OKANAGAN-KOOTENAY STERILE INSECT RELEASE PROGRAM

MEASURING PROGRAM SUCCESS: 2023 SEASON RESULTS

INTRODUCTION

The Okanagan-Kootenay Sterile Insect Release (SIR) Program is an area-wide, integrated pest management program that exists to protect the pome fruit (apple, pear, and quince) industry in the Okanagan, Similkameen, and Shuswap Valleys from infestations of the codling moth in an environmentally friendly way. Four regional districts participate in the Program, including the Regional District of Okanagan Similkameen (RDOS), Regional District of Central Okanagan (RDCO), Regional District of North Okanagan (RDNO), and Columbia Shuswap Regional District (CSRD).

When the Program began releasing sterile insects in 1994, its objective was to eradicate the codling moth from the pome fruit growing regions of the southern interior of British Columbia. Eradication was to proceed progressively from south to north across 3 eradication zones. By the early 2000's, it was evident that achieving this objective would be significantly more difficult and more expensive than expected, and it was abandoned. The program changed its objective to managing codling moth to economically tolerable levels that would not require growers to spray for codling moth. The target of ≤0.2% infested fruit in > 90% of the Program area is set as its new goal. Today the Program no longer manages in terms of eradication zones, but it does manage this pest on an area-wide basis. An area-wide approach is the most efficient and effective way of managing mobile pests because pests do not respect property boundaries. The Program provides several services to support growers in managing this pest, including sterile insect releases, monitoring, supplemental control strategies (mating disruption, fruit removal, tree removal, etc.), recommendations on how to best integrate pest management tools, and has the legal authority to enforce the removal of abandoned orchards and wild pome fruit trees. The Program supports the industry through a coordinated approach, allowing all growers to benefit collectively from the low pest population. While the Program supports growers, it cannot and should not run their farms for them. The ultimate responsibility to mitigate undue growth and spread of this serious pest lies with the property owner. The Program is the only of its kind and coveted by pome fruit industries around the globe.

The following document reports measures of codling moth populations, fruit infestation, pesticide usage, and infested backyard trees in urban properties for the 2023 growing season. These results are summarized and placed in historical context.

This document reports codling moth conditions for the 2023 growing season in the OKSIR Program area. This column will provide a quick summary of the main results. More detail is provided in the main body of the report.

The background information and historical context in this document will not change year over year; however updated results for the current season will be highlighted in this box for quick reference.

What is the codling moth?

The codling moth is the most serious pest of apples around the globe and is an important pest of pears. Larvae (caterpillars) of the codling moth tunnel into fruit to feed on the seeds, making it unfit for human consumption and unsaleable. Once the moth larvae are inside the fruit, they cannot be killed by pesticides or predators, making this pest very difficult to manage. After the larvae finish feeding, they transform into moths that can fly long distances to infest more fruit and more trees. If codling moth populations are left unmanaged, they can rapidly grow to a point where 90% of the fruit in an orchard will be rendered unfit for sale and human consumption.

Measuring codling moth populations

The Program uses different methods to collect information about codling moth populations. Each of these monitoring tools has their own strengths and limitations. No one method alone can provide all the information needed to monitor populations and manage this pest.

- *Pheromone Traps* — Pheromone baited traps exploit the chemical communication between adult male and female moths. Female moths release sex pheromones that attract potential mates. Male codling moths are attracted to traps baited with a synthetic sex pheromone, tricking the males into thinking they are finding a mate. Instead, the males are caught inside the trap on a sticky card. These traps provide information about codling moth populations BEFORE eggs hatch and crops are infested, providing an important early warning for growers. However, trap effectiveness is limited by wind, rain, cold temperatures, topography, proximity to the wild moth populations, and competition from pheromones produced by the sterile insects we release. Consequently, traps can sometimes miss wild populations. The Program operates over 3 000 pheromone baited traps. There is a minimum of 1 pheromone trap per ha in every pome fruit orchard in the Program area. Traps are checked weekly during the time codling moths are flying. All wild and sterile moths caught on the sticky cards are counted and the sticky bottoms are replaced.

The Program uses traps, damage surveys, and bands to collect information about codling moths. Each of these techniques captures a snapshot of a different life stage of the codling moth and they are used together to understand how populations are impacting growers and changing year over year.

- *Damage Surveys* — Counting infested fruit provides important information about the size and location of a codling moth population, as well as an assessment of the tools that supplement sterile insect releases. Unfortunately, once the larvae are in the apple and damage can be seen, it is too late to prevent it. Counting infested fruit can be expensive. Surveys can be either widespread (when Program staff are "scouting" for damage during their regular orchard work and covering large areas) or focussed (when they are conducted in a systematic manner to gauge moth population changes year over year). Damage scouting during the season is an important tool for monitoring codling moths operationally; however, these observations are hard to standardize and analyse. This report focusses on standardized damage samples conducted at harvest time.

- *Larvae Traps (Bands)* — Codling moths spend the winter as larvae, spinning cocoons in the cracks and crevices of the bark of apple and pear trees. A strip of corrugated cardboard wrapped around the trunk of the tree resembles a suitable overwintering site for larvae and "catch" larvae when they spin their overwintering cocoons. These cardboard strips can be removed at the end of the year and larvae can be easily counted. These "bands" provide information about where and how many moths will emerge the following season.

There are multiple tools in the pest management toolbox. Sterile insect releases, judicious pesticide applications, mating disruption, and cultural control methods are combined to provide, effective, economical, and environmentally friendly codling moth control.

Managing codling moth populations

Collectively, the Program and growers use different tools to manage this pest. As with monitoring tools, management tools have their own strengths and limitations as well. The Program's goal is to help growers combine the appropriate tools from their toolbox to provide effective, economical, and environmentally friendly control of the codling moth.

- *Sterile Insect Release* — In order for sterile insects to be effective, the chances of two wild insects finding each other must be extremely low. This is achieved by greatly outnumbering the wild population with sterile insects. The larger the wild population, the harder and more costly it is to outnumber the population and prevent mating. Sterile insect technique works best and is most cost effective for small to moderate pest populations.

- *Pesticides* — Pesticides are the sledgehammer in the pest management toolbox. A conventional pesticide spray typically kills 90% of the target life stage (less for organic sprays) regardless of the population size.

This makes pesticides very cost effective for controlling large populations, but less cost effective for controlling small populations. The downsides of pesticides are that they can have negative impacts on the environment, farm workers, and beneficial insects; pests can develop resistance to pesticides over time; and the costs of multiple applications of pesticides can quickly add up. Relying on pesticides alone creates a "pesticide treadmill", where continuous applications of pesticides, in increasing concentrations, are needed to keep pest populations in check.

- *Mating Disruption* — Pheromone-mediated mating disruption (MD) is another soft approach to pest management. Like SIR, it disrupts mating between wild pests. It works by flooding a target area with synthetic sex pheromone of the pest. When working as it should, the sexual-chemical communication between moths is disrupted and mating is prevented or delayed. This approach has many of the same strengths and weaknesses as SIR. Mating disruption is used in many places around the world as the foundation of codling moth management. The Program tested the use of mating disruption against the codling moth in half of its area from 2011-2014. Wild moth populations, fruit damage, and sprays increased in the areas where MD was being used compared to the area that remained under SIR. The Program returned to area wide releases of sterile insects in 2015. Today the Program will layer MD on top of SIR to combat codling moth hotspots. This is particularly useful in organic orchards, where the pesticides available are limited.

- Cultural Control — Cultural control methods refer to growing practices that can be used to reduce codling moth numbers. Removing infested fruit from trees and the ground, and disposing of it properly, eliminates moths that were missed by other tools. This can be an important tool in organic orchards where sprays are not very strong or in conventional orchards with severe infestations. Appropriate pruning and fruit thinning improves spray coverage which helps with the management of many pests, including codling moths. In some instances, fruit stripping and hard pruning may be required to eliminate an infestation. Hard pruning and fruit stripping work best on single trees or tiny, non-commercial blocks where the owner may not be able to care for the tree(s) properly.

The Program recommends pesticides are used only to bring large populations, or "hotspots", down to the size where they can be controlled by sterile insect releases alone. Hotspot orchards can be defined as properties that harbor a disproportionately high population of codling moths compared to the surrounding areas. Wild moths from these orchards cause economically significant losses to the crop within that orchard and create serious

problems for neighboring orchards as well. If wild females mate in a hotspot and then they disperse to neighboring properties, the sterile insects released in a pest free orchard cannot protect that property from the problem population. Hotspots occur when a moderate size wild population goes undetected or is detected but the grower decides not to supplement SIR with additional control measures (spraying, removing infested fruit, etc.). Uncontrolled hot spots grow exponentially, creating serious problems.

Codling moth adult (left) and larvae feeding on the core of an apple (right). Photos courtesy BC Ministry of Agriculture.

Adult Codling moth (left) and codling moth larvae feeding on an apple (right). Photos courtesy BC Ministry of Agriculture

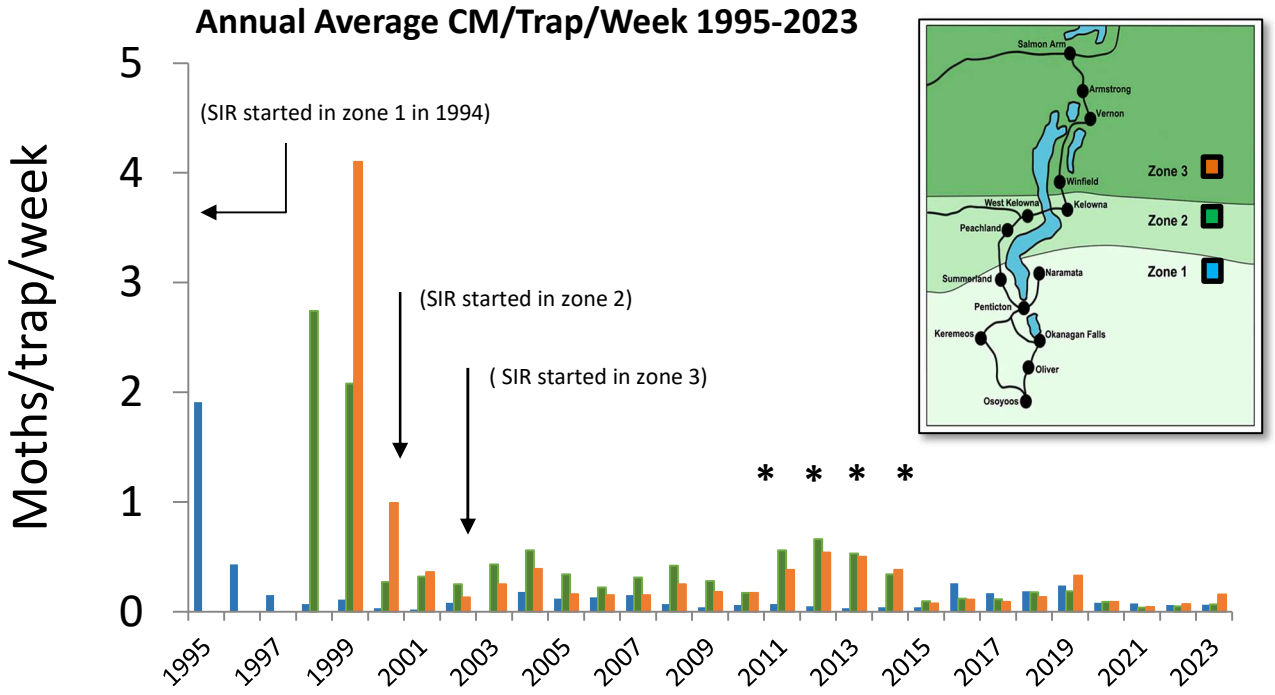
As mentioned above, pheromone baited traps can provide early warnings of damage caused by the codling moth. When the program is working as intended, wild moths (where present) are captured in traps by Program staff. This information is relayed to the grower and posted online in real-time. Information about local moth populations, historical infestation levels, weather, and pest-development models are synthesized by the Program's Entomologist, Mr. Evan Esch MSc PAg, to prescribe a management program for the grower. If the management program (increased releases of sterile insects, pesticide sprays, cultural control, etc.) is executed correctly, damage can be prevented, or at least, minimized. Evaluations of damaged fruit are necessary to determine effectiveness of the Program's and growers' combined management efforts. Different measures of codling moth populations and pesticide usage are discussed in five sections below.

Evan Esch MSc is the Program's Entomologist and is a Professional Agrologist in good standing with the BC Institute of Agrologists. Pest management recommendations are made under his direction in accordance with Provincial legislation outlined in the Professional Governance Act.

SECTION 1
Wild Codling Moth Captures in Pheromone Baited Traps

Codling moth captures in historical context

The Program traps moths in every apple/pear orchard in the Program area weekly, during the apple growing season. All this data, except for 1994, has been archived by the Program. Sterile insect releases began in 1994, 2000, and 2002 in zones 1,2, and 3 respectively. Wild codling moth captures decreased precipitously in each Program Zone, due to pre-release sanitation efforts and sterile moth releases. Average, weekly wild codling moth captures have decrease by 96-97% from pre-program levels, depending on the Program zone.



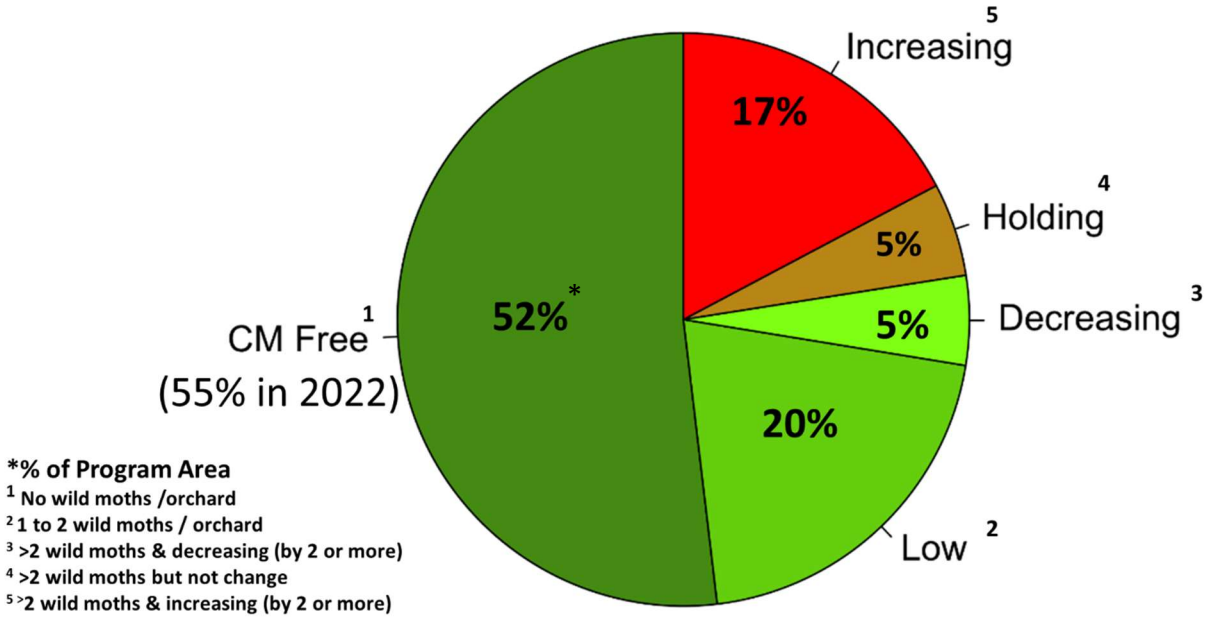
* Mating disruption was used in zones 2 & 3 instead of SIR, and the Program used a differnt type of pheromone to monitor moths, so these years are not directly comparable with the others.

Wild codling moth populations have decreased by 96-97% compared to preprogram levels. *The heights of the bars in the figure indicate average wild codling moths caught each week for a given year and zone. Shorter bars, indicate lower weekly catches.*

Weekly codling moth captures have decreased by 97% compared to pre-program levels.

Changes in wild codling moth captures from 2022 to 2023

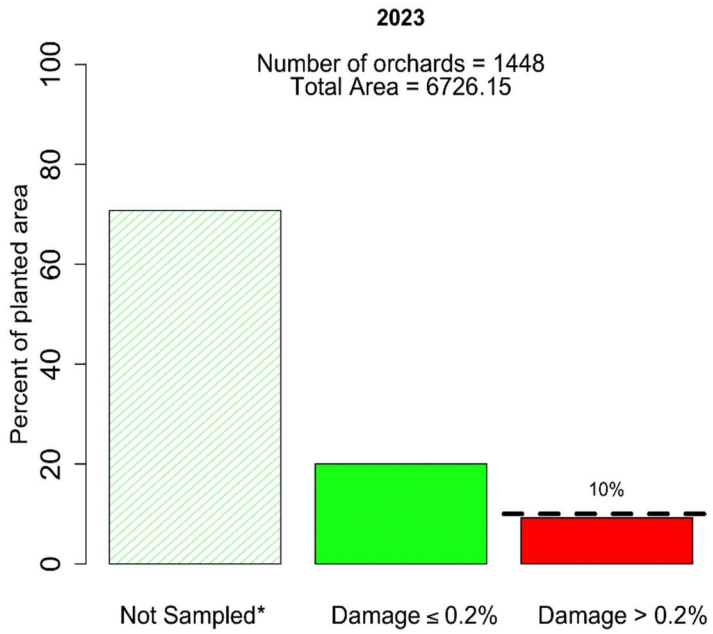
While average moth captures show a dramatic decrease in the codling moth population from preprogram levels, averaging these captures across more than 3 000 traps obscures localized hotspots. In 2023, 52% of the Program area did not capture any wild moths *(CM Free*) while 20% had extremely small (*Low*) levels of codling moth; however, just over a quarter of the program area, captured more than 2 wilds moths during the season. While capturing more than 2 moths in an orchard during an entire season does not necessarily constitute a problem, it is important to recognize that traps only capture a small segment of the underlying population, meaning that more than 2 moths are present. Of all the program area that had a detectable moth populations, 5% of the orchards had fewer moths this year than last year (*Decreasing*), 5% stayed the same (*Holding*), and 17% captured more wilds this year than last year (*Increasing*). The worst 10% of the orchards in the Program area account for 76% of all the wild moths captured in the entire program area. Further to this point, **the 10 most infested orchards account for 35% of all the wild moths captured but represent less than 2% of the Program area.** Overall, more wild codling moths (26%) were captured in 2023 than in 2022. It should be noted that 81% of this increase is from a single orchard with a severe codling moth infestation.



The slices of the pie indicate changes in wild moth captures from last year to this year. ***Most of the program area has no or very few codling moths*** *(CM Free & Low slices). Of the 27% of orchards that had a detectable moth population 17% (red slice) had populations that got bigger in 2023.*

SECTION 2
Infested Fruit
Program area meeting damage targets

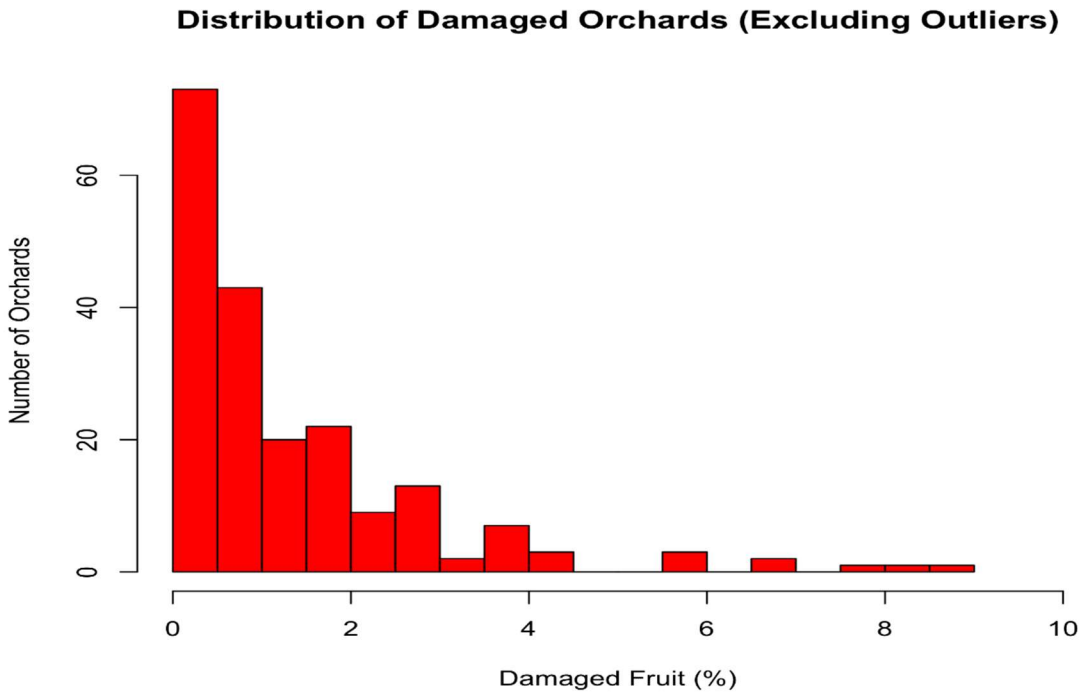
The Program's target of ≤0.2% infested fruit in > 90% of its area represents an extremely low codling moth population. At 0.2% infested fruit, the economic losses to the crop are negligible and no supplemental management measures (such as sprays) are needed. 0.2% infested fruit equates to 1 in 500 fruit or approximately 1 unmarketable fruit for every 7 boxes of apples produced. To evaluate changes in codling moth damage year over year, systematic damage surveys are conducted in orchards with known or suspected wild moth populations. As mentioned above, three quarters of orchards have no detectable or extremely low levels of codling moth. Because systematic surveys of codling moth damage are costly and time consuming, they were not conducted on orchards with extremely low populations. Systematic damage surveys were conducted on 30% (437 orchards) of the program area, just prior to harvest. **These surveys are not random, they target infested areas within infested orchards, meaning they overestimate the total amount of damage in an orchard**. The Program targets problem orchards, because hotspots account for the majority of wild moths, and require special attention. **90% of orchards had ≤0.2% infested fruit in 2023**.



90% of orchards had ≤0.2% infested fruit in 2023. *The height of these bars represents the percentage of apple acreage that met our damage target of ≤0.2% infested fruit. The hashed green bar accounts for orchards with no detectable or extremely low moth populations that were not sampled. The solid green bar represents the orchards that were sampled and met the target, and the red bar indicates the percent of program area above the damage target.*

Damage severity

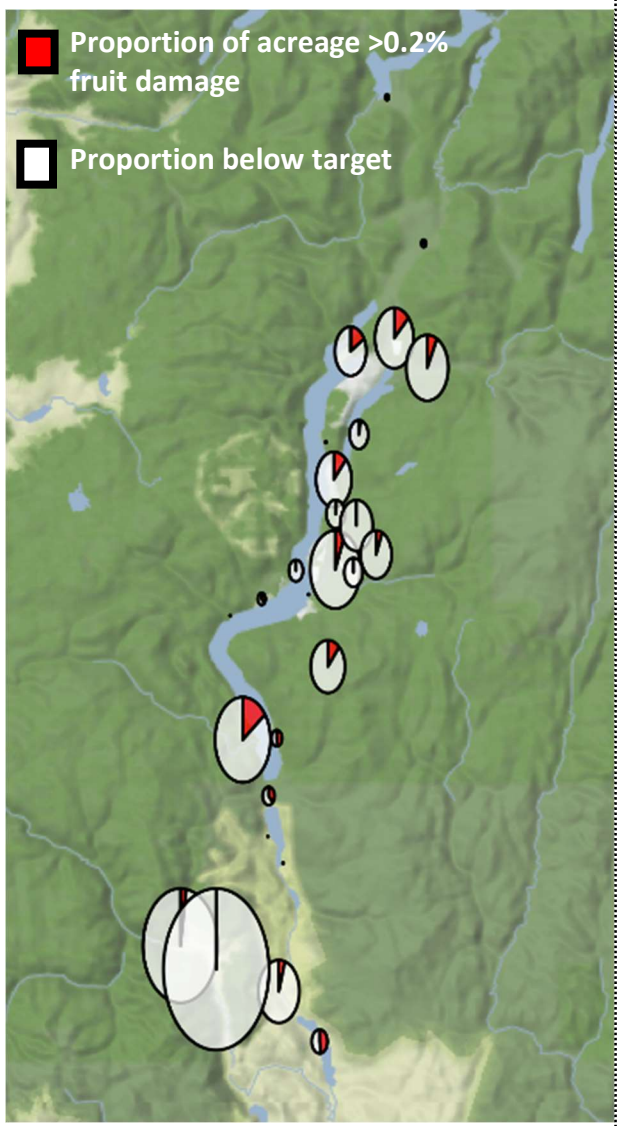
10% of the program area had > 0.2% infested fruit (in at least part of the orchard). Of these orchards exceeding our damage targets, most were just above the damage threshold. The histogram below shows the number of orchards with fruit infestation levels in 0.5% increments from >0.2% to 10% (e.g. > 0.2% to 0.5%, 0.5 % to 1.0%, 1.0% to 1.5%, ... 9.5-10%). Most of the orchards that exceeded our damage target had 1% infested fruit or less, an amount considered negligible to most growers. A handful of orchards (12 properties that can be considered outliers) had greater than 10% infested fruit, with the damage ranging from 10.6% to 46% of fruit infested. Damage this severe is the result of willful neglect and disregard for the prosperity of neighboring pome fruit growers. If orchards continue to be severely infested for several seasons, and there are no signs of improvement, this may trigger referral to the Program's compliance department which is responsible for enforcing pest management bylaws.



90% of the program area met our damage target, meaning 10% of the Program area had >0.2% infested fruit. Of those orchards that exceeded this level, most exceeded it by a small amount. The heights of the bars indicate the number of orchards with increasing degrees of infestation in 0.5% increments, form >0.2% to 10%. Of those above the target, most had 1% or less damaged fruit, still a very low level of fruit loss.

Fruit damage by region

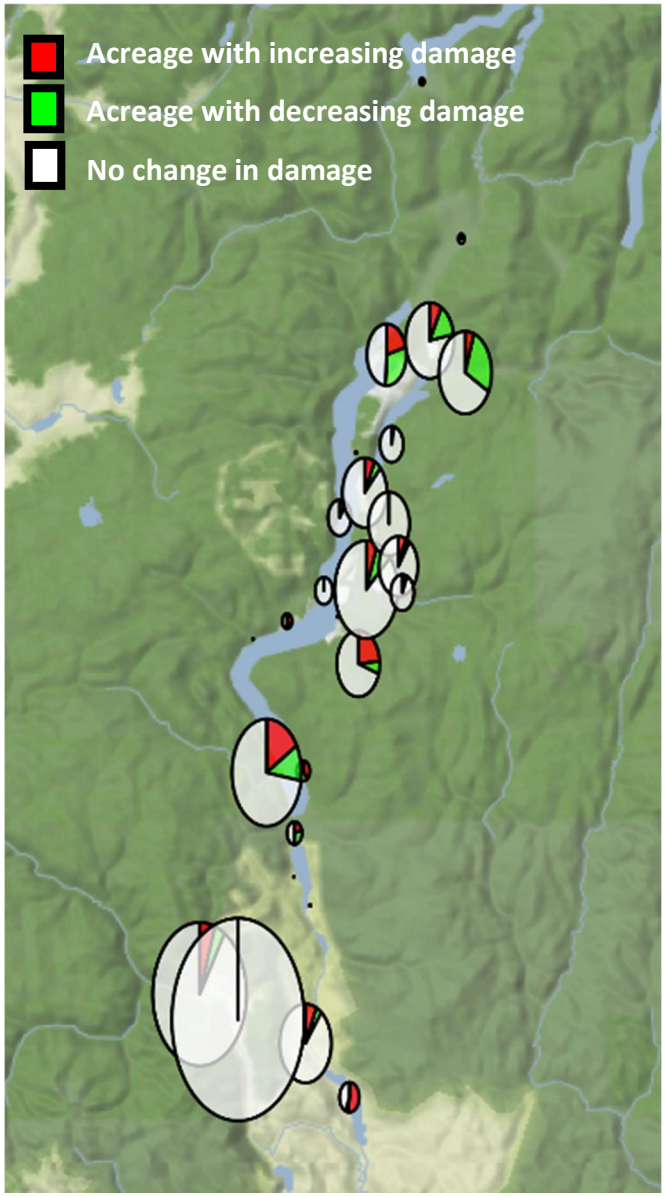
The Program spans nearly 200 km, from Canada's southern border to Salmon Arm. Different regions grow different amounts of pome fruit (in terms of planted acres) and may have different resident codling moth populations, depending on many different factors. This map depicts how many acres of pome fruit are grown in each region (based on size of the pie chart) and the proportion of the orchards within that region that are above the damage target (red slice of the pie chart). Generally, the main pome fruit producing regions have the lowest levels of damage, while the smaller regions, with fewer commercial growers and more hobby farms, have more hotspots and greater concentrations of damage. Treating each region independently, Cawston, Keremeos, Oliver, OK Falls, Benvoulin, Belgo, East Kelowna, Rutland, Glenmore, Ellison, Carr's Landing, Oyama, Coldstream, and Spallumcheen had 90% or more of their acreage at or below 0.2% infested fruit. These regions represent the majority of commercial pome fruit production. Other regions, including Osoyoos, Kaleden, Summerland, Penticton, Naramata, Peachland, West Kelowna, South Kelowna, Okanagan Mission, Winfield, BX, Bella Vista, and Salmon Arm did not meet the Program's damage target individually. These regions constitute a minority of the Program's area. Total pome fruit acreages, and the proportion of orchards in each region reaching the program's damage target are reported in the Appendix.



This map shows where most of the apples & pears are grown based on the size of the pie charts. Larger pie charts represent more pome fruit acreage in that area. Red slices of the pie chart represent the proportion of orchards in that region that had greater than 0.2% infested fruit.

Changes in fruit damage

Tracking changes in the amount of infested fruit between years is important for understanding where the program is succeeding and where it needs to invest more resources, engage growers to consider supplementary tools, or consider compliance actions to contain codling moth populations. Like the map on the previous page, this map depicts the acreage of pome fruit orchards in each region, based on the size of the pie chart. Red slices of the pie charts represent orchards that had more infested fruit in this year compared to last, while green slices represent orchards that had less damage this year than last year. White slices represent orchards that had no change in damage fruit (this includes orchards that have no damage or were not sampled). There were more orchards reaching the program's damage target in 2023 (90%) compared to 2022 (88%). However, some areas had more damage this year than last year, like Osoyoos, Summerland, East Kelowna, Keremeos. Other areas had less damage this year compared to last year, with the most improvement in BX, Coldstream, Belle Vista, and Glenmore. While large changes show overall trends, tracking small changes is also important in areas with extremely low levels of codling moth infestation, such as Cawston, Keremeos, and Oliver.



This map, like the one above, shows where most of the apples & pears are grown (based on the size of the pie charts). Red slices of the pie charts represent the proportion of orchards where there was MORE damage this year than last. Green slices indicate orchards where there was LESS damage this year than last. White slices represent orchards with NO change in damage or were not sampled.

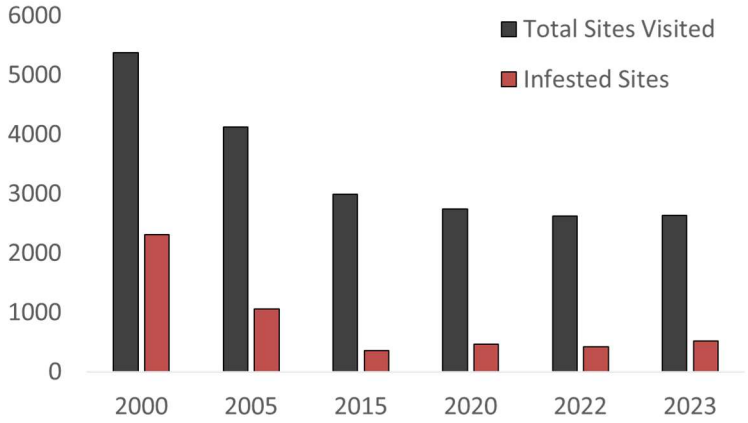
SECTION 3
Codling Moth Larvae (Banding)

Cardboard bands are used to monitor codling moth populations in both orchards and backyard trees. Bands are applied in the most infested parts of the most infested orchards to evaluate the success of control measures and predict how many moths will emerge the following spring. In 2023, 485 bands were applied in 8 orchards and 3950 larvae were collected from these bands. Fewer bands were placed in 2023 growing season compared to previous years as staffing issues and the rapid onset of warm weather this spring shortened the window of time staff had to complete this work.

In 2020 many bands were placed across the apple growing regions of BC to collect wild larvae to refresh the genetic diversity for the moth colony at the rearing facility. The more generations the moths spend in the rearing facility, the more inbred they can become. Adding wild genetics to the colony ensures the colony moths are compatible and competitive with wild moths. As the Program continues to reduce wild moth populations, it becomes more difficult to collect them. Program staff had to travel outside the Program area to the Creston Valley to collect enough wild material to refresh the colony. The program then reared the wild × regular colony hybrid strain in parallel with the regular colony for several generations to ensure it was free of disease and suitable for release. The Program began releasing moths from the refreshed colony in 2022.

The banding data corroborates the trapping data and fruit infestation data, confirming that a relatively small number of hot spot orchards contribute to the majority of codling moth infestations in the program area.

SECTION 4
Backyard Apple Trees



While many Okanagan residents enjoy growing backyard fruit, most fruit tree owners do not manage pests with the same rigor as commercial fruit growers; many residents lack the knowledge, resources, or physical ability to manage pests in their trees; while others may be unaware that fruit trees are growing on their property. Backyard apple and pear trees can create problems for commercial orchards because pests do not respect property lines. If wild moths mate and become fertilized in backyard trees, then fly to a neighboring commercial orchard, the sterile moths released in that orchard will not protect the fruit in that orchards from being damaged. Consequently, a community-based approach to pest management is required.

When the program first started, and its goal was eradication, it worked very aggressively to remove as many wild trees and abandoned orchards as possible. These trees were refuges for the wild pest populations and a barrier to eradication. As the program's mandate has evolved from eradication to management, so did its approach to backyard apple and pear trees. Today the Program focusses its resources on backyard apple, pear, and quince trees within 200 m of commercial orchards. Program staff visit these trees multiple times a season to ensure responsible tree ownership and that they are free from infestation. If trees are found to be infested, program staff work with the homeowner to convey the importance of pest management and provide information necessary for the homeowner to take care of their backyard trees. If homeowners refuse to reduce pest populations in their backyard trees, the program can carry out this work itself and charge the cost to a homeowner's taxes as a last resort. Over the years, both the total number of backyard trees and the number of sites with infested trees have declined. In 2023, 511 of the 2646 properties with backyard

82% of the urban residences with pome fruit trees that were within 200 m of commercial orchards are free of codling moth. While the number of infested backyard trees has gradually decreased over the years, this pest remains present in backyard trees and homeowners require continued encouragement to keep their trees pest free.

trees had some level of infestation. This represents a 27% increase in the number urban properties with infested trees. Most of these increases were not in urban buffer zone within 200 m of commercial orchards. The program does not release sterile insects in backyards, instead we recommend homeowners hire professionals to spray or to pick off the infested fruit by hand. This increase indicates that the weather conditions this season were conducive for codling moth population growth.

Keeping infestations out of backyard trees allows all members of the community to benefit from reduced pesticide usage in the region.

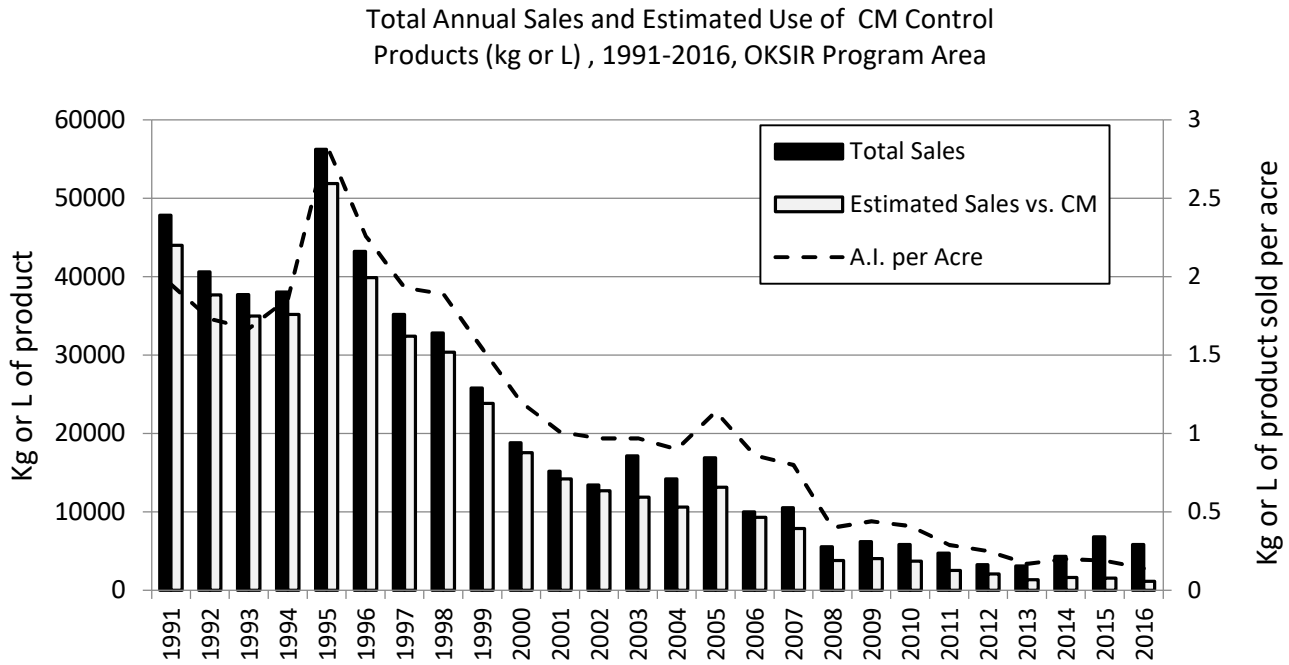
SECTION 5
Pesticide Reduction

For most of the 20th century, pesticides were the main tool for controlling all agricultural pests, including the codling moth. Before the onset of the OKSIR Program, the average grower applied 2-3 applications of broad-spectrum insecticides per season to control the codling moth. These pesticides not only killed pests, but also the beneficial insects that lived in the orchards. These pesticides also created hazards for farm workers and those living on and around orchards. Supporting local agriculture while reducing pesticide usage is the main reason for the Program's existence. While pesticides are still used judiciously to control codling moth hot spots, the amount of pesticide, in terms of both the kilograms of pesticides used and number of sprays applied (and/or recommended), have decreased dramatically since the Program began.

Pesticide usage estimates from registered sales

It is difficult to measure exactly how much pesticide is used against the codling moth every season. One way to do this is to look at the amount of pesticide sold in the Program area. Pesticides sales are provincially regulated, thus all sales are recorded in a government database and are available for analysis. Between 1991 and 2016, the quantity (Kg or L of active ingredient) of pesticides sold (that are registered for use against the codling moth) has decreased by 88%. However, the total acreage of pome fruit in the Okanagan has also decreased from 1991-2016, so it is likely that the quantity of pesticides would also decrease. Taking the

decrease in acreage into account, the quantity of pesticide (active ingredient of pesticide/acre) has decreased by 93%. Furthermore, some of these pesticides sold are used against more than one pest and/or on different crops. For example, Delegate® is a pesticide used to control spotted wing drosophila, a serious pest of cherries, as well as the codling moth. The increased sales of Delegate® is most likely driven by the invasion of this serious pest, rather than increased codling moth populations. This increase can be seen starting in 2013, around the time when this pest was becoming a serious problem. Local pesticides sales representatives and former Ministry of Agriculture staff have estimated that the pesticides used against the codling moth have decreased by 97% from 1991 to 2016. Over the past 30 years, the formulations and active ingredients have changed as well. Newer formulations of pesticides require a lower amount of active ingredient per acre, sometimes by as much as 75% less, which would also account for some of this decrease. While none of these measures are perfect, they all suggest major decreases in pesticide usage in the Program area.



Pesticide usage against the codling moth is difficult to measure, because it would require voluntary reporting by every grower. Pesticide sales data suggest that it has decreased by 88-97%, when correcting for changes in acreage and usages against other pests.

Pesticide usage estimates from spray recommendations

Another way to evaluate pesticide usage is through counting the number of sprays applied. As active ingredients and formulations of pesticides have changed, more sprays are needed to attain the level of control of the older, more toxic pesticide products. Prior to the outset of the program, experts estimated the average grower applied 2-3 applications of broad-spectrum insecticides per season to control codling moth. Broad spectrum residues would last 3-4 weeks and kill any insects that contacted them, including beneficial ones. Today, 3-8 applications of "reduced risk" insecticides are needed to achieve the same level of control as with 2-3 of the older products. Reduced risk insecticide residues last for 10-14 days and need to be either ingested by the pest or applied directly to the eggs. This means that the days of controlling multiple orchard pests with a single spray are largely behind us. The Program's Professional Agrologist makes recommendations to growers based on the amount of infested fruit and/or the number of wild moths captured. The program estimates that approximately 18% of growers were spraying for codling moth in 2023, based on its recommendations. Some of these growers are spraying once or twice while others need to spray more.

The majority of pome fruit growers do not spray to control the codling moth. The Program recommends that 18% of growers supplement sterile insect releases with at least 1 application of pesticide.

Year	No spray recommended	1-2 sprays Recommended	3+ sprays Recommended
2019	72%	13%	15%
2020	76%	8%	15%
2021	79%	5%	9%
2022	84%	3%	13%
2023	82%	5%	13%

Conclusions

The SIR Program continues to work with growers and residents to keep codling moth populations at extremely low levels. Over half the orchards have no detectable codling moths and 90% had extremely low (≤0.2%) levels of infested fruit. Furthermore, 82% of residential properties with pome fruit trees (that are adjacent to commercial orchards) are free of codling moth. The Program reached its target of 90% of orchards with ≤0.2%, infested fruit. This is remarkable, given that we estimate that 82% of the orchards are not applying any pesticides to control the codling moth. The measures the program uses to gauge its success have limitations; however, they all independently support the same conclusion, that the SIR Program is achieving effective, economic, and environmentally friendly control of the codling moth on 90% of the acreage.

While codling moths are not a problem in most orchards, detectable populations of note exist on 10-25% of the Program area. A very small number or orchards, much less that 10%, account for the majority of wild moths and infested fruit. These problem populations often exist on the same orchards year after year and are often clustered in the same geographical region. Once moth populations reach the size where they escape the control of sterile insect releases, they grow exponentially if unchecked. The challenge for the Program is to identify these growing populations and work to coordinate pest management activities to contain these problems before they grow and spread.

Problem populations can develop in several ways. The most common way a problem population starts is when it moves into a previously uninfested orchard from an outside source. The outside source can be a wild population in a backyard or wild apple tree, adult moths flying long distances from an existing hotspot, or dormant larvae being transported on apple bins or on infested firewood. When mating occurs in an external location and then the moths move into an orchard, the pheromone traps in that orchard are not well suited to detect the invading moths. This is because traps exploit the chemical communication between mating moths to trap them and are not suited to find dispersing female moths. If these new incursions are undetected or ignored, they can grow to serious problems. The removal of many old, un-economical orchards means that lots of potentially infested wood is moving around the Okanagan and Similkameen Valleys.

Problem populations can persist for several reasons. Reducing the size of a large codling moth population takes continued effort against multiple generations of this pest over multiple growing seasons. This is because control

strategies will never kill 100% of their target and because a segment of the codling moth population remains dormant every generation. These dormant moths emerge up to 2 years later, hedging their bets for survival against bad weather and light fruit crops. Populations will decline more rapidly when they are addressed more aggressively (more supplementary tools used together); however, not all growers have the resources to or see the value in aggressively controlling moth populations. This is particularly true on abandoned on unmanaged orchards or with orchardists that might not grow their fruit for commercial sale. Older planting systems with mature trees also contribute to persistent codling moth problems, as these trees are harder to spray and provide better overwintering sites for moth larvae. Organic production systems can also contribute to persistent codling moth problems because organic control methods are not as strong as conventional ones. Lastly, a lack of knowledge may contribute to persistent codling moth populations. Because moth populations are so low, many growers may not have had to deal with a codling moth problem in many years. Over this time, the tools and best management practices for controlling this pest have changed. In other instances, new growers may never have experienced a codling moth problem. Returning a codling moth population back to the level where it can be controlled by sterile insects alone often takes more time and resources than growers expect. The program continues to work with local pome fruit producers to identify, contain, and stamp out codling moth hot spots.

Appendix

Area	Total Acreage	Acres Above Target	Acres Below Target
Bella Vista	301.5	50.0	251.6
Belgo	178.7	0.0	178.7
Benvoulin	134.1	0.0	134.1
BX	370.6	49.2	321.4
Carrs Landing	11.2	0.0	11.2
Coldstream	404.0	31.2	372.8
Cawston	1014.2	0.0	1014.2
East Kelowna	482.5	31.1	451.4
Ellison	313.6	0.0	313.6
Glenmore	176.8	3.4	173.4
Kaleden	4.4	1.8	2.6
Keremeos	717.4	17.8	699.6
Naramata	101.7	48.3	53.4
OK Falls	9.7	0.0	9.7
Oliver	394.9	18.9	376.0
OK Mission	6.9	1.1	5.8
Osoyoos	151.0	72.2	78.8
Oyama	177.7	5.9	171.8
Peachland	5.9	5.9	0.0
Penticton	114.4	43.6	70.8
Rutland	297.3	19.3	278.1
Salmon Arm	34.4	31.2	3.2
Spallumcheen	46.2	1.9	44.2
Summerland	531.6	79.4	452.3
South Kelowna	327.6	38.1	289.5
Winfield	341.3	41.5	299.7
West Kelowna	75.0	28.5	46.5