of the supply and demand curves.

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References

Australian Bureau of Statistics (ABS) (2022a). 5206.0 – *Australian National Accounts: National Income, Expenditure and Product, Dec 2021*. Table 5. Expenditure on Gross Domestic Product (GDP), Implicit price deflators. Retrieved from: https://www.abs.gov.au/statistics/economy/national-accounts/australian-national-accounts-national-income-expenditure-and-product/latest-release#data-download. Accessed July 2022.

Australian Bureau of Statistics (ABS) (2022b). 7121.0 – *Agricultural Commodities, Australia 2020-21*. Agricultural commodities by Natural Resource Management regions - 2020-21. Retrieved from: https://www.abs.gov.au/statistics/industry/agriculture/agricultural-commodities-australia/latest-release#data-download. Accessed July 2022

Barkley, P. and Beattie, A. (2013). *Huanglongbing (citrus greening) and the Asiatic citrus psyllid, presentation for the Murray Valley Citrus Board*. Retrieved from http://mvcitrus.org.au/mvcb/wp-content/uploads/2013/07/Huanglongbing%20and%20the%20Asiatic%20Citrus%20Psyllid%20-%20Pat%20Barkely.pdf. Accessed July 2022.

Bove, J. (2006) Huanglongbing: a destructive, newly-emerging, century-old disease of citrus. Journal of Plant Pathology 88: 7-37

Chudleigh P. (2021). Horticulture ex-post impact assessment program (MT18011) 2019-20: Appendix 5: Maximise the biosecurity of the Australia Citrus Industry Budwood Facility (CT17003 Impact Assessment). Retrieved from https://www.horticulture.com.au/growers/help-your-business-grow/research-reports-publications-fact-sheets-and-more/mt18011/. Accessed July 2022.

Citrus Australia. (2022). *Our Industry — Australian Citrus*. Retrieved from https://citrusaustralia.com.au/growers-industry/our-industry Accessed July 2022.

Commonwealth of Australia (2015a). *Agricultural Competitiveness White Paper*. Retrieved from https://www.awe.gov.au/agriculture-land/farm-food-drought/agriculture-white-paper. Accessed July 2022.

Commonwealth of Australia (2015b). *Strategic Science and Research Priorities*. Canberra: Commonwealth of Australia. Retrieved from https://www.industry.gov.au/data-and-publications/science-and-research-priorities#:~:text=Australia%20depends%20on%20science%20and,and%20improve%20national%20well%2Dbeing. Accessed July 2022.

Council of Rural Research and Development Corporations. (2018). *Cross-RDC Impact Assessment Program: Guidelines*. Canberra: Council of Rural Research and Development Corporations. Retrieved from http://www.ruralrdc.com.au/wp-content/uploads/2018/08/201804_RDC-IA-Guidelines-V.2.pdf. Accessed July 2022.

Hafi, A, Addai, D, Zhang, K & Gray, EM 2015, *The value of Australia's biosecurity system at the farm gate: an analysis of avoided trade and on-farm impacts*, ABARES research report 15.2, Department of Agriculture, Canberra, June.

Hort Innovation (2017). *Citrus Strategic Investment Plan 2017-2021*. Retrieved from https://www.horticulture.com.au/globalassets/hort-innovation/levy-fund-financial-and-management-documents/sip-pdfs-new/hortinnovation-sip-citrus-2017-2021.pdf. Accessed June 2022.

Hort Innovation (2022a). *Citrus Strategic Investment Plan 2022-2026*. Retrieved from https://www.horticulture.com.au/globalassets/hort-innovation/levy-fund-financial-and-management-documents/sip-2022-2026-pdfs/hort-innovation-sip-2022-26-citrus-r.pdf. Accessed June 2022.

Hort Innovation (2022b). *Horticulture Statistics Handbook* 2012-13 to 2020-21. Received from Hort Innovation pers comm. Data available https://www.horticulture.com.au/growers/help-your-business-grow/research-reports-publications-fact-sheets-and-more/grower-resources/ha18002-assets/australian-horticulture-statistics-handbook/

New South Wales Department of Primary Industries (NSW DPI) (2018). *Citrus budget handbook and Excel spreadsheets*. Retrieved from: https://www.dpi.nsw.gov.au/agriculture/horticulture/citrus/content/business/budget-handbook-and-spreadsheets. Accessed July 2022.

New South Wales Department of Primary Industries (NSW DPI) (UNK). *Huanglongbing (HLB) worldwide update*. Retrieved from: https://www.dpi.nsw.gov.au/agriculture/horticulture/citrus/content/insects-diseases-disorders-and-biosecurity/disease-overseas-factsheets/huanglongbing-hlb-worldwide-update. Accessed July 2022.

Plant Health Australia (PHA) (2021) *Improving biosecurity preparedness of the Australian citrus industry (CT17001)*. Final report, funded by Hort Innovation using the citrus research and development levy and contributions from the Australian Government. Retrieved from https://www.horticulture.com.au/growers/help-your-business-grow/research-reports-publications-fact-sheets-and-more/ct17001/. Accessed June 2022.

Queensland Department of Agriculture, Fisheries and Forestry (QDAF). (2013). *Threat specific contingency plan for huanglongbing and its vectors*. Accessed through Plant Health Australia https://www.planthealthaustralia.com.au/pests/huanglongbing-or-citrus-greening-asiatic-strain/. Retrieved July 2022.

United States Department of Agriculture (USDA). (2016). *Fact sheet — Huanglongbing (HLB)*. Retrieved from https://www.nifa.usda.gov/sites/default/files/resource/Citrus_Greening_Huanglongbing_HLB_%20Fact_Sheet_Rev1.pdf. Accessed July 2022.

United States Department of Agriculture (USDA). (2021). *Animal and Plant Health Inspection Service — Citrus Greening*. Retrieved from https://www.aphis.usda.gov/aphis/ourfocus/planthealth/plant-pest-and-disease-programs/pests-and-diseases/citrus/citrus-greening. Accessed July 2022.

Glossary of economic terms

Cost-benefit analysis	A conceptual framework for the economic evaluation of projects and programs in the public sector. It differs from a financial appraisal or evaluation in that it considers all gains (benefits) and losses (costs), regardless of to whom they accrue.
Benefit-cost ratio	The ratio of the present value of investment benefits to the present value of investment costs.
Discounting	The process of relating the costs and benefits of an investment to a base year using a stated discount rate.
Internal rate of return	The discount rate at which an investment has a net present value of zero, i.e. where present value of benefits = present value of costs.
Modified internal rate of return	The internal rate of return of an investment that is modified so that the cash inflows from an investment are re-invested at the rate of the cost of capital (the re-investment rate).
Net present value	The discounted value of the benefits of an investment less the discounted value of the costs, i.e. present value of benefits - present value of costs.
Present value of benefits	The discounted value of benefits.
Present value of costs	The discounted value of investment costs.

Abbreviations

CRRDC Council of Rural Research and Development Corporations

DAFF Department of Agriculture, Fisheries and Forestry (Australian Government)

GDP Gross Domestic Product

GVP Gross Value of Production

IRR Internal Rate of Return

MIRR Modified Internal Rate of Return

PVB Present Value of Benefits

PVC Present Value of Costs

RD&E Research, Development and Extension

SIP Strategic Investment Plan