

# A Benefit-cost Analysis of the Okanagan Kootenay Sterile Insect Release Program



Prepared for:  
Okanagan Kootenay Sterile Insect Release Program

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## Executive Summary

In the Okanagan/Similkameen region, the tree fruit industry value chain forms a significant part of the Agricultural Products Cluster. In 2011, 8,677 acres of apples comprised 38% of the total horticulture land base. The remaining acreage was planted primarily to sweet cherries (3,500 acres) and wine grapes (8,100 acres). However, the tree fruit industry value chain is undergoing significant transformational change as the apple acreage has declined from 13,430 acres in 2001, a loss of 4,753 acres. This change in the primary production base has had profound processing and marketing implications for the apple sector, and for the government programs such as the OKSIR that provide services to the sector. These changes lead to the research question: Are the benefits of the SIR program, to control Codling moth, greater than the cost of delivering the program?

### Methodology

A social benefit-cost analysis (B/C) was used to evaluate the Okanagan Kootenay Sterile Insect Release Program (OKSIR). This analysis measures both the benefits, in the form of cost savings and SIR services that accrue to the commercial apple and pear producers, and the benefits that non-agricultural residents receive, the consumer surplus. The study compares the Benefit/Cost ratios for both the existing Sterile Insect Technique (SIT) to control Codling moth and the use of a mating disruption (MD) technique.

The consumer surplus is measured using the Contingent Valuation, or willingness to pay (WTP) method. WTP is the highest price that a person would pay to have use of the product rather than go without it. WTP differs from 'market price' which is the price at which goods are exchanged in competitive markets; that is, a market with more than one seller. The WTP technique is often used to measure the social benefit associated with public goods, such as the SIR program.

Secondary data provided by the OKSIR program staff was used to measure the operating and administration costs of delivering the SIR program to commercial producers and regional district residents. Secondary data was also used to measure the benefits for the commercial producers. Primary data was collected to measure the benefits for the non-agricultural residents of the four regional districts. Primary data was collected through the use of survey questionnaires.

### Results

The benefit to the producer is derived from pesticide cost savings, monitoring cost savings, and Codling moth injury reduction, and is \$395.00/acre for SIT and \$377.30/acre for MD.

Residents of all four Regional Districts show a strong preference for reduced pesticide use: on their personal property, use by farmers, and pesticide residue in food. And 90.4% of residents are willing to pay \$0.8 - \$2.0 million annually to support pesticide reduction by the SIR program. The consumer surplus of \$1.5 million is the same for both SIT and MD, as residents enjoy the same benefit regardless of which control method is used. Some residents, 9.6%, are not willing to support the program. Reasons for this decision fall into 6 broad themes:

1. Orchardists Should Support The Program Themselves

2. Not Enough Information to Make Informed Decision
3. Not Relevant to Resident
4. Do Not Want to Pay More Taxes
5. Don't Believe the Program is Working
6. General Protest Vote

In addition to the consumer surplus, the region derives economic benefit from employment created by the SIR program. The total employment associated with the AW-IPM will contribute \$2.2 million, or \$251/acre, to the regional GDP

The cost to provide the SIT or MD program to 8,840 acres in 2014 is \$2,692,655 and \$2,350,700 respectively, or \$319.02/acre and \$278.51/acre. SIT is more costly to deliver due to the insect rearing and disbursement costs.

A summary of the Benefit Cost analysis is provided below.

	<b>Producer B/C</b>	<b>Total B/C</b>	<b>NPV</b>
<b>Sterile Insect Technique</b>	1.19	2.51	51,121,013
<b>Mating Disruption</b>	1.35	2.37	39,050,406

For both SIT and MD, the B/C ratio is greater than 1.0. This means that the benefits are greater than the costs, and therefore both methods are more efficient than the use of pesticides to control Codling moth. Mating disruption has the highest B/C ratio, primarily due to the lower costs associated with MD, indicating that it is the more efficient way to control Codling moth. However, due to the higher social benefit of delivering SIT, the net benefit for SIT (\$509.77/acre), is higher than for MD (\$454.67/acre). This is also reflected in the higher NPV for SIT.

The break-even point for SIT is 6,238 acres and 1,264 acres for MD. The lower acreage requirement for MD reflects the lower costs associated with MD, and supports the idea that MD is a viable method for controlling Codling moth in areas with relatively small acreages.

### *Opportunities for the Sterile Insect Technique Facility*

The study investigated two broad strategic alternatives for expanding the SIR program: a Scale strategy to produce sterile Codling moths for export out of the region, and a Scope strategy to diversify to the SIT to control Spotted Wing Drosophila (SWD) in sweet cherries.

The Scale Strategy has a higher B/C ratio than the Scope strategy (2.87 vs. 2.46). Although Scale has a higher B/C ratio, the NPV for the Scope Strategy (\$87.8 million) is considerably higher than the NPV for Scale (\$59.7 million), indicating that the industry cluster and the region's economy would benefit more by diversifying the SIT program into other regional commodities, such as sweet cherries and/or grapes. Diversifying into other commodities also brings more acreage under AW-IPM. This can be leveraged into a regional competitive advantage, as results of this study clearly show that consumers prefer to purchase fruit that is produced using fewer pesticides. However, there is significantly higher risk associated with

implementing the Scope alternative. The probability of achieving a Scope B/C ratio of 2.46 is 31.8%, compared to 70.6% to achieve a Scale B/C ratio of 2.87. Furthermore, the nature of the risk is fundamentally different for the two alternatives. The Scale (export) strategy has high marketing risk and low production risk; whereas the Scope (SWD) has high technical (production) risk and low marketing risk.

The two alternatives are not mutually exclusive, but due to limited resources, it would be difficult to implement them together. It is however, possible to implement them at different times in the future. The Scale strategy could be implemented in the short run, while investing in research and development to reduce the uncertainty of using SIT to control SWD. If technically feasible, the Scope strategy could then be implemented over a longer term.

Finally, implementing the diversification strategy will require changes to Section 283 of the Municipal Enabling and Validating Act (MEVA), and a commitment by the Federal government to fund the research necessary to extend the SIT to other insect pests. Perhaps the results of this study may be helpful in bringing about these changes.

## Introduction

Since 1992, the Okanagan Kootenay Sterile Insect Release Program (OKSIR), has been providing an Area-Wide Integrated Pest Management (AW-IPM) service to agricultural producers in the Regional District of the Okanagan Similkameen (RDOS), Regional District of the Central Okanagan (RDCO), Regional District of the North Okanagan (RDNO), and the Columbia Shuswap Regional District (CSRD) (see Figure 1). The role of the Sterile Insect Technique (SIT) as an effective component of sustainable AW-IPM is well understood (Vreysen, Hendrichs & Enkerlin, 2006). The focus of the OKSIR program is to control Codling moth, *Cydia pomonella*, in apple and pear crops. Codling moth is a serious insect pest of apples, pears, and English walnuts<sup>1</sup>. Failure to control Codling moth can result in significant economic damage to the tree fruit industry in these regions.

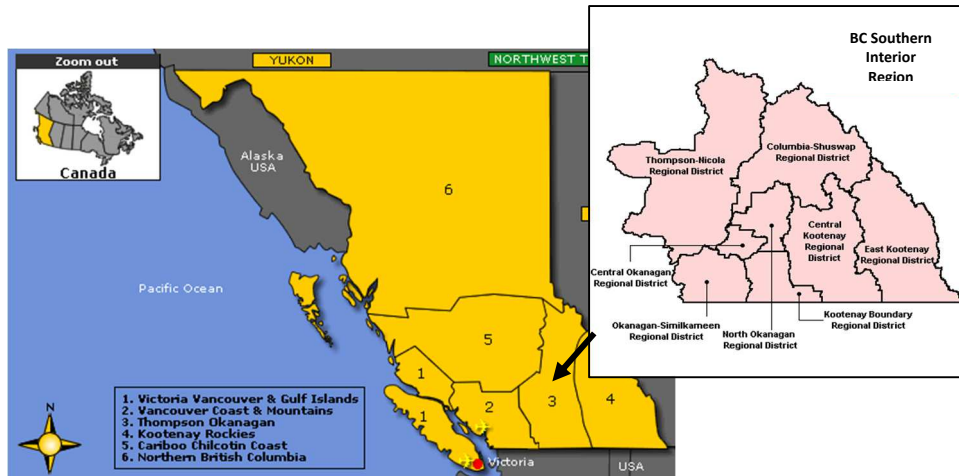


Figure 1: Sterile Insect Release Program Area

AW-IPM in the Okanagan is evolving. Results from a three year pilot project using multi-lure (codling moth/leaf roller) mating disruption (MD) in Zone 2 and 3 (Central and North) indicate that the Program can afford to provide SIT in Zone 1 where growers have been very satisfied with results and can also provide multi-lure MD in Zones 2 & 3 which seems to satisfy growers. The direction of AW-IPM is further affected by the options for the rearing facility: should further investment be made to maintain its status as a world-class SIT facility, or should it be phased out?

## Background to the Study

In the Okanagan/Similkameen region, the tree fruit industry value chain is a major part of the Agricultural Products Industry Cluster; furthermore, this industry cluster makes a significant contribution to the regional economy. There is strong evidence to support the proposition that industry clusters are major drivers of rural regional development (Irshad, 2009). When firms cluster, innovation and productivity are enhanced, this in turn improves industry competitiveness (Arikan, 2009, Porter, 2003). Moreover, there is a strong relationship between entrepreneurship

<sup>1</sup> University of California Agriculture & Natural Resources.  
<http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn7412.html>.

and industry cluster formation. Entrepreneurship stimulates cluster development and growth, which in turn fosters innovation and new business creation. This positive ‘reinforcing loop’ is the engine that drives regional economic performance (Cartier, 2012; Cartier, 2013). In the Okanagan region, the ‘Agricultural Products’ industry cluster makes a significant contribution to the region’s economy. Data developed by Cartier (2013), shows that this cluster outperforms the region in terms of GDP growth, employment growth, and new firm creation. But the structure of the industry cluster is changing, and so too, the government services provided to the cluster change as well.

In the Okanagan/Similkameen region, approximately 23,000 acres of land is used for tree fruit and grape production. An analysis of Census of Agriculture data from 2001, 2006, and 2011<sup>2</sup> show a significant decline in the apple acreage from 13,430 acres in

Table 1: Changes in Tree Fruit and Grape Acreage

	Acres			CAGR
	2011	2006	2001	
Apples	8,677	10,005	13,430	-4.3%
Pears	479	602	753	-4.4%
Plums	314	323	311	0.1%
Cherries (sweet)	3,532	2,515	1,930	6.2%
Cherries (sour)	75	147	254	-11.5%
Peaches	1,209	1,387	1,357	-1.1%
Apricots	216	320	433	-6.7%
Grapes	8,136	7,012	6,532	2.2%
<b>Total</b>	<b>22,638</b>	<b>22,311</b>	<b>25,000</b>	

2001 to 8,677 acres in 2011 (Table 1). Much of this apple acreage was replaced with sweet cherries which increased from 1,930 to 3,532 acres, and wine grapes which increased from 6,532 to 8,136 acres. This change in the primary production base has had profound implications for the processing and distribution segments of the value chain, and the services provided by government agencies. The loss of 4,753 acres of apple production

has resulted in major consolidation of the apple processing and packaging capacity, where many processing plants were either closed or retooled. The implications of this industry transformation for the OKSIR are significant. As the apple acreage has decreased, the fixed cost of delivering the SIR program to apple and pear growers, on a per acre basis, has risen. As the cost per acre rises, stakeholders begin to question the economic efficiency of the program. That is: is the cost of delivering the SIT program greater than the benefits derived from the program? Related to this question are a number of issues important to the OKSIR’s Board of Directors:

- Alternatives to SIT, such as Mating Disruption, are being investigated. Are there more efficient ways to control Codling moth other than SIT? What are the options for best utilization of the facility?
- Tax revenue to support the program has decreased as the apple acreage required to support the program has decreased.
- With limited funding, there are human resource succession issues, as long time managers approach retirement.
- There is limited technical support within Canada for SIT. There is limited extension support within the program (and industry overall). Limited research for program advancement and improvements (i.e. reduction in costs – improvement in rearing processes or distribution of sterile release)

<sup>2</sup> Source: Statistics Canada. <http://www.statcan.gc.ca/ca-ra2011/>



- Some municipalities only have residential host trees with few to no commercial apple plantings and question whether they should continue to contribute tax revenues to a program from which their rate payers may receive little or no direct benefit.

As the Agricultural Products cluster continues to evolve, new factors have emerged that are beginning to influence the future of the cluster and the OKSIR program's contribution to the cluster. A new pest, the Spotted Wing Drosophila (SWD), *Drosophila suzukii*, has now invaded the Okanagan/Similkameen regions. SWD is capable of causing considerable damage to the region's cherry producers and the organic fruit sector. Can SIT be used to control this most damaging pest? Regional government, through an effective AW-IPM program, can continue to play a vital role by supporting the changing nature of the cluster.

## Research Problem and Objectives

The purpose of this research is to measure the benefits and costs of the existing AW-IPM program. The research question guiding this investigation is "Are the benefits of the SIR program, to control Codling moth, greater than the cost of delivering the program?" The five research objectives developed to answer this question are listed below.

1. What are the economic benefits of the SIR program for the commercial tree fruit producers located in the four regional districts?
2. What are the economic benefits of the SIR program services for non-agricultural residents of the four regional district areas?
3. What are the costs of delivering the SIR program to the four regional district areas?
4. What is the most efficient method of controlling codling moth populations in the four regional districts?
5. What opportunities exist for the OKSIR to expand their services to new regions?

## Methodology

A social benefit-cost analysis is used to measure the effectiveness of the SIR program. Benefit-cost analysis (B/C) is drawn from economics and is a technique for comparing alternative investment opportunities; for government, B/C analysis is used to prioritize project funding. B/C analysis has also been used to measure the effectiveness of SIT in other regions of the world. Anaman, Atzeni, Mayer and Stuart (1993) used B/C analysis to measure the effectiveness of using SIT to eradicate the Screwworm fly in Australia, and B/C analysis was used by the International Atomic Energy Agency to evaluate three control options for the Mediterranean fruit fly (IAEA, 1995).

This study compares the Benefit/Cost ratios for both SIT to control Codling moth and the use of a mating disruption technique.

Two types of economic benefits are measured, as illustrated in Figure 2. First, the producer surplus (green shaded area), in the form of cost savings and AE-IPM services, that accrue to the commercial tree fruit producers, and second, the consumer surplus (yellow shaded area): the benefits that accrue to the non-agricultural residents. These benefits are is illustrated in Figure 2. The social benefit is the sum of the producer and consumer surplus. The opportunity

cost (purple shaded area) in Figure 2 is the cost the deliver the SIR services. MSC is the Marginal Social Cost curve and MSB is the Marginal Social Benefit curve.

Three producer benefits were identified for commercial apple and pear producers.

1. Savings in the cost of pest control chemicals that would otherwise be used to control Codling moth and the cost associated with the application of these pesticides.
2. Savings in the cost associated with monitoring Codling moth levels in their orchards.
3. Revenue loss due to pre-harvest Codling moth injury associated with pesticide control.

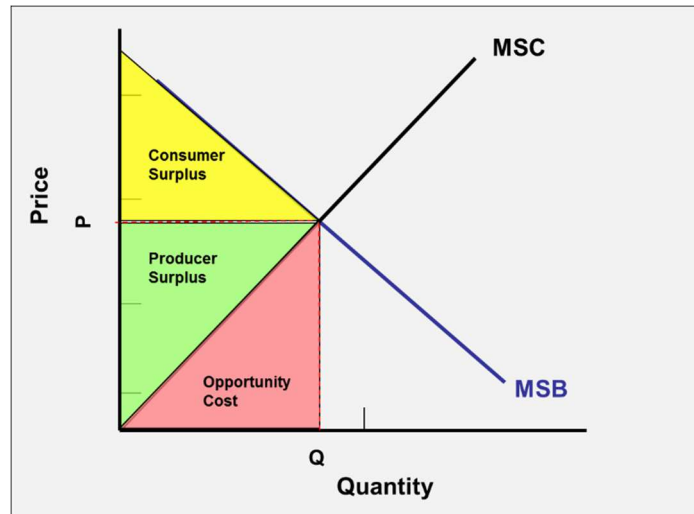


Figure 2: Consumer and Producer Surplus

The consumer surplus is the value to the consumer above the price they pay for a product, and arises from both the direct benefits to residents and the external benefits from the positive externalities associated with the SIR Program. Externalities are an important concept in economics, as their presence can lead to inefficient market outcomes. Externalities are unintended third party consequences that arise from transactions between two other parties. There are both negative externalities, such as the costs to society that result from pollution, and positive externalities, such as the benefits to society that are derived from research and education. A number of benefits have been identified for this study:

- An increase in the supply of pesticide reduced apples and pears. This can also result in market gains due to meeting higher quality standards for 'low-pesticide level products' (IAEA, 1995).
- Cash savings for residents that no longer have to use expensive pesticide sprays (deBiasio, 1988), or hire commercial pesticide services to spray their home apple (including ornamental crab apple) and pear trees.
- Improved health due to a reduction in the amount of pesticides in the environment, and from the handling of these pesticides (deBiasio, 1988). Also, pesticide use to protect agricultural crops has caused insecticide resistance to develop in insect vectors of disease, such as mosquitos. For example, this has been an important factor in the resurgence of malaria (Klassen, 2005).
- Protection of household pets, livestock, wildlife, and beneficial insects, such as honey bees, that might otherwise be harmed by the use of pesticides (deBiasio, 1988).
- A reduction of pesticide spray drift onto neighboring residential properties (Klassen, 2005).

The consumer surplus is measured using the Contingent Valuation, or willingness to pay (WTP) method. WTP is a fundamental tool of applied welfare economics and measures an individual's willingness to pay for a good or service. It is the highest price that a person would pay to have use the product rather than go without it. WTP differs from 'market price' which is the price at

which goods are exchanged in competitive markets; that is, a market with more than one seller. The WTP technique is often used to measure the social benefit associated with public goods, such as medical programs (Olsen & Donaldson, 1998; Donaldson, 1990; Garming & Waibel, 2006), and to control Asian Tiger Mosquito in New Jersey (Halasa, Shepard, Wittenberg, Fonseca, Farajollahi, Healy, Gaugler, Strickman & Clark, 2012).

The OKSIR program also provides other economic benefits to the region.

- The employment impacts associated with delivering the SIR program (deBiasio, 1988). These impacts replace the labour associated with pesticides that are produced outside of the region but are imported into the region. There are three types of employment impacts:
  - *Direct impacts* - measure the actual wages paid to SIR employees.
  - *Indirect impacts* - measure the economic activity generated by other firms supplying goods and services to the SIR program. An example of an indirect impact would be the legal and accounting services provided to the SIR program.
  - *Induced impacts* - measure the impact on the economy of spending by workers employed in the SIR program. BC Stats assumes that in BC, \$0.80 of each dollar earned from employment, will be spent in BC<sup>3</sup>. This 'ripple effect' results in increased economic activity in other BC industries.
- Additional revenues from increased regional tourism. The region's landscape, especially the presence of orchards and vineyards, is particularly distinctive and attractive to visitors. This appeal is enhanced by the minimal use of chemical pesticides and the high quality fruits that are produced. Also, many of the outdoor recreational opportunities such as golf, eco-tourism, agri-tourism, bird watching, and a variety of water sports all benefit from a clean environment (OKSIR, 2011).
- Additional revenues for non-apple producers through improved crop yields. The use of broad spectrum pesticides kills beneficial insects such as honey bees that pollinate crops and produce honey, and lady beetles and parasitic wasps that control other damaging insect pests (deBiasio, 1988).

The SIR program costs are the relevant operating and administration costs associated with the program, and were provided by the Regional District of the Central Okanagan.

Analysis of secondary data provided by the OKSIR program staff was used to measure the operating and administration costs of delivering the SIR program to commercial producers and regional district residents. Secondary data was also used to measure the direct economic benefits for the commercial producers. Primary data was collected to measure the program benefits for the non-agricultural residents of the four regional districts. Primary data was collected through the use of survey questionnaires.

### *Sample Design*

There are two populations associated with this study. The first population is comprised of the commercial apple and pear producers who are directly impacted by codling moth damage. The second population is comprised of the non-agricultural residential property owners that live in the four regional districts: RDOS, RDCO, RDNO, and CSRD. Primary data was only collected from the non-agricultural producers.

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<sup>3</sup> BC Stats, British Columbia's Fisheries and Aquaculture Sector, 2007

## Primary Data Collection

Primary data was collected through a combination of internet surveys and print surveys of the non-agricultural property owners. A link to the internet survey was sent to property owners, where e-mail addresses were available, and by posting a link to the survey on municipal websites. Additional primary data was collected through direct mail and convenience sampling at two shopping malls in the region.

In total 506 survey responses were received, with property owners representing 90.4% of respondents. The number of responses and the margin of error for each of the four Regional districts is provided in Table 2. The response rate from Columbia Shuswap Regional District is very low so the CSRD is underrepresented in the sample.

Table 2: Survey Responses and Margin of Error

Regional District	Number of Responses	Margin of Error*
South Okanagan/Similkameen	178	± 1.0%
Central Okanagan	208	± 1.4%
North Okanagan	109	± 1.1%
Columbia Shuswap	10	N/A
Not specified	1	
<b>Total</b>	<b>506</b>	<b>± 1.2%</b>

\* The margin of error is calculated using a 95% confidence level.

## Data Analysis

Data collected from the surveys was subjected to suitable pre-analytical checks to trap response errors and administrative errors. The cleaned data was then subjected to standard descriptive statistical tests including frequency distributions and contingency tables, and mean and standard deviation calculations. The data was then analyzed using standard benefit-cost calculation methods.

## Results and Discussion

This study compares the use of SIT and MD in controlling Codling moth populations in the four Regional Districts (the 'region'). A Benefit/Cost (B/C) ratio is calculated for each method of control. The method with the highest B/C ratio is considered to be the most efficient method.

Table 3: Producer Benefit Composition per Acre 2014

	SIT		MD	
Pesticide cost saving	166.61	42%	166.61	44%
Monitoring cost saving	80.00	20%	80.00	21%
Injury reduction	148.39	38%	130.69	35%
	395.00	100%	377.30	100%

### Economic Benefits of the SIR Program for Commercial Tree Fruit Producers

Three producer benefits are identified: savings in pesticide costs; savings in the cost associated with each orchardist monitoring Codling moth levels in their orchard; and revenue loss due to pre-harvest Codling

moth injury associated with pesticide control. The producer benefits per acre for the year 2014 are provided in Table 3. The pesticide cost saving includes the chemical and application cost, and is the same for both SIT and MD. The chemical cost was provided by Grower's Supply Limited, and is based on the standard pesticide protocol for Codling moth prescribed by the BC Ministry of Agriculture. The application cost includes the machine cost developed from standard agricultural engineering tables, fuel, and operator cost. The monitoring cost saving is based on the cost/acre of hiring a crop management consultant to monitor Codling moth levels.

### **Codling Moth Injury Reduction**

The pre-harvest injury for pesticide control, SIT, and MD are provided in Figure 3. The injury level of 3.1% associated with pesticide control is taken from the work of McGhee, P, Epstein, D, & Gut, L. (2011) in Michigan. Their four year study compared Codling moth injury levels in orchard blocks using conventional pesticide control to blocks using MD. This 3.1% injury level is consistent with injury levels measured in Creston, BC<sup>4</sup>. In 2013, injury levels for pesticide managed blocks was 3.57%, compared to 62% for abandoned orchards, and 34% for organic producers.

Injury levels for SIT control and MD control are taken from the report prepared by Paramjit Gill (2014). This study showed that there is a statistically significant difference in the injury levels in SIT blocks (0.04%) compared to MD blocks (0.41%).

The injury reduction benefit reported in Table 3 is calculated by converting the pre-harvest injury levels into revenue loss per acre. The apple price used for the revenue calculation is the five year average price developed from apple pool closing reports provided by BC Tree Fruit Cooperative.

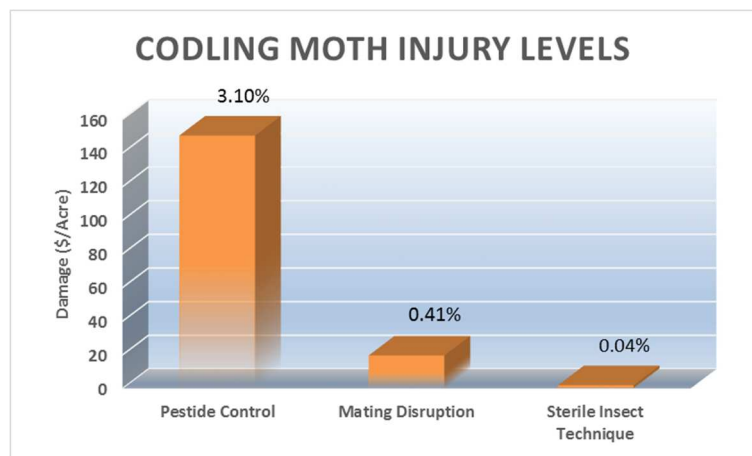


Figure 3: Codling Moth Injury Levels

### **Economic Benefits of the SIR Program Services for Non-Agricultural Residents**

This section examines three aspects of economic benefits for non-agricultural residents: the perceived benefit associated with reduced pesticide use, the willingness to pay for these benefits, and the employment impact related to the Area Wide IPM program.

#### **Pesticide Use**

Residents were asked to rank their preferences regarding three aspects of pesticide use in the region:

1. the use of pesticides on their property.

<sup>4</sup> Year To Date Summary of Codling Moth Captures, Creston Valley, 2013. Data Collected by Duane Holder

2. the use of pesticides by farmers.
3. pesticide residue in food.

For each aspect they were asked to rank their attitude towards the use of pesticides on a scale of 1 – 5, where 1=strongly disagree and 5 = strongly agree. The results are provided in Figure 4.

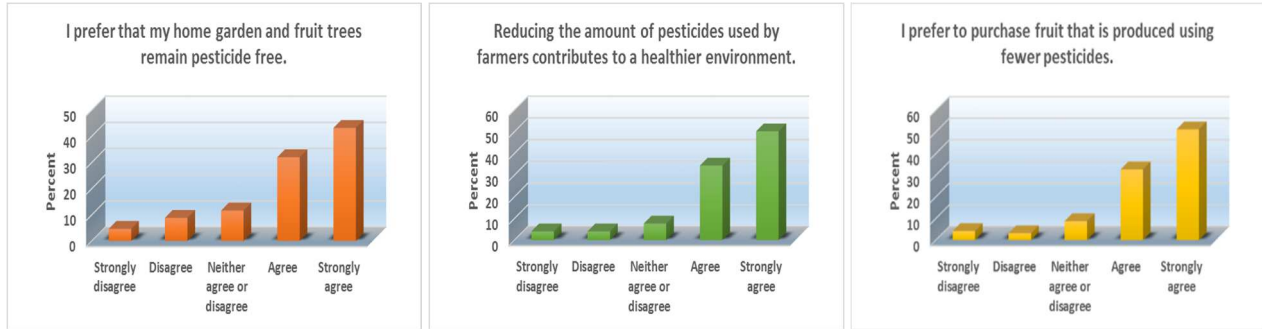


Figure 4: Preference for Reduced Pesticide Use

The data indicate that there is strong preference to reduce the amount of pesticides that are used in the region, both on their own property, and by commercial producers. The data also show a strong preference for purchasing fruit that is produced using fewer pesticides. The mean score, on a scale of 1 – 5, for each aspect is shown in Table 4.

Table 4: Pesticide Reduction Scores

Use of Pesticides	Mean Score (Scale of 1 – 5)	Standard Deviation
I prefer that my home garden and fruit trees remain pesticide free.	4.00	1.146
Reducing the amount of pesticides used by farmers and pest control companies contributes to a healthier environment for my family.	4.23	1.023
I prefer to purchase fruit that is produced using fewer pesticides.	4.24	1.025

A One Way Analysis of Variance (ANOVA) was conducted to identify any differences in the attitudes toward pesticide use between residents of the four Regional Districts. The results of the ANOVA are found in Appendix A. There is a statistically significant difference at the  $P < .05$  level in residents' tolerance for the use of pesticides between the four Regional Districts. Post-hoc comparisons using the Tukey HSD test indicated that residents' tolerance for pesticide use in the Central Okanagan is significantly higher than for residents in the other three Regional Districts.

Respondents were grouped into three age groups:  $\leq 40$  years, 41 to 66 Years,  $> 67$  years. There is no significant difference between the age groups and their attitudes regarding the use of pesticides.

### *Willingness to Pay*

Willingness to pay is the highest price that a person would pay to have the use a service rather than go without it. For the SIR program, it is the maximum amount of property tax/year that a



resident is willing to pay to support the SIR program in their region. It is a measure of the value to them, of living in a community that uses less pesticide.

Respondents were asked to choose one of six property tax amounts. These are provided in Table 5. The table also translates the amount of tax they are willing to pay into a value, based on the residential land value for the four Regional Districts. Respondents were also allowed to indicate if they did not want to support the SIR program; the values in the table are adjusted for the percentage of residents that are not willing to support the SIR program.

Table 5: Land Value Tax Levy Rates

Annual Property Tax	Value
\$6.00	\$865,121
\$8.00	\$1,155,302
\$10.00	\$1,442,772
\$12.00	\$1,730,241
\$14.00	\$2,020,423

The maximum amount of tax that property owners are willing to pay is provided in Figure 5. The data shows that 65% of these are willing to pay \$10.00 or more per property. The 46 non-property owners also replied to the willingness to pay question. Although they were excluded from the willingness to pay calculations, their intention to pay if they were property owners, is an indication of the value of the program to non-property owners. There was no significant difference in the mean willingness to pay between property and non-property owners.

The consumer surplus, as calculated from the data in Table 5 and Figure 5, is \$1,543,505, or \$182.87/acre. The consumer surplus is the total amount of tax that property owners are willing to pay to support the SIR program.



Figure 5: Property Owners Willingness to Pay

It does not matter to residents whether SIT or MD is the method used to control Codling moth. That is, the value of the SIR program to them is independent of the control method. The consumer surplus, therefore, is the same for both SIT and MD.

### Unwillingness to Pay

Of the property owners, 9.6% said they did not want to support the SIR. They were asked to comment as to why they were unwilling to support the program. Their comments were then organized into six themes as presented in Table 6.

Table 6: Why I don't want to support the SIR program.

	Percent
1. Orchardists Should Support The Program Themselves	12.9
2. Not Enough Information to Make Informed Decision	9.7
3. Not Relevant to Resident	12.9
4. Do Not Want to Pay More Taxes	16.1
5. Don't Believe the Program is Working	38.7
6. General Protest Vote	9.7

## Employment Impacts

The wages that are paid to SIR program employees are an economic benefit to the region. These wages form part of the value added associated with the region's AW-IPM program as they replace the labour associated with pesticides that are manufactured outside of the region.

In 2014, the SIT program is expected to pay \$1.2 million in direct wages. The indirect and induced impacts associated to these direct wages are \$605,103 and \$302,552 respectively. The indirect and induced impacts are calculated using the BC Provincial Economic Multipliers<sup>5</sup> for Municipal Government Services. The total employment impact for SIT in 2014 is \$2.1 million or \$250.92/acre.

Direct wages, in 2014, for the MD program are expected to be \$834,412. The indirect and induced impacts associated to these direct wages are \$417,206 and \$ 208,603 respectively. The total employment impact for SIT in 2014 is \$1.5 million or \$173.00/acre.

## Cost of Delivering the SIR Program

The cost to provide SIT or MD to 8,440 acres in 2014 is \$2.7 million and \$2,3 million respectively, or \$319/acre and \$279/acre. The cost structure for both SIT and MD is provided in Figure 6.

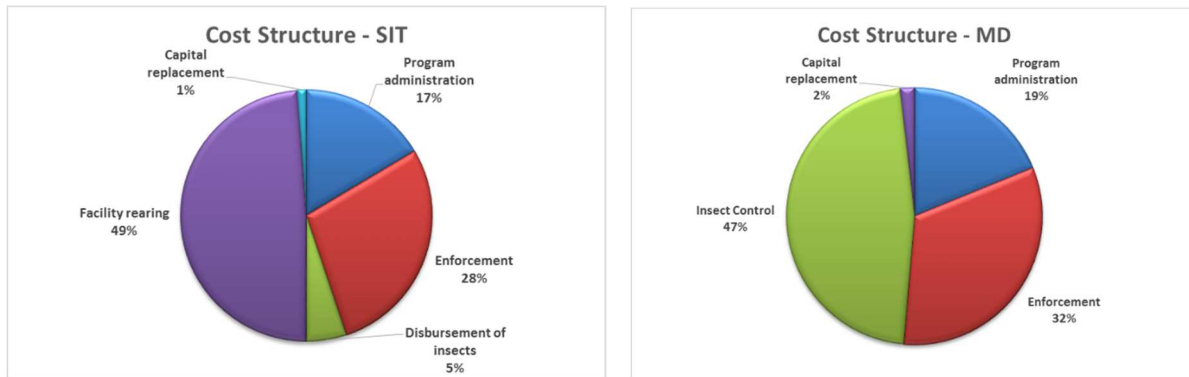


Figure 6: Cost Structure for the SIT or MD Methods

SIT is more costly to deliver. This is due to the rearing and disbursement costs of \$1.4 million compared to \$1.1 million for MD. The administration cost of \$443,348, and enforcement cost of \$764,258, are the same for both SIT and MD. The ongoing capital replacement costs are \$32,000 annually for SIT and \$42,000 annually for MD.

In addition to the ongoing annual operating and capital replacement costs there is a non-recurring cost of replacing the gamma cell at the rearing facility. If SIT were applied to all 8,440 acres, the gamma cell would be replaced in 2016 and is expected to cost \$1.3 million.

<sup>5</sup> Source: BC Stats (2008)



## Comparison of Sterile Insect Technique to Mating Disruption for Controlling Codling Moth Populations

The B/C ratio is calculated as the Present Value (PV) of the cash flows associated with the benefits divided by the PV of the cash flows associated with the costs. The discount period selected for the PV calculations is 30 years. The discount rate is 8%, as recommended by the Treasury Board of Canada for evaluating public projects<sup>6</sup>.

The results of the B/C analysis are provided in Table 7. For each control method, SIT and MD, the producer benefit/cost ratio is reported separate from the total B/C/ ratio. The total B/C ratio is the sum of the benefits for producers (producer surplus), the benefits for residential property owners (consumer surplus), and the economic impact related to the SIR program.

Table 7: Benefit/Cost Analysis Summary

	Producer B/C	Total B/C	NPV
<b>Sterile Insect Technique</b>	1.19	2.51	51,121,013
<b>Mating Disruption</b>	1.35	2.37	39,050,406

For both SIT and MD, the B/C ratio is greater than 1.0.

This means that the benefits are greater than the costs, and therefore both methods are more efficient than the use of pesticides to control Codling moth. Mating disruption has the highest B/C ratio, primarily due to the lower costs associated with MD, indicating that it the more efficient way to control Codling moth.

The minimum number of acres required to have the producer B/C ratio = 1.0 is considered to be the break-even point; below this acreage minimum the costs are greater than the benefits. The break-even point for SIT is 6,238 acres and 1,264 acres for MD. The lower acreage requirement for MD reflects the lower costs associated with MD, and supports the idea that MD is a viable method for controlling Codling moth in areas with relatively small acreages.

Another important consideration is whether SIT and MD are substitutes for each other. If this is the case, then it could be argued that SIT in the region should be abandoned in favor of the more efficient MD method. Entomologists attending the recent SIT research sessions<sup>7</sup> believe that SIT and MD are compliments of each other rather than substitutes, and can be combined in some cases to provide more effective control than either SIT or MD alone.

Finally, Table 3 also provides the Net Present Values (NPV) for each method. NPV is calculated as PV benefits – PV costs. The range of NPV reported in the table reflects the range of values that residents are willing to pay. The NPV calculations show that the benefits to both the producers and the residents far exceed the cost of maintain the SIR program.

<sup>6</sup> Treasury Board of Canada Secretariat (2007). Canadian Cost-Benefit Analysis Guide: Regulatory Proposals.

<sup>7</sup> Final FAO/IAEA Research Co-ordination Meeting on 'Increasing the Efficiency of Lepidoptera SIT by Enhanced Quality Control'. June 2 – 6, 2014

## Benefits and Costs per Acre

The benefits, costs, and net benefits per acre for the year 2014 are provided in Table 8. The higher producer benefit for SIT reflects the lower Codling moth injury levels associated with SIT. The willingness to pay of \$182.87 is the same for both methods. The willingness to pay value is the total from the survey results. The total benefit per acre for SIT and MD is \$828.79 and \$733.18 respectively. The cost per acre to provide SIT is higher than for MD, \$319.02 and \$278.51 respectively. This is due to the rearing costs associated with producing sterile moths. Due to the higher social benefit of delivering SIT, the net benefit for SIT (\$509.77/acre), is higher than for MD (\$454.67/acre). This is also reflected in the higher NPV for SIT.

Table 8: Net Benefits per Acre 2014

	SIT	MD
Producer benefit	395.00	377.30
Employment impact	250.92	173.00
Willingness to pay	182.87	182.87
Total benefit	828.79	733.18
Cost	319.02	278.51
Net benefit	509.77	454.67

## Opportunities for the OKSIR to Expand their Services to New Regions

Currently, the SIT facility in Osoyoos produces sterile Codling moths to supply Zone 1, approximately 3,750 acres. Mating disruption is used to control Codling moth in Zones 2 and 3. At this level of production, the plant is operating far below its capacity. This provides an opportunity for the SIR program to expand its SIT services. The main question posed by SIR management is: Which direction should they go in order to maximize the value of the investment in the SIT facility? This section of the report considers two possible strategic directions. However, due to the limited amount of information available at this time, the discussion in this report is at a very general level, and is intended to identify areas for further investigation rather than provide recommendations. For each alternative, the report discusses: the advantages and disadvantages, an economic analysis, a risk assessment, and areas for further investigation.

The two broad strategic alternatives are summarized below.

1. **A Scale Strategy:** this strategy involves producing sterile Codling moths for export to other regions, either in Canada or other countries. It is a scale strategy in that by increasing production, the SIT program will capture economies of scale associated with the higher production. The net revenues from the sale of moths will be applied directly to the regional SIR program, resulting in a lower cost for local apple and pear producers.
2. **A Scope Strategy:** this strategy involves extending the SIT technology to other horticulture crops, such as sweet cherries, in the SIR region. It is a scope strategy in that production at the plant will be diversified into new insect pests. This diversification will allow the SIT program to capture economies of scope. All of the production will be used within the SIR region — no insects will be exported. At its core, this is a 'new product development' strategy.

The two alternatives are not mutually exclusive. That is, they could be implemented at the same time; however, it is unlikely that there are sufficient resources available to do this. It is more

reasonable to consider the scale strategy as a short term option, and the scope strategy as a long term option.

## The Scale Strategy: Exporting Sterile Codling Moths

There are a number of advantages associated with this alternative. Some of these are listed below.

- The OKSIR has extensive experience in the production of sterile Codling moths, and a proven track record of producing high quality moths.
- The existing plant has capacity to produce 337,000 petri dishes for export.
- The operation has an existing highly skilled production team that could increase production quickly.
- The existing facility is state-of-the-art, and the SIT program has recently undergone an extensive external review of its operations to insure that the production process utilizes best practices in Codling moth production.
- The demand for pesticide reduced insect control methods is increasing globally, especially in developed countries in Europe and the United States.

There are also a number of disadvantages associated with an export strategy. Many of these are related to the marketing of sterile moths. Some of the disadvantages are listed below.

- The size and growth rate of the potential market for sterile Codling moths is unknown.
- The potential trade barriers are poorly understood. There may be non-tariff barriers to overcome in developing these new markets.
- There is no existing market of the sale of sterile insects, so there is great uncertainty related to the price that customers would be willing to pay for moths. It is unlikely that a potential customer would be willing to pay more to purchase moths than it would cost them produce them.
- A list of potential customers, in order of attractiveness, would have to be developed. This will require extensive marketing research and could be time consuming and expensive.
- The OKSIR does not have a marketing and sales department. This will have to be created, and there is a high learning curve cost associated with developing new markets.

### Benefit-Cost Analysis

The model developed to calculate the B/C ratio for SIT was expanded to include the export of moths. A number of assumptions were used to develop the scale strategy. These assumptions are shown in Table 9. The assumptions around the export price, sales quantity, and additional fixed production cost were provided by management. The marketing and sales cost was developed from financial information available from Industry Canada for NAICS code 3254 -

Table 9: Assumptions Used to Develop the Scale Strategy B/C Analysis

Number of petri dishes sold	187,364
Additional fixed production cost	\$45,000
Marketing and sales cost (% of sales)	15.0%
Codling moth export Price/Petri dish	6.00
Cost/petri dish exported	3.80
Net revenue/petri dish	<u>\$2.20</u>

Pharmaceutical and Medicine Manufacturing. This is the closest industry classification to sterile

insect moth production and sales. The data is for incorporated businesses with annual revenues \$30,000 - \$5,000,000 for the year 2011.

The B/C analysis for the scale alternative is shown in Table 10. The B/C ratio and NPV for the status quo is also provided. The Producer B/C ratio increases from 1.19 to 1.48. The increase in the producer B/C ratio is due to the net revenues generated from the sale of moths (Table 9). The export net revenues of \$2.20/petri dish reduce the cost of the SIT program for the local growers.

Table 10: B/C Analysis for the Scale Strategy

	Producer B/C	Total B/C	NPV
SIT for apples only	1.19	2.51	51,121,013
SIT with export sales	1.48	2.87	59,722,069

The net revenues also result in a 14% increase in the NPV. This is the minimum impact to the agricultural products cluster and residents of the four Regional Districts.

### Risk Analysis

A risk analysis was performed using a Monte Carlo simulation. The projected B/C ratios and NPVs are based on the assumptions shown in Table 9. The greater the uncertainty associated with these assumptions, the greater is the risk, or probability, that the outcome (expected B/C ratio) will not be achieved. Monte Carlo is a mathematical simulation that calculates these probabilities based on a number of iterations of the model. The Monte Carlo probability analysis is well understood and was used to estimate the risk to the U.S. apple, grape, orange and pear industries from the Light Brown Apple Moth (Fowler, Garrett, Neeley, Magarey, Borchert & Spears, 2009). The analysis establishes a range of estimates: minimum (most pessimistic), most likely (expected), and maximum (most optimistic) for each variable. It then runs a number of iterations of the model by taking a random sample from each range during each iteration. If enough iterations are completed, the probability that the expected outcome will be achieved is established.

Table 11: Variables Used in the Scale Strategy B/C Analysis

Variable	Minimum	Expected	Maximum
Codling moth export Price/Petri dish	\$4.80	\$6.00	\$7.20
Number of petri dished sold	0	187,364	337,364
Additional fixed production cost	\$26,000	\$45,000	\$60,000
Marketing and sales cost (% of sales)	12.0%	15.0%	18.0%

The range of estimates were provided by management for each of the variables used in the analysis and are provided in Table 11.

The simulation is based on 500 iterations. That is, the assumptions were tested 500 times, each time with a different value; it would be conceptually similar to running the business for 500 years. The probability table is provided in Table 12.

Table 12: Probability Analysis of Scale Strategy

	Producer B/C	Total B/C	NPV
Maximum (Most Optimistic)	2.19	3.88	75,666,583
Expected (based on projected values)	1.33	2.79	54,587,344
Minimum (Most Pessimistic)	1.12	2.41	48,485,689
Variance from projected	0.21	0.39	6,101,654
Probability of achieving "Expected value"	70.6%	61.4%	72.4%

The producer B/C ratio shows a range from 1.12 to 2.19 with a probability of achieving the expected ratio of 70.6%. That is, there is a 70.6% probability that the strategy will achieve its projected outcome. The probability distribution and cumulative probability for the producer B/C ratio is shown in Figure 7.

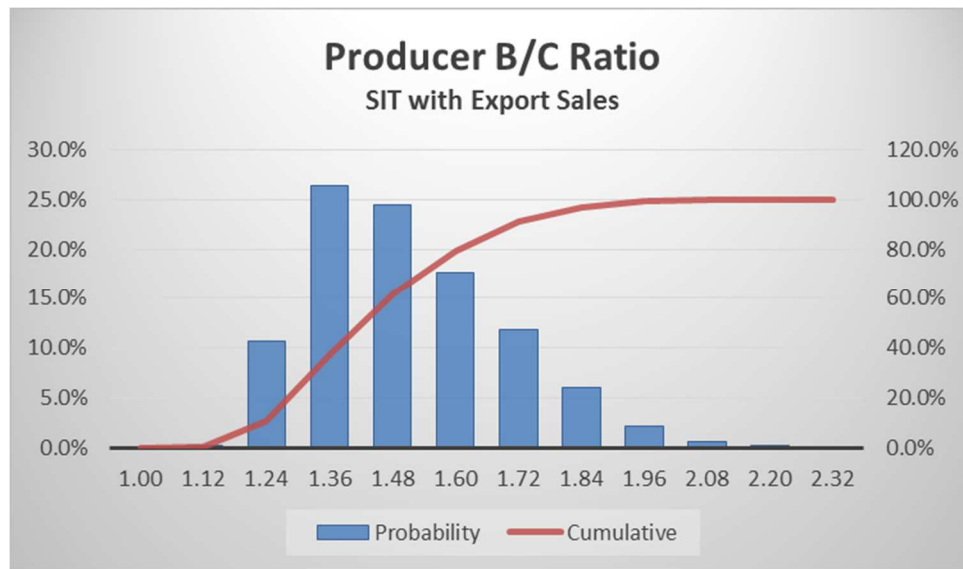


Figure 7: Probability Distribution for the Scale Strategy

### Areas for Further Investigation

To lower the risk associated with the assumptions used to develop the model, further marketing research is required. The size and growth rate of the market must be established, and a short list of 'qualified' customers for sterile moths prepared. The adoption rates by these customers must be established together with an appropriate pricing strategy. From this research, a marketing mix strategy: product, price, distribution, and promotion, can be developed and the cost of implementing the strategy established. An economic and financial analysis can then be prepared. This should lead to a go or no-go decision.

## The Scope Strategy: Extending SIT to Other Horticulture Crops

This strategy is focused on the application of SIT to control Spotted Wing Drosophila (*Drosophila suzuki*) in sweet cherries. It is recognized however, that this same strategy could be applied to other insect pests.

There are a number of advantages associated with this alternative. Some of these are listed below.

- It brings more horticulture acreage under the AW-IPM program.
- Extending the SIT to other horticultural crops in the region, provides a larger acreage base over which the fixed costs may be applied. There are approximately 4,400 acres of sweet cherries in the region.
- SIT can often be used as a weapon to control new invasive insect pests, and in some instances eradicate these pests.
- It further reduces the use of pesticides in the region to control insect pests of other crops.

There are also a number of disadvantages associated with a diversification strategy. Many of these are related to the technical aspects of using SIT on Spotted Wing Drosophila (SWD). Some of the disadvantages are listed below.

- It is unknown whether SIT can be used to control SWD in sweet cherries. Some entomologists attending the Final FAO/IAEA Research Co-ordination Meeting believe that SIT will not be effective against this insect.
- The incremental costs of adapting the SIT facility for SWD are not well known.
- There may be resistance by commercial cherry growers to adopting SIT for SWD.

### Benefit-Cost Analysis

The assumptions used to develop this strategy are provided in Table 13. The assumptions for apples are taken from the B/C analysis for apple SIT (see Table 3). Cherry acreage is taken from the 2011 Census of Agriculture (Stats Canada); the pesticide cost saving is developed from the BC Ministry of Agriculture spray protocol for cherries and chemical costs provided by Growers' Supply Ltd.; injury levels from SWD are estimates developed from discussions with the BC Tree Fruit Cooperative and the Canadian Food Inspection Agency. The additional fixed production cost and capital replacement are provided by management.

Table 13: Assumptions Used to Develop the Scope Strategy B/C Analysis

<b>Apples:</b>	
Number of acres	8,840
Pesticide cost saving/acre	\$166.61
Monitoring cost saving/acre	\$80.00
Injury reduction/acre	\$148.39
<b>Cherries:</b>	
Number of acres	4,434
Pesticide cost saving/acre	\$490.31
Injury reduction/acre	\$858.00
Additional fixed production cost	\$45,000
Number of petri dishes required per acre	31
Additional capital replacement	\$158,000

The B/C analysis for the scope alternative is shown in Table 14. The B/C ratio and NPV for the status quo is also provided for comparison. The producer B/C ratio increases from 1.19 to 1.72. The increase in the Producer B/C ratio is due to the chemical costs to control SWD and a reduction in the insect injury levels associated with pesticides to control the insect.

Table 14: B/C Analysis for the Scope Strategy

	Producer B/C	Total B/C	NPV
SIT for apples only	1.19	2.51	51,121,013
SIT for apples and cherries	1.72	2.46	87,781,192

Increasing the number of acres under the program results in a 42% increase in the NPV. This is the minimum impact to the agricultural products cluster and residents of the region, and is considerably larger than that provided by the scale strategy.

### Risk Analysis

As for the scale strategy, a risk analysis was performed using a Monte Carlo simulation. The projected B/C ratios and NPVs are based on the assumptions shown in Table 13. The range of estimates were provided by management for each of the variables used in the analysis and are provided in Table 15.

Table 15: Variables Used in the Scope Strategy B/C Analysis

Variable	Minimum	Expected	Maximum
Additional fixed production cost	\$40,000	\$45,000	\$50,000
Number of petri dishes required per acre	30	31	32
Additional capital replacement	\$125,000	\$158,000	\$175,000

The simulation is based on 500 iterations. The probability table is provided in Table 16.

Table 16: Probability Analysis of Scope Strategy

	Producer B/C	Total B/C	NPV
Maximum (Most Optimistic)	2.52	3.26	135,556,314
Expected (based on projected values)	2.05	2.86	102,552,014
Minimum (Most Pessimistic)	1.60	2.34	80,684,178
Variance from projected	0.45	0.51	21,867,836
Probability of achieving "Expected value"	31.8%	20.8%	50.4%

The producer private B/C ratio shows a range from 1.60 to 2.52 with a probability of achieving the expected ratio of 31.8%. That is, there is a 31.8% probability that the strategy will achieve its projected outcome. The probability distribution for the producer B/C ratio is shown in Figure 8. Although the potential outcomes are greater for the scope strategy, there is greater risk associated with the scope strategy compared to the scale strategy.



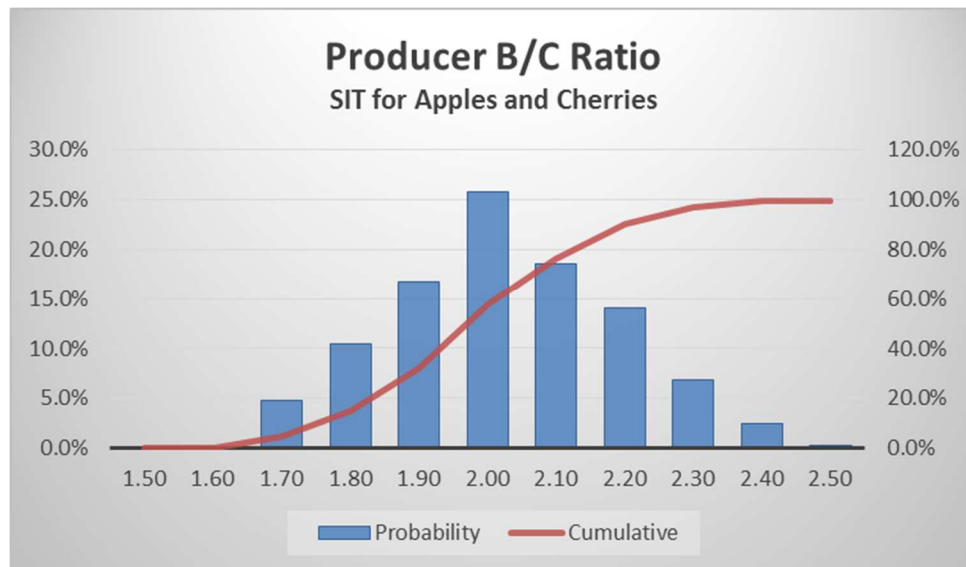


Figure 8: Probability Distribution for the Scope Strategy

### Areas for Further Investigation

To be successful, a new product development strategy, such as SIT for SWD, must pass four tests:

1. Is there a market for the new product?
2. Is it technically feasible to produce the new product?
3. Is the opportunity economically sound?
4. Is the opportunity financially feasible?

The answer to all four questions must be ‘yes’. A failure to pass any of the tests will insure disaster. The major source of uncertainty associated with using SIT to control SWD is question 2: the technical feasibility of SIT to effectively control SWD. More research into this issue is essential before any further implementation can be considered. Discussions with entomologists indicate that the necessary research could be completed within two years if adequate research resources are provided.

There is sufficient cherry acreage to support a viable SIT program and should the research show that SIT is effective for SWD, then the strategy should be both economically sound and financially feasible. If the results of the research show that SIT will not control SWD, then the OKSIR management should identify another insect pest to control.

### Conclusions

This study investigates the value of the AW-IPM program to control Codling moth, in the four Regional Districts that comprise the Okanagan/Similkameen region, using a Benefit-Cost approach. This analysis measures both the benefits that accrue to the farmers (the producer



surplus) and the benefits that non-agricultural residents receive (the consumer surplus). The results indicate that the social benefits are greater than the cost to provide the AW-IPM program.

There is a significant benefit for regional apple and pear growers; the producer surplus for SIT and MD, at \$395/acre and \$377 respectively, is greater than the cost of \$319/acre. The study also compared the producer B/C ratios for both SIT and MD to control Codling moth. MD has a higher B/C ratio than SIT, due to the lower cost per acre of providing MD services; however, SIT and MD are considered to be complimentary tools for an Area-wide Integrated Pest Management program. SIT delivers higher producer benefits, but MD requires fewer acres to break-even than does SIT, and can be used in areas that are too small to sustain a SIT program.

The benefits to residents of the four Regional Districts are derived primarily from the reduction in the use of pesticides to control Codling moth. Moreover, 90% of residents clearly value living in a community that uses fewer pesticides; they are willing to pay \$0.8 - \$2.0 million annually to enjoy these benefits, with a resulting consumer surplus of \$1.5 million. The consumer surplus is the same for both SIT and MD as residents enjoy the same benefit regardless of which control method is used. In other words, the externality is the same for SIT and MD. In addition to the consumer surplus, the region also derives economic benefit from employment created by the SIR program. In 2014, the employment associated with the AW-IPM will contribute \$2.2 million, or \$251/acre, to the regional GDP.

The SIR program is limited to Codling moth control in apples, crab apples, and pears. As the apple and pear acreage decreased to 8,440 acres, and with the adoption of MD to control Codling moth in Zones 2 and 3, the remaining acreage under SIT treatment is below the break-even point. This means that the SIT facility in Osoyoos is under-utilized, with considerable excess capacity to produce more sterile insects. Also, the SIR program is limited by legislation to the control of Codling moth, further limiting the potential use of the facility. In spite of these challenges, this study explored two broad strategic alternatives for expanding the SIT program: a Scale strategy to export sterile Codling moths out of the region, and a Scope strategy to diversify SIT into the control of Spotted Wing Drosophila (SWD) in sweet cherries.

Results from the analysis indicate that the Scale (export) Strategy provides greater benefits (a higher B/C ratio) for apple and pear growers than the Scope (cherry) strategy, as it lowers the cost to produce sterile Codling moths. This strategy also overcomes the poor plant utilization rate. However, the Scope strategy also improves plant utilization and shows a higher NPV, indicating that the Scope alternative would provide greater benefits to both the Agricultural Products Cluster and the region. Overall, the industry cluster and the region's economy would benefit more by diversifying the SIT program into other regional commodities, such as sweet cherries and/or grapes. Diversifying into other commodities also brings more acreage under AW-IPM. This can be leveraged into a regional competitive advantage, as results of this study clearly show that consumers prefer to purchase fruit that is produced using fewer pesticides.

However, there is significantly higher risk associated with implementing the Scope alternative, and the nature of the risk is fundamentally different for the two alternatives. The Scale (export) strategy has high marketing risk and low production risk; whereas the Scope (cherry) strategy has high technical (production) risk and low marketing risk.

It is important to understand that the two alternatives are not mutually exclusive, so it is possible to implement the Scale strategy over the short run, while investing in research and development

to reduce the uncertainty of using SIT to control SWD. If technically feasible, the Scope strategy could then be implemented over the long term.

Finally, implementing the diversification strategy will require changes to Section 283 of the Municipal Enabling and Validating Act (MEVA), and a commitment by the Federal government to fund the research necessary to extend the SIT to other insect pests. Perhaps the results of this study may be helpful in bringing about these changes.

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## Appendix A – Attitudes to the Use of Pesticides

Strategic Focus	ANOVA	Okanagan/ Similkameen	Central Okanagan	North Okanagan	Columbia/ Shuswap
Pesticide use on their property	$F(3, 496) = 5.48, p=.001$	M=4.11, SD=1.11	M= 3.77, SD=1.24	M= 4.27, SD=0.97	M= 4.10, SD=1.15
Pesticide use by farmers	$F(3, 496) = 3.31, p=.020$	M=4.30, SD=1.01	M= 4.06, SD=1.11	M= 4.39, SD=0.83	M= 4.50, SD=0.53
Pesticide residue in food	$F(3, 497) = 3.30, p=.021$	M=4.23, SD=1.06	M= 4.11, SD=1.12	M= 4.10, SD=0.74	M= 4.24, SD=1.03