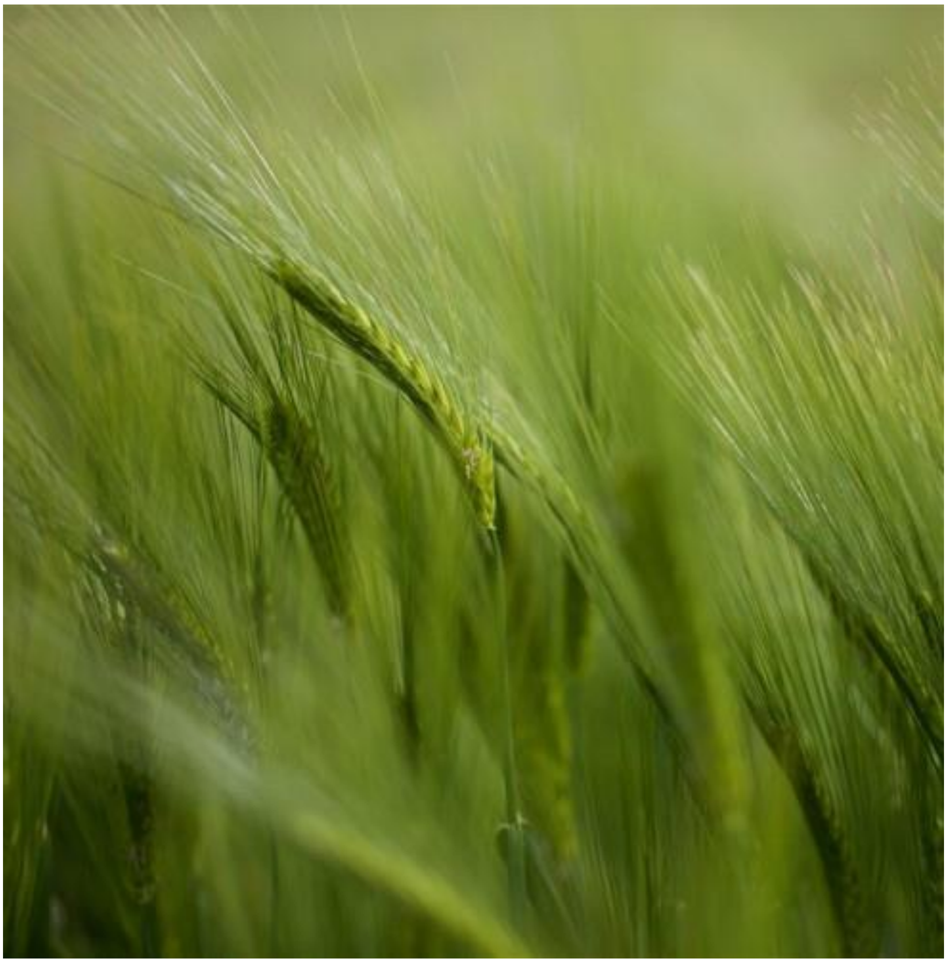
A targeted analysis of the impact of insecticide withdrawals in Scotland, in the context of alternative control options

Project Final Report



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This work has been undertaken in accordance with the quality management system of RSK ADAS Ltd.

Content

1 Executive Summary

Scottish agricultural, horticultural and forestry crop production systems are heavily reliant upon the use of chemical insecticides. The principles of UK regulatory controls means that the availability of active chemical substances is likely to become increasingly restricted in response to human and environmental health concerns. At the same time, the efficacy of some insecticides is declining due to rising pest resistance and alternative control methods – included within Integrated Pest Management (IPM) – can incur additional costs and/or offer less effective protection. Consequently, it is likely that maintenance of yields, product quality and profitability will become increasingly challenging.

This report is an assessment of these challenges, based on analysis of current crop production patterns and usage of active substances, likelihood of regulatory withdrawal for different active substances, and stakeholder views on the effects of withdrawal and the potential for other control methods.

Some land parcels in production receive insecticide treatments whilst others receive none. For example, forestry usage is mainly concentrated on planting and replanting, which only accounts for c.20k ha out of total woodland of c.1.5m ha. Moreover, some crops receive multiple sprays. Estimated total spray areas (i.e. treated area multiplied by number of times sprayed) during 2019/20 are shown in Table E1.

The figures reveal the most commonly used insecticides and also the relative usage across different sectors. For example, lambda-cyhalothrin is the active substance used on the greatest area, and is applied across arable, vegetable, soft fruit and forestry production. Esfenvalerate is the next most used but is used only in arable production. Equally, some active substances, such as chlorantraniliprole and pyrethrins, are used on only relatively small areas in vegetable and soft fruit production respectively but are important for those sectors.

This relative importance of different active substances can be compared to the estimated risk of their regulatory withdrawal, colour coded in Table E1 as green for low, amber for medium and red for high, plus grey for now withdrawn. Domestic UK regulation is under review. Pesticide approval is currently assessed using criteria under EU regulation EC 1107/2009, as retained.

A high proportion of insecticide actives used in Scotland in 2019/20 are estimated to be at high or medium risk of withdrawal; six have already lost their authorisations for use in the UK. Moreover, many of the common active substances have the same mode of action (MoA), meaning that if a target pest species develops resistance to an active substance, all products with the same MoA will provide less effective crop protection. Forestry and arable production are particularly exposed to this risk, vegetables and soft fruit less so.

The practical significance of withdrawal also depends on the availability and cost-effectiveness of substitute protection methods, included within IPM. Stakeholder interviewees emphasized that withdrawal of active substances would negatively impact yields and quality plus raise production costs through greater reliance on less efficient management practices (including fallowing, changing of sowing and harvesting dates, cultivation of less suitable but clean sites, additional field operations and increased use of fungicides and herbicides). This would decrease profitability and, in some cases, render production unviable in some areas. Estimated production losses are subject to various uncertainties, but are shown in Table E2, ranging from £15m to £64m per sector, c.6% to c.25% per sector with larger decreases in gross profits (other things remaining equal). Potential losses for forestry, potatoes, vegetables and soft fruit are particularly significant.

Table E1: Estimated spray area of different actives in 2019/20 by production type, with Mode of Action (SASA, 2021)

Active Substance	Arable	Vegetables	Soft Fruit	Forestry	Mode of Action
Lambda-cyhalothrin	115,705 ha	16,940 ha	1,732 ha	variable	3A
Esfenvalerate	40,885 ha				3A
Acetamiprid	8,689 ha	755 ha		c.20,000 ha	4A
Thiacloprid	14,054 ha	2,534 ha	1,542 ha		4A
Cypermethrin				variable	3A
Tau-fluvalinate	11,293 ha				3A
Flonicamid	8,033 ha	866 ha			29
Deltamethrin	3,264 ha	4,308 ha	183 ha		3A
Pirimicarb		6,646 ha			1A
Spirotetramat	1,298 ha	2,840 ha	1,402 ha		23
Indoxacarb	503 ha	4,790 ha	131 ha		22A
Spinosad		1,846 ha	617 ha		5
Pymetrozine		2,315 ha			9B
Oxamyl	2,532 ha	1,073 ha			1A
Bifenazate			787 ha		20D
Fosthiazate	744 ha				1B
Clofentezine			466 ha		10A
Spirodiclofen			339 ha		23
Alpha-cypermethrin	324 ha				3A
Etoxazole			271 ha		10B
Cyantraniliprole		137 ha	30 ha	trial use only	28
Cyflumetofen			150 ha		25A
Fatty acids C7-C20			149 ha		UNE
Abamectin			112 ha		6
Chlorantraniliprole		39 ha		trial use only	28
Pyrethrins			32 ha		3A

Risk of withdrawal: green = low, amber = medium, red = high; grey = already withdrawn

Table E2: Production sectors with annual gross value added and potential losses if actives at high and moderate risk of withdrawal become unavailable

Crop	Output Value (£m)	Potential output loss (%)	Potential output loss (£m)	Potential impact on Gross Margin (%)
Barley	£362.2m	13.8% - 15.5%	£50m to £54m	-22.6% to -24.6%
Potatoes	£253.7m	20%	£51m	-50.3%
Vegetables	£128.5m	25%	£32.1m	-50%
Wheat and Oats	£211.3m	7%	£14.8m	-10.7%
Soft fruit	£153.9m	23%	£35.4m	-221%
Forestry	£529m	10%	£53m	-27.4%

2 Introduction

Insecticides have an important role to play in Scottish agriculture, horticulture and forestry and are also widely used for amenity and environmental management. Their availability and permitted uses are tightly regulated, and concerns regarding the impacts of insecticides on human health and the environment have led to the withdrawal of around half of the active substances that were available in the previous decade. At present Scottish agricultural and horticultural crop production systems remain heavily reliant on insecticides, but under the Scottish Government Integrated Pest Management (IPM) Plan (Scottish Government 2016) they are just one of the options within IPM programmes that are now being promoted.

Also, whilst the UK plant protection product (PPP) renewal process has been independent since the beginning of 2021 (HSE, 2021), the outlook of domestic administrations may remain broadly aligned with such supranational environmental concerns as exemplified by the EU's Green Deal, which proposes to halve the amount of all pesticides used in the EU by 2030 (EU Commission, 2022a). Almost inevitably, this means that there is a high risk both of further withdrawals and that fewer approvals will be granted for new products.

These ongoing losses are of great concern to users. Several insecticide modes of action (MoA) have been removed from the market altogether, with others re-authorised with tighter controls such as restriction to use only in protected production. Continuing product withdrawals further impact on the utility and longevity of remaining actives, since repeated use of products with the same mode of action increases selection pressure for pesticide resistance.

The regulatory process is therefore increasingly constraining the ability of farmers, growers and foresters to protect commodity production from damage that may lead to reduced output value because of lower yields and/or quality. Costs may also increase and so further reduce profit margins or the affordability of amenity maintenance.

The risk of damage could be further exacerbated through resistance development in key Scottish pests. Insecticides play a critical role in supporting Integrated Pest Management (IPM) programmes. Some of these losses will be mitigated through the use of alternatives, but their practicality and cost under Scottish conditions is unknown.

This project assesses the likely impact of further insecticide withdrawals in Scotland by:

- Determining the main contributions to the Scottish rural economy in arable, horticultural and forestry sectors in terms of cultivated area and crop value.
- Using survey data to assess the scale of insecticide usage by active substance and (indirectly) dependence in each sector.
- Assessing risks of withdrawal under existing EU and UK legislation, together with identification of short- to medium-term risks of revocation of existing approvals for use or re-registration of active substances using the 'traffic light' classification of the estimated risk to actives used by Evans & Burnett (2020).
- Summarising insecticide availability by sector.
- Seeking expert stakeholder opinion through a series of case studies covering major crops within the arable, horticultural and forestry sectors with regard to key threats to the viability of their enterprises.
- Evidence gathered is presented as maximum estimated impacts on output values, and the likely impacts if alternatives and mitigation activities are adopted, following Burnett *et al.* (2021).

Note: In establishing the independent national PPP regulatory system on 1 January 2021, all active substances that were approved in the EU on 31 December 2020 remained approved in Great Britain, and to facilitate an orderly transition while the new regime was established, all active substances with an expiry date before 31 December 2023 were extended by 3 years (HSE 2021a). The hiatus this extension offers gives farmers and growers more time to consider options available to them if important insecticides are subsequently withdrawn.

HSE, however, retains - and has exercised - the option to review active substance approvals at any time where new evidence identifies any concerns to human health or the environment.

3 Insecticide Usage in Scotland

3.1 Major crops grown in Scotland

The Scottish Government no longer provide regular updates to the Economic Report on Scottish Agriculture, and the latest Total Income From Farming (TIFF) data published is for the 2019/2020 crop year. Therefore, to provide a realistic assessment of the scale and importance of insecticides used by Scottish farmers and growers economic data sources from multiple sources was utilised. Three- year average crop areas were used with estimated per hectare output and gross margin data to make estimates of the total value of farmgate output, as well as a measure of estimated gross margin (total output less total variable costs), for each crop for Scotland. Leading enterprises, ranked by the extent of cultivated areas, are shown in Table 1.

Table 1. Leading agricultural and horticultural crops grown in Scotland ranked by 2021 area; estimated values also shown where available.

Sector	Av. 2019-2021 Ha[6]	Farmgate Output £/Ha	Farm Gross Margin £/Ha	Scotland Farmgate Output Value £	Scotland Farm Gross Margin £
Forestry[1]	**1.5m**			**£529m**	**£193m**
Barley[4]	**295.0k**	**£1,228**	**£749**	**£362.2m**	**£220.9m**
- Spring[2]	249.9k	£1,090	£707	£272.4m	£176.7m
- Winter[2]	45.0k	£1,993	£981	£89.8m	£44.2m
Wheat[2]	**101.9k**	**£1,731**	**£1,142**	**£176.3m**	**£116.3m**
Oats[4]	**33.2k**	**£1,053**	**£643**	**£35.0m**	**£21.3m**
- Spring[2]	23.9k	£920	£524	£22.0m	£12.5m
- Winter[2]	9.3k	£1,395	£946	£13.0m	£8.8m
Oilseed rape (winter)[2]	**31.6k**	**£1,912**	**£1,423**	**£60.4m**	**£44.9m**
Potatoes[4]	**28.4k**	**£8,933**	**£3,550**	**£253.7m**	**£100.8m**
- Ware[2]	**16.2k**	£9,300	£4,533	£150.3m	£73.3m
- Seed[2]	**12.2k**	£8,448	£2,253	£103.4m	£27.6m
Vegetables[4]	**20.8k**	**£6,175**	**£3,085**	**£128.5m**	**£64.2m**
- Peas (fresh)[2]	**8.8k**	£1,060	£786	£9.4m	£6.9m
- Carrots[3]	**3.3k**	£13,200	£4,430	£43.9m	£14.7m
- Brussels sprouts & other veg	**2.9k**	£14,300	£7,304	£41.1m	£21.0m
- Beans (fresh/dried)[2]	**2.1k**	£1,260	£835	£2.7m	£1.8m
- Turnips/swede[5]	**1.5k**	£10,912	£5,695*	£16.7m	£8.7m
- Calabrese[2]	**1.6k**	£6,625	£4,975	£10.9m	£8.2m
- Cauliflower[2]	**0.5k**	£8,190	£6,072	£3.9m	£2.9m
Soft Fruit[4]	**2.1k**	**£72,597**	**£7,549**	**£153.9m**	**£16.0m**
- Blueberries[5]	**0.3k**	£50,140	£10,220*	£12.6m	£2.6m
- Blackcurrants[3]	**0.3k**	£4,688	£1,935	£1.4m	£0.6m
- Raspberries[3]	**0.2k**	£75,350	£11,954	£18.5m	£2.9m
- Strawberries[3]	**1.2k**	£102,000	£8,485	£119.4m	£9.9m
- Other fruit[5]	**0.2k**	£12,948	£10,220*	£2.0m	£1.6m

*** Average of gross margins of** similar **crops**; [1] **Scot Govt (2022)** [2] **SAC Consulting (2021);** [3] **ABC (2022);** [4] **Defra (2022);** [5] **Weighted calculation**; [6] Scot Govt (2021)

Noting that there can be significant annual variations in estimated economic values of crops due to farmgate and input cost variations, the major crops are summarised by the farm gate output (and estimated gross margin generated) to the Scottish economy in Table 2. In 2021 it was estimated these crops generated c.£1.7bn in sales across Scotland generating total gross margins of c.£777m. The difference in output and gross margin demonstrates that the growing of these crops led to c. £922m being spent on variable costs such as seeds, sprays and fertiliser in 2021. Any reduction in gross margins reduces the ability for farmers to generate profit from their crops after expenditure on wages, depreciating assets, and other overheads (e.g. fuel, repairs, electricity) are accounted for. Further economic benefits from these crops are derived from many 'downstream' manufacturing, transport and retail/hospitality sectors.

Table 2. Major crops grown in Scotland ranked in order of estimated annual output value (£ million); 2021

Crop	Total Output	Total Gross Margin
Forestry	**£520m**	**£193m**
Barley	**£362.2m**	**£220.9m**
Potatoes	**£253.7m**	**£100.8m**
Wheat	**£176.3m**	**£116.3m**
Soft Fruit	**£153.9m**	**£16.0m**
Vegetables	**£128.5m**	**£64.2m**
Oilseed rape	**£60.4m**	**£44.9m**
Oats	**£35.0m**	**£21.3m**
Total	**£1.7bn**	**£777.3m**

3.2 Insecticide usage: Scottish agriculture and horticulture

Combining the most recent estimated pesticide usage data produced by the Science and Advice for Scottish Agriculture (SASA, 2021) with production area enables calculation of active substance use. Table 3 lists the principal insecticides used in each sector by area. Arable and soft fruit data were available for 2020, and the most recent data for vegetables was from 2019.

Table 3. Insecticides: area of active substance applied by sector in 2019/20 (units are spray hectares – i.e. the area of crop sprayed multiplied by the number of spray applications) (SASA, 2021)

Active Substance	Arable (ha) (2020)	Vegetables (ha) (2019)	Soft Fruit (ha) (2020)	Total
Lambda-cyhalothrin	115,705	16,940	1,732	**134,377**
Esfenvalerate	40,885			**40,885**
Thiacloprid	14,054	2,534	1,542	**18,130**
Flonicamid	8,033	866		**8,899**
Tau-fluvalinate	11,293			**11,293**
Acetamiprid	8,689	755		**9,624**
Deltamethrin	3,264	4,308	183	**7,755**
Pirimicarb		6,646		**6,646**
Spirotetramat	1,298	2,840	1,402	**5,540**
Indoxacarb	503	4,790	131	**5,424**
Oxamyl	2,532	1,073		**3,605**
Spinosad		1,846	617	**2,463**
Pymetrozine		2,315		**2,315**
Bifenazate			787	**787**
Fosthiazate	744			**744**
Clofentezine			466	**466**
Spirodiclofen			339	**339**
Alpha-cypermethrin	324			**324**
Etoxazole			271	**271**
Cyantraniliprole		137	30	**167**
Cyflumetofen			150	**150**
Fatty acids C7-C20			149	**149**
Abamectin			112	**112**
Chlorantraniliprole		39		**39**
Pyrethrins			32	**32**

3.3 *Insecticide usage: Scottish forestry*

No directly comparable data to SASA's surveys is available for Scottish forestry, but the scale of insecticide use can be approximated since their main use is to control pine weevil *Hylobius abietis* in conifer restocking areas. Forest Research (2022) report that the public sector restocking programme of around 22-25 million conifers in Scotland covered 8,300ha in 2021-22. Information on active substances in use in the sector is given in Table 4.

Table 4. Insecticide active substances approved for use in Scottish forestry

Active Substance	Target(s)	Approval status
Acetamiprid	Pine weevil (*Hylobius abietis*)	Approved to 2024, high revocation risk
Lambda-cyhalothrin	Aphids, weevils, lepidoptera, etc.	Approved to 2025
Cypermethrin	Pine weevil (*Hylobius abietis*)	Approved to 2024

4 Insecticides at risk of withdrawal

4.1 Identification of active substances at risk of withdrawal

The identification and categorisation of insecticides at risk of withdrawal follows the approach used by Evans and Burnett (2020), applying the following traffic light rating:

The domestic programme for granting and reviewing pesticide approvals is under development and is scheduled to be in place before December 2023 (HSE, 2021), the criteria used in this report, therefore, reflect those of European Union Regulation EC 1107/2009, which covers this role within the EU. Its substitution by UK law is given in HM Government (2020).

Under this regulation, active substances classified as toxicity category 1A & 1B for reproduction, carcinogenic and mutagenic hazards under Classification, Labelling and Packaging (CLP) Regulations (EU Parliament & Council, 2008) will not be renewed by the European Food Standards Agency (EFSA), so are listed as *high risk of withdrawal* in Table 5 of this report. Similarly, actives classified as toxicity category 2 in *more than one* of the categories of reproduction, carcinogenic or mutagenic, are listed as ***medium*** risk of withdrawal, as this is likely to be stated as a reason for non-renewal. Actives classified as toxicity category 2 in *all three* categories are rated as ***high risk*** of withdrawal. Actives determined to be endocrine disruptors have already been withdrawn.

Actives currently under elevated scrutiny are classified as Candidates for Substitution (CfS) and are listed by the European Union (EU Commission, 2015), supplemented by EU Commission (2022b). Specific conditions for products to be included as CfS are given in Annex II point 4 of the Regulation.

Another growing concern is the use of organofluorine compounds in agriculture (listed by Ogawa *et al.* (2020) here). Their high stability means they can deliver long-term efficacy in a wide range of agrochemicals, but this stability leads to potentially problematic persistence and many are now strongly suspected of exhibiting environmental toxicity due to their contribution to the bio-accumulation of perfluoroalkyl substances (PFAS) (Ogawa *et al.* 2020).

CfS and organofluorine insecticides are therefore listed as at least of *medium risk of withdrawal.*

Active substances are also listed by Insecticide Resistance Action Committee (IRAC) Mode of Action (MoA) Classifications (IRAC, 2022) (found here) to provide a framework for optimising use of currently available plant protection products within appropriate integrated pest management (IPM) schemes.

Table 5 shows that a high proportion of the most commonly-used insecticide actives in Scotland in 2019 and 2020 across all sectors are assessed to be at high or medium risk of withdrawal, and in six cases have already lost their authorisations for use in the UK. The arable and vegetable sectors are under significant pressure, and forestry appears to be potentially hardest hit of all, with all actives with full authorisation for use being at medium risk of withdrawal at best.

Table 5. Risk status of insecticide actives listed by sector in order of area applied in Scotland in 2019/20, categorised according to CLP Regulations, CfS and PFAS classes as described in Section 3.1. Insecticide Resistance Action Committee (IRAC) Modes of Action (MoA) are also listed.

Active Substance	Status	Arable	Vegetables	Soft Fruit	Forestry	IRAC
Lambda-cyhalothrin	CfS, PFAS	medium	medium	medium	medium	3A
Esfenvalerate	CfS	high				3A
Thiacloprid	withdrawn	withdrawn	withdrawn	withdrawn		4A
Tau-fluvalinate	PFAS	medium				3A
Flonicamid	PFAS	medium	medium			29
Acetamiprid	neonicotinoid	high	high		high	4A
Deltamethrin		medium	medium	medium		3A
Pirimicarb	CfS		high			1A
Spirotetramat		low	low	low		23
Indoxacarb	PFAS		high	high		22A
Spinosad	PFAS		medium	medium		5
Pymetrozine	withdrawn		withdrawn			9B
Oxamyl	withdrawn		withdrawn			1A
Bifenazate				low*		20D
Clofentezine				low		10A
Spirodiclofen	withdrawn			withdrawn		23
Etoxazole	CfS, PFAS			medium*		10B
Cyantraniliprole			low	low	trial use only	28
Cyflumetofen	PFAS			medium*		25A
Fatty acids C7-C20				low		UNE
Abamectin	PFAS			medium*		6
Chlorantraniliprole			low		trial use only	28
Pyrethrins				medium		3A
Alpha-cypermethrin	withdrawn				withdrawn	3A
Cypermethrin					medium	3A
Diflubenzuron	withdrawn				withdrawn	15

*CfS = Candidate for Substitution; PFAS = Organofluorine insecticide; *protected crops only*

4.2 Observations

4.2.1 Arable

All but one of the actives in widespread recent use in this sector are under high or medium risk - and in the case of thiacloprid, has already been withdrawn. A recent study in the EU (EFSA, 2022) concluded that evidence against acetamiprid was inconclusive, but continuing political pressure on neonicotinoids means that acetamiprid remains at risk of having its approval revoked.

Resistance management options are limited - four of the seven actives available on arable crops are pyrethroids and therefore share the same mode of action (MoA) (3A), to which resistance is widespread in several target species. Nonetheless they remain as important elements in the crop protection armoury for many farmers and growers and are the most widely used actives across all sectors in Scotland. Alternative MoAs for aphid control are provided by both flonicamid and spirotetramat.

4.2.2 Vegetables

Of the 13 actives in use on vegetables in 2020, thiacloprid, pymetrozine and oxamyl have now been withdrawn and a further three - acetamiprid, pirimicarb and indoxacarb - are at high risk – indeed indoxacarb has already been withdrawn in the EU. Only spirotetramat and the recently introduced ryanoid actives, chlorantraniliprole and cyantraniliprole are classified as low risk in this sector.

At present, nine IRAC MoAs are available, so resistance management options may be available, although ultimately each crop is subject to specific approvals for use.

4.2.3 Soft fruit

This sector is under least pressure from insecticide withdrawals – of the 15 actives in use in 2020, thiacloprid and spirodiclofen have been lost and only indoxacarb is at high risk. Meanwhile five actives are classified at low risk and 11 MoAs are available for resistance management. However this situation is somewhat clouded since several of these actives, as indicated with an asterisk in Table 4 can only be used on soft fruit crops growing under protection.

4.2.4 Forestry

The situation in forestry is more challenging. Of the five actives in use in 2020, diflubenzuron and alpha-cypermethrin have been withdrawn whilst acetamiprid, on which the sector depends heavily, is under substantial threat. The two remaining products, lambda-cyhalothrin and cypermethrin are classified at medium risk but are of declining utility as pyrethroid resistance grows. Meanwhile the ryanoid actives chlorantraniliprole and cyantraniliprole are only approved for use in trials and are unlikely to be fully approved before 2026.

5 Stakeholder consultation

The project team selected the following crop production systems based on their contributions to the Scottish rural economy and how well they represent market sectors:

- Arable: Winter and spring barley
  Seed potatoes
- Vegetables: Brussels sprouts
  Carrots
- Soft Fruit: Strawberries
- Forestry: Public sector

Stakeholders, listed below for each sector, were consulted by emailed questionnaires in Autumn 2022.

Questions, given in Appendix 1, sought responses detailing main threats from insect pests in their sector in prevalence and economic damage, which insecticide actives are most effective in their cropping systems and possible alternatives in terms of both chemistry and broader IPM options.

5.1 Winter and spring barley

Aphid control: in the absence of pyrethroids (lambda-cyhalothrin, deltamethrin, esfenvalerate) to control BYDV in winter barley and prior to adopting alternative IPM practices expectation for potential yield loss is 15-25%, but in extreme circumstances could be as much as 50%. Spring barley is expected to be less impacted with losses of 10-15%. IPM measures are viewed as partially effective in mitigating yield loss both for autumn and spring infections.

The value of winter barley in crop rotations in the absence of pyrethroids will be reduced, and in some high-risk areas (e.g. coastal Fife) the BYDV risk is so high that winter barley will no longer be a viable option. In high aphid years, potential losses from BYDV and reduction in quality will reduce marketable yield and may make the crop uneconomic, with impacts on domestic production damaging maltsters' supply chains.

Cereal leaf beetle is also a threat, and loss of the incidental control provided by pyrethroids can also cause yield losses of up to 25%.

In the absence of pyrethroids, crop management strategies for winter barley would see the greater use of varieties with BYDV tolerance. These currently carry a 10% yield penalty over the best non-tolerant varieties, while having higher seed costs. Currently available tolerant varieties are not optimised for Scottish conditions and will lead to greater use of fungicides and growth regulators.

There is concern surrounding strategies for spring barley due to the lack of resistance through variety choice. In certain areas it may lead to major cropping changes and reduced spring barley production, potentially impacting on the rapidly growing Scottish Malt whisky distilling sector that already needs all the distilling barley Scotland produces.

The best option for aphid control in barley is lambda-cyhalothrin – resistance has been observed with deltamethrin.

Short term impact for the crop following a full withdrawal is seen as potentially highly damaging to malt production in Scotland. Increased costs of production are also likely to have significant impacts - increased seed costs in tolerant winter barley that are up to 10% lower yielding than existing standards will reduce and threaten the viability of winter barley in arable rotations.

Effects on spring barley are potentially even worse. Lower yields and losses in quality could have very serious impacts on the Scottish malting sector, with consequent economic losses to the Scottish economy. No current IPM options for spring barley offer adequate options to replace the best pyrethroid options.

5.2 Seed potatoes

The seed potato crop is inspected and classified as part of the SPCS (Seed Potato Classification Scheme) – tolerances, particularly for the home (GB) market are extremely strict and even a small ingress of virus into seed crops could have disastrous consequences. At present, with the current range of actives there are very few fails or downgrades in our production systems, but if a downgrade occurs losses can be substantial – ranging from £50 /t to £110 /t on one merchant's contract (15% to 35% approx. of value) to a complete write off if no grade is achieved. Specialist varieties destined for export markets with no options for use as a ware crop in the UK have no value in the ware market.

If a seed crop has received a full legal insecticide program, it is unlikely to find a market as a ware crop due to the legalities of using these crops for human consumption. Commercial value of seed is estimated at £280 /t (2021 prices) and an average graded saleable seed yield of 35 t/ha. A total of 51 ha of crops that were entered for certification failed due to virus and represents a total value of £499,800 in the 2021 marketing season.

While vector pressure is relatively low in Scotland, potato mosaic virus accounted for more of the seed area not holding grade at inspection than any other growing crop inspection fault in 2021, including blackleg. Potato leafroll virus has increased in the past three years. It is important to emphasise that for seed potatoes, losses will occur in the following daughter crop, and these can be very large if virus control has been poor.

Potatoes are a vegetatively propagated crop, and with every field, generation issues worsen, and losses can mount. Given the current environment following Brexit, English growers cannot import seed from the EU legally. Scotland is, of course, a protected area in that regard – but Scottish seed growers may need to increase field generations to meet the supply demands of their customers south of the border, exposing them to more risk.

Implementing sustainable and environmentally friendly integrated pest management (IPM) strategies to control insect-transmitted viruses with fewer chemical tools have become a challenge to the potato industry and the seed sector impacting on trade and livelihood.

One responder perceived the industry as having too much of a reliance on pyrethroids (esfenvalerate and lambda-cyhalothrin). Scottish growers who are waiting for colonizers like *Myzus persicae* (Peach-Potato Aphid) to appear in yellow water traps before applying resistance breaker products such as spirotetramat, flonicamid and acetamiprid are missing out on managing the non-colonizing aphids that move through crops which are the major virus transmitters. In an IPM approach the use of pyrethroids does nothing to help the beneficial insect population. Without the full chemistry tool kit there would undoubtably be losses both in terms of quality and yield. The impact will be uneven as it will depend on variety. Relying on IPM measures more heavily (mineral oils, mulches, etc.) is a potential alternative approach, but there could be a yield penalty from these measures alone (mineral oils in particular).

In the event of the loss of all actives, growers would take a long, hard look at the viability of growing seed potato crops. The ware market does not have sufficient elasticity to absorb a substantial number of seed producers switching to ware, causing oversupply issues. Reputational damage is a risk with key export partners and may be difficult to repair.

IPM options are insufficiently developed and much work needs to be done for effective control options to be available for seed potato production if suitable chemical control options are unavailable. More focus would be put on IPM methods such as mineral oils and straw mulches. There are limits to what they can achieve though – mineral oils are only approved up until tuber initiation limiting their use to a maximum of three sprays. They can only be mixed with a small number of blight sprays. Straw mulching looks promising, but realistically due to the costs and time involved will only work on the highest-grade stocks or on high-risk varieties with small areas. To straw 10,000 ha of Scottish seed production is unrealistic currently. It would need 60,000 t of straw at a time of year when there is little if any in stock and it is at its highest price. A very long-term solution would be breeding for virus resistance, but this takes over 10 years currently and is not a key factor when new varieties are being selected by breeders. Gene editing could speed up the process and allow older varieties to be retained. The most effective short-term solution would be to make it compulsory to use certified seed for ware production. It would make the whole production system more resilient and reduce virus levels in the environment. Seed growers would benefit, ware growers would potentially see increases in yield and quality but would be faced with higher seed costs and be resistant to this change.

Increased reliance on IPM strategies is not without cost; higher rogueing costs, increased sprayer costs if mineral oils must be applied separately due to mixing issues. This could add £100 /ha to costs. There are also issues with crop canopy collapse when large numbers of oil sprays are applied. If crop yields decline due to virus, then the cost per tonne goes up and margins are squeezed. If growers try to isolate crops by moving into more marginal land, then costs will go up due to lower yields and higher transport costs. Lower yields and longer transport distances from marginal land mean larger carbon footprints as well as higher costs. Virgin potato land in marginal areas has historically been avoided for particularly good reasons – it is higher risk due to the local climate and land being unsuitable to provide reliable yields. Commercial seed growers might have to replace their stocks more regularly – reducing future field generations from 3 to 2 for example. For many, this will be a significant increase in costs.

5.3 Brussels sprouts

The main threat to Brussels sprouts is from aphid infestation, which can reduce crop value by as much as 80%. Esfenvalerate and lambda-cyhalothrin (both pyrethroids) are the most important actives used for their control. Whitefly are not a major threat in Scotland. Caterpillars, including silver-y-moth are well controlled by indoxacarb, but if all actives are withdrawn, caterpillar damage will be a major concern.

Cyantraniliprole and spinosad are valuable alternatives to pyrethroids and indoxacarb since they are less harmful to beneficials. Some biopesticide-based IPM practices have been implemented, with a reported 60% increase in application costs over conventional pesticide programmes and inconsistent efficacy.

Loss of actives is highly likely to lead to inefficiency and wastage through higher proportions of crops being unmarketable, leading to the need for substitution for Scottish produce through importation. Crop output could be halved, thereby doubling the cost of production.

5.4 Carrots

Damage to carrot production in Scotland is primarily from willow-carrot aphid, followed by carrot fly and cutworm. Neither lambda-cyhalothrin nor deltamethrin are reported to have useful efficacy on willow-carrot aphid although both are effective against carrot fly and cutworm, with growers rating lambda cyhalothrin as a better control option than deltamethrin.

The loss of pyrethroids would be most damaging to carrot fly control, although chlorantraniliprole (Voliam) and cyantraniliprole (Minecto One) both offer good activity against this pest at significant cost increase. Cultural controls including irrigation management may also be beneficial. Biopesticides may also be used, but these are expensive and offer inconsistent efficacy.

In terms of aphid control there would be no impact of losing the pyrethroids, since spirotetramat (Movento), acetamiprid (Gazelle SG) and flonicamid (Teppeki) provide economic control of aphids and subsequent virus transmission. Carrot viruses are generally semi-persistent, and the incidence is normally higher than visual symptoms suggest. There is a background level of yield impact, particularly from carrot motley dwarf complex. The control of aphids for subsequent virus control is essential for maintaining carrot yield and quality.

The current practice for aphid control is based around timing treatments based on yellow water trap and suction trap data for the start of control programmes built around spirotetramat, acetamiprid and flonicamid. Loss of pyrethroids would lead to a greater reliance on chlorantraniliprole and cyantraniliprole; both of which should provide greater persistence against the target pest than pyrethroids and with potentially greater selectivity.

Carrot fly incidence is likely to be more sporadic with more sheltered fields/areas being at higher risk and more cultural controls available for control – particularly drilling date management where this can be used within the constraints of crop planning for maturity and harvest planning. Some fields would see large increases in carrot fly damage and the presence of larvae in the roots which would have a significant effect on marketability. Overall, one would expect to see a reduction in gross and marketable yield and an increase in defect roots that would not be able to enter the food chain. Processing quality would also be reduced, particularly where carrot yellow leaf virus was present, creating internal browning symptoms.

Full loss of insecticide actives would impact on a range of areas of carrot production. Consideration would be needed as to plant populations (to dilute the impact of aphid pressure with higher plant stands – increasing seed costs). For carrot fly, crops may need to be drilled later to avoid first generation fly risk – this would impact on potential crop continuity for maturity and harvest and also on yield potential. Crops grown in the 'risk' period would be under greater threat, and this may lead to more area being grown to compensate for crop losses. The use of physical barriers for both aphid and carrot fly could be considered, either sowing barrier crops around the outside of carrot fields, or (with significant cost implications) covering the required area, with the practical implications of labour etc to set up more physical barriers.

The loss of the listed actives would add significantly increased risk of yield and quality loss and would put genuine question marks over the future viability of carrots in the rotation.

5.5 *Strawberries*

Western flower thrips and spider mite are reported to be capable of halving crop value in the absence of full active availability. Responders comment that in the absence of actives, changes to crop management strategies would not be sufficient to maintain economic crop viability. Biological control alone would not control any of these pests enough to prevent losses in fruit quality and yield. Increases in fruit wastage would occur and different tunnel structures would be needed. No significant pest resistance is currently reported, citing that products are already used sparingly as part of IPM programmes to avoid over-application.

The most critical products for growers to retain if insecticides were partially withdrawn are reported to be lambda-cyhalothrin followed by etoxazole and indoxacarb.

Short term impacts from full withdrawal are likely to be substantial, including both losses in yields and higher levels of crop wastage. Growers are already struggling with rising input costs so in the event of soft fruit production becoming uneconomical, they may switch to other crops such as cereals.

Production costs will also rise where conventional products are replaced with biological control, since more labour is necessary for more frequent biocontrol applications, for removal of waste fruit and also for quality control work in both field and packhouse. There will also be an increased risk of customer rejections due to pest/biocontrol contamination.

5.6 *Forestry*

Large pine weevil, *Hylobius abietis,* is identified as the most significant forestry pest for both the private and public forestry sectors. Acetamiprid is widely used to protect restock conifer saplings against *Hylobius*, and also occasionally for broadleaves. Two potential actives for *Hylobius* control, chlorantraniliprole and cyantraniliprole are currently approved for trial use only, with operational approval expected to take at least until 2026. *Hylobius* resistance to insecticides has not been observed in public or private forestry sectors.

Acetamiprid is also used alongside lambda-cyhalothrin against aphids on Christmas trees. The latter active is only approved for farm woodland applications.

Cypermethrin (previously used for *Hylobius* control) is approved for use until 2024 but due to its *highly hazardous* status its use is not permitted in FSC-certified forests in the UK. Approval for lambda-cyhalothrin expires in 2025 respectively.

Currently all forestry uses of acetamiprid (Gazelle) for Hylobius control will cease in July 2024. Authorisation for Gazelle was renewed by HSE on the 25/1/23 but without forestry uses. Reinstatement of the EAMU for forestry is currently under discussion.

Alternative options were available for some existing pests (e.g., anti-feeding products for Christmas tree aphids), whereas others were already devoid of active options (e.g., lepidopteran pests of pine) but this hadn't caused a noticeable increase in damage reports.

The lack of active options for future forest pest threats (e.g. *Ips typographus*) is also as a concern.

In terms of economic damage, if actives are used in conjunction with a broader IPM approach, sapling mortality was estimated at c.10%. However, this may vary depending on other site factors (e.g. previous crop species, proximity to adjacent clear fell sites, timing of insecticide applications).

IPM measures alone (including the use of fallow periods, nematode applications, and physical barriers) are thought to be partially effective for *Hylobius* control. Specific issues identified include increased need for cultivation and weed control when using fallow periods, operational issues associated with nematode drench applications, and insufficient or inconclusive evidence from trials to date that have tested other methods. In the absence of acetamiprid it is predicted that sapling mortality would still vary depending on other site factors, but overall, it would increase by at least double and probably much higher on some sites even up to total losses.

The withdrawal of acetamiprid would have an immediate and substantial impact on the restocking of commercial conifers in Scotland. All conifer species planted on restock sites are susceptible to *Hylobius* (c.95% of production forestry on the public estate in Scotland is under a clearfell and restock management programme). The industry would need to apply very quickly for emergency approval or an extension of authorisation for minor use (EAMU) for chlorantraniliprole (Coragen®) and / or cyantraniliprole. An existing formulation of chlorantraniliprole (Acelepryn®) has emergency approval for turf pest control (e.g., on golf courses), however this product is very expensive and would require separate approval for forestry use.

Without other chemical insecticide options, both the public and private forestry sectors would become more reliant on fallow periods (leaving sites unplanted for 2-5years). This would have big implications for cultivation and weed control on fertile sites, resulting in the need for increased herbicide use and more ground disturbance prior to later planting. Due to financial pressures to replant, it is likely the private sector would also take more risks and adopt less-effective measures such as physical barriers.

Bacillus thuringiensis (Bt) is approved for use against lepidopteran pests, but not for aerial applications and is not currently used in Scotland. There are currently no actives available to target lepidopteran pests of pine (e.g., pine looper, pine beauty moth). Other actives were used to control Lepidopteran pine defoliators in the past, but these pests have not caused significant issues recently, possibly due to a reduction in pine plantations due to *Dothistroma* needle blight.

If a serious Lepidopteran pest emerged, then Bt would be considered as a potential control option, but would need approval from NatureScot due to its likely high impact on non-target lepidopterans (especially in Caledonian pine forests). Likewise, approval for Bt use may be sought for the control of caterpillars that pose a public health risk (e.g., oak processionary moth) on amenity trees.

The direct cost of managing *Hylobius* in the UK, with the actives currently available, is estimated at £7million a year. Of this total, c.£4.7million/year can be allocated to Scotland, based on 67% (8,300Ha) of publicly funded conifer restocking occurring in Scotland of an overall UK total of 12,400Ha (2021-22) (Forest Research, 2022).

It is very difficult to quantify how much these costs would increase, were acetamiprid to be withdrawn and not replaced with another similarly priced active, as it is difficult to predict how the industry would react and therefore calculate the associated costs.

Several possible management and behaviour changes were identified, all of which would have financial impacts:

- Potential for larger private estates to move to planting / growing productive broadleaves rather than conifers (slower growing but more valuable crop, which would require investment in harvesting / processing operations)

- Higher risks and greater uncertainty (e.g. higher risk of planting failures or greater establishment costs) may reduce business from the investment community, therefore reducing annual restocking programmes.
- Public sector likely to switch to greater reliance on fallow periods. No recent costings available for this strategy, but loss of production due to delay in planting (3-5 years of 35year Sitka spruce rotation) resulting in big impact on marginal profits. Plus, fallow incurs additional herbicide application and cultivation costs.

Actives are mainly used in UK forestry to target *Hylobius* weevils on restock sites. The risk of these actives being withdrawn therefore has a much higher impact on Scotland (at least double) than elsewhere in the UK due to the greater prominence of production conifer forestry, particularly restocking, in Scotland.

Of 19,300Ha of conifers planted in the UK in 2021-22, 14,600Ha were planted in Scotland (6,300Ha of new planting plus 8,300Ha of restocking). In Scotland, the public sector has an annual restock programme of c.22-25million conifers compared to c.6million conifers in England (where the majority of production forestry is concentrated in Kielder Forest), c.3million conifers in Wales and c.2.5million conifers in N. Ireland (Forest Research, 2022).

6 Economic impacts of insecticide withdrawals

Table 6: Summary of production sectors with annual gross value added and potential losses if actives at high and moderate risk of withdrawal become unavailable

Crop	Output Value (£m)	Potential output loss (%)	Potential output loss (£m)	Potential impact on Gross Margin (%)
Barley	£362.2m	13.8% - 15.5%	£50m to £54m	-22.6% to -24.6%
Potatoes	£253.7m	20%	£51m	-50.3%
Vegetables	£128.5m	25%	£32.1m	-50%
Wheat and Oats	£211.3m	7%	£14.8m	-10.7%
Soft fruit	£153.9m	23%	£35.4m	-221%
Forestry	£529m	10%	£53m	-27.4%

6.1 *Winter and spring barley*

Barley production in Scotland covered 292,000 hectares generating an estimated £447 million output in 2022. Grower estimations from losses of aphid control options are in the region of 15-20%, up to 50% in some instances, and in some areas risks to the crop will be so high that barley is no longer an economic option. In this scenario, few arable alternatives exist. Current crop protection practices are also effective against cereal leaf beetle, which can cause 25% losses.

On this basis, a conservative projection of crop losses in barley grown without insecticides is around 15%. At the 2022 estimated values shown in Table 1, this represents a reduction of approximately **£54 million** in turnover in the Scottish rural economy (ignoring any supply and demand rebalancing) that may further impact downstream on malting barley supplies (and provenance) in the Scotch Whisky supply chain.

If IPM measures are adopted using BYDV-resistant barley varieties, seed costs are estimated to be 10% higher with additional fungicide and growth regulator applications needed. In this scenario 10% lower yields are projected, worth **£45m** in crop output using 2022 values compared to non-BYDV-resistant crop. It is anticipated there would be further additional costs for seed of £11/ha and sprays at £25/ha (SAC Consulting, 2022) on 292,200 ha of barley worth approximately **£11m**.

6.2 *Potatoes*

Potatoes were grown on 28,400 hectares and were estimated to have generated £254 million farmgate value in 2022. Around 43% of this area is covered by Scotland's iconic potato seed industry, which depends entirely on the ability to control aphid vectors to prevent the spread of viruses. If a downgrade of a seed crop occurs because of viral contamination, financial losses can range from 15-35%, or if no ware market can be found (insecticide treatment programmes can mean that crops grown for seed cannot be sold for human consumption) crops can be close to valueless (stock feed or anaerobic digestion feedstock). In 2021 a total of 51 ha of crops with a value of £0.5m were lost, because of failed certification, despite the availability of a range of effective insecticides. In addition to single year losses, expensive losses of following daughter crops will also occur if virus control is inadequate.

IPM methods such as mineral oils and straw mulches are also costly. Mineral oil applications are estimated to add £100 per hectare to spraying costs. A 6 t/ha straw mulch – if straw is available in sufficient quantity due to competition with high demand from Scottish livestock producers – will add a further £390 per hectare at £65/t. Isolating crops by using more remote and marginal land may be an option, but this will further decrease seed production viability through unreliable cropping, lower yields and higher transport costs. Increased likelihood of viral contamination could also mean that seed growers need to replace their stocks more regularly, reducing future field generations and thereby increasing production costs.

Projections of financial losses are difficult, but the loss of effective aphid control could threaten the viability of much of Scotland's seed potato industry. A conservative estimate might be a 20% loss in value of Scottish £254m potato production, around **£51m**. It is worth noting that these reduced economic impacts would most likely be felt in the more remote communities of the seed potato growing areas of the Highlands, Moray and Aberdeenshire.

6.3 Brussels sprouts

Field vegetable production in Scotland was worth nearly £129m at the farmgate in 2022. Since aphid damage can cause 80% losses in Brussels sprouts and challenges from lepidopteran pest species are currently managed by indoxacarb, loss of control in these areas would be damaging to growers.

Currently, cyantraniliprole and spinosad are alternatives to at risk pyrethroids and indoxacarb, and some biopesticide-based IPM practices have been implemented, although with a reported 60% increase in application costs over conventional pesticide programmes and inconsistencies in efficacy.

Expert opinion is that insecticide withdrawals will substantially increase wastage through higher proportions of crops being unsaleable, and that marketable **yields are likely to be halved that could reduce farmgate output by about £21m**. Similarly, in other field vegetable crops such as calabrese, visible pest damage or insect contamination will lead to retailer rejections if aphids and caterpillars cannot be controlled.

6.4 Carrots

Impacts of insecticide withdrawals on the £44m carrots produced in 2021 are also difficult to quantify – the impact of carrot viruses is generally higher than visual symptoms suggest, with a background level of yield losses arising mostly from the carrot motley dwarf complex, and also from quality losses arising from carrot yellow leaf virus. Aphid control measures are therefore essential for maintaining carrot yield and quality. Carrot fly damage is likely to be more of a problem in the absence of pyrethroids, with the presence of larvae in the roots reducing marketability.

In the short term, withdrawals of at-risk actives may be mitigated using products such as cyantraniliprole, chlorantraniliprole and spirotetramat, although these are more costly than many currently favoured actives.

IPM options for carrot fly include cultural controls such as drilling date management to avoid first generation fly risk, but this would impact on crop maturity timing and reduce yields. Irrigation management and the use of barriers to carrot fly ingress may also be used, either as crops or by using physical barriers – these will both have cost implications. Biopesticides may also be used, but these are expensive and offer inconsistent efficacy.

Withdrawal of all insecticide actives would add significantly increased risk of crop yield and quality loss and would put genuine question marks over the future viability of carrots in the rotation.

Considering the issues highlighted by stakeholders for both carrots and Brussels sprouts, the impact of insecticide withdrawals of Scotland's £129m field vegetable sector can be conservatively projected to result in losses of at least 25% of current market values, amounting to more than **£32m**.

6.5 Strawberries

Strawberry production was estimated to generate £119m in farmgate revenues in 2021. Stakeholders report that in the absence of effective active substances, Western flower thrips and spider mite could halve the value of the crop, and that changes to strawberry production strategies would not be sufficient to maintain economic crop viability since biological control alone would not provide sufficient control of any of these pests to prevent losses in fruit quality and yield. Growers are badly impacted by rising input costs, so the need to restructure production systems and increase labour costs for frequent biocontrol applications and much more quality control work in both field and packhouse is likely to make soft fruit production uneconomical, forcing a switching to less demanding crops such as cereals.

If losses from thrips and mites, increased labour and restructuring costs combined with loss of production area amount to a quarter of current strawberry production, this would amount to £30m. Projecting similar impacts to Scotland's £154m (2021) soft fruit production would result in over **£35m** of losses and it is estimated that gross margins would become negative (i.e. unsustainable) without significant production cost restructuring or a rise in output value.

6.6 Forestry

In 2020-21, the public sector forestry programme planted 6,300 ha of new forestry and restocked 8,300 ha of felled areas from a total woodland area of c.1.5m ha. The establishment costs of this was estimated at £83m in 2020 (noting that current timber output is unaffected by planting effects) and it is estimated that gross value added of £193m is derived from £539m turnover. All conifer species planted on restock sites are susceptible to *Hylobius* damage, and protecting new saplings is the main need for insecticide use in this sector, with sapling mortality using current insecticides and IPM practices estimated at around 10%, depending on factors such as previous crops, proximity to clear fell sites and insecticide application timings.

Loss of acetamiprid would have an immediate and substantial impact on the restocking of commercial conifers in Scotland - the industry would need to apply very quickly for emergency approval or an extension of authorisation for minor use (EAMU) for chlorantraniliprole and / or cyantraniliprole. An existing formulation of chlorantraniliprole (Acelepryn®) has emergency approval for turf pest control, however this product is very expensive (*Hylobius* management with acetamiprid currently costs £4.7m per annum) and would require separate approval for forestry use.

IPM measures alone (e.g. fallow periods, use of entomopathic nematode applications and physical barriers) can be partially effective for managing *Hylobius* damage, but overall, without effective insecticides it would increase by at least double, with much higher damage on some sites, even up to total losses.

The use of fallow periods (i.e. leaving sites unplanted for 3-5 years) would have major implications for cultivation and weed control on fertile sites, resulting in the need for increased herbicide use and more ground disturbance prior to later planting. Reduced productivity from long planting delays will have a damaging impact on the economic viability of a typical 35-year Sitka spruce rotation already running with marginal profits.

A doubling of insecticide costs if emergency approval is needed for chlorantraniliprole and/or cyantraniliprole would cost Scotland's forestry sector an additional **£5m** per annum, whilst even excluding additional losses from *Hylobius* damage when using IPM practices alone, adding 3-5 years to a 35-year rotation is likely to lead to at least a 10% loss in annual revenue from sales. If all Scottish production was similarly affected, at current prices this would cost the sector around **£53m** a year.

7 Conclusions

Insecticides are widely used in Scotland, and withdrawal of several key actives would inflict losses and disruption across many areas of land use and are likely to negatively impact supply chains and employment in iconic economic activities in Scotland such as whisky distilling, forestry and seed potato production.

In summary, estimates of annual losses from each sector may be in the region of:

- Winter and spring barley – £50m - £54m (impacts on wheat and oats may add a further £15m)
- Potatoes – £51m
- Field vegetables – £32m
- Soft fruit – £35.4m
- Forestry – £53m

The uptake of IPM practices and voluntary stewardship schemes may help to reduce industry reliance upon pesticides and could help to prolong regulatory approval for an adequate range of active substances, but it is clear from stakeholder engagement that farmers and growers generally have little confidence that IPM practices without the support of insecticides will enable them to avoid substantial losses from existing enterprises. At present, an immediate loss of key insecticides is likely to have a very damaging impact on many Scottish farmers, growers and the supply chains that they serve.

However, if withdrawals are ultimately considered necessary to protect human health and the environment, if there is sufficient notice period and adequate investment into developing varieties and IPM practices that work in the Scottish climate there is the potential to mitigate some of those risks. Therefore, a gradual, phased approach could help to protect employment in rural sectors and the wider Scottish economy. In addition, use of voluntary stewardship schemes can demonstrate the willingness of farmers, growers and foresters to work to reduce insecticide dependence where possible, thereby gaining sufficient political support to minimise future withdrawals.

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9 Appendix 1: Stakeholders

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10 Appendix 2: Example of Stakeholder Questionnaire

Crop:	**winter and spring barley**
Actives:	deltamethrin, lambda-cyhalothrin, esfenvalerate
Pest:	aphid
Disease:	BYDV and spring colonisation
Product names:	Decis Protech, Clayton Sparta, Hallmark, Karis, Lambdastar, Sumi-Alpha

1. In the absence of pyrethroids to control BYDV in winter barley and prior to adopting alternative IPM practices what is your expectation for potential yield loss?
   - express as a %
2. In the absence of pyrethroids to control aphids in the spring/summer on winter barley and spring barley and prior to adopting alternative IPM practices what is your expectation for potential yield loss?
   - express as a %
3. How effective do you believe IPM measures can be on their own in mitigating any yield loss with regards to BYDV transmission?
   - fully effective
   - partially effective
   - ineffective
4. How effective do you believe IPM measures can be on their own in mitigating any yield loss with regards to aphid colonisation of barley crops in the spring/summer?
   - fully effective
   - partially effective
   - ineffective
5. Would the withdrawal of pyrethroids change your perception of the viability of the inclusion of winter barley in the rotation and if so why?
6. Would the withdrawal of pyrethroids change your perception of the economic viability of the inclusion of spring barley in the rotation and if so why?
7. How, if at all, would your crop management strategy change if pyrethroids were withdrawn for the control of aphids in winter barley?
8. How, if at all, would your crop management strategy change if pyrethroids were withdrawn for the control of aphids in spring barley?
9. Have you experienced aphid resistance to deltamethrin, lambda-cyhalothrin or esfenvalerate that will impact on how you will use these products in the future?

10. List, in order of preference, the actives most critical for retention given a partial withdrawal scenario with reasons
11. How would you summarise the impact in the short-term following a full withdrawal of these actives?
12. Can you quantify any increased cost of production arising from full loss of actives listed?

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