Agriculture and Agri-Food Canada / Agriculture et Agroalimentaire Canada

Crop Profile for Lowbush Blueberry in Canada, 2011

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Canada

Electronic version available at
www.agr.gc.ca/pmc-cropprofiles

Catalogue No. A118-10/31-2012E-PDF
ISBN 978-1-100-20656-1
AAFC No. 11751E

Paru également en français sous le titre:
« Profil de la culture du bleuet nain au Canada, 2011 »

Preface

National crop profiles are developed under the Pesticide Risk Reduction Program (PRRP), a joint program of Agriculture and Agri-Food Canada (AAFC) and the Pest Management Regulatory Agency (PMRA). The national crop profiles provide baseline information on crop production and pest management practices and document the pest management needs and issues faced by growers. This information is developed through extensive consultation with stakeholders.

Information on pest management practices and pesticides is provided for information purposes only. No endorsement of any pesticides or pest control techniques discussed is implied. Product names may be included and are meant as an aid for the reader, to facilitate the identification of pesticides in general use. The use of product names does not imply endorsement of a particular product by the authors or any of the organizations represented in this publication.

For detailed information on growing lowbush blueberry, the reader is referred to provincial crop production guides and provincial ministry websites listed in the Resources Section at the end of the profile.

Every effort has been made to ensure that the information in this publication is complete and accurate. Agriculture and Agri-Food Canada does not assume liability for errors, omissions, or representations, expressed or implied, contained in any written or oral communication associated with this publication. Errors brought to the attention of the authors will be corrected in subsequent updates.

Agriculture and Agri-Food Canada gratefully acknowledges the contributions of provincial crop specialists, industry specialists and growers in the gathering of information for this publication.

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The lowbush blueberry is a perennial, native fruit that grows in treeless barrens, fields and burned over areas of north eastern North America. It is a member of the Ericaceae or heath family. The crop is unique in that it is not planted, but is harvested from managed, wild stands. This is unlike the highbush blueberry that is planted and maintained in an orchard. Harvested lowbush blueberry species include *Vaccinium angustifolium, V. angustifolium f. nigrum* and *V. myrtilloides.*

Lowbush blueberries were harvested by native peoples before European settlers arrived in North America. Some native peoples encouraged blueberry growth by periodically burning blueberry fields, which would quickly grow again with new plants. Early settlers in the Atlantic Provinces first harvested the fruit for their own use or for local distribution. Improvements in marketing and shipping and the establishment of canneries in Maine and along the Canada–US border in the mid-1800's expanded the markets. Improved harvesting methods and management resulted in an expansion of production throughout the 20^{th} century. Since the 1980s, production has increased dramatically because of advancements in management including improved weed control and the increased use of introduced bees for pollination.

Lowbush blueberry fruit is rich in antioxidant compounds that fight free radicals that are associated with cancer, heart disease and premature aging and are high in vitamin C, manganese and fibre. Most of the lowbush blueberry crop is sent to processing plants to be frozen using "Individually Quick Freezing (IQF)" technology. The berries may then be sold frozen or further processed into products such as pies, yogurt, ice cream, jams and syrups. Less than 5% is sold fresh at local markets.

Crop Production

Industry Overview

Blueberries rank as the number one fruit crop in Canada with respect to area under production. General production information is presented in Table 1. Production in Quebec and the Atlantic provinces comprises 45% of world production

Table 1. National blueberry production statistics

Canadian production (2011)[1,2]	112,363 metric tonnes 38,413 hectares
Farm gate value (2011)[1,2]	$ 203 million
Domestic consumption (2009)[1,3]	0.78 kg/person
Lowbush blueberry exports (2010)[4]	$8,060,784 (fresh)
	$122,248,533 (processed)

[1]Includes highbush and lowbush blueberries
[2]Source: Statistics Canada, *Fruit and Vegetable Production*, February 2012, Catalogue no. 22-003 X, vol. 80, no. 2
[3]Source: Agriculture and Agri-Food Canada, *A Snapshot of the Canadian Fruit Industry*, 2009. ISSN 1925-279X , AAFC No. 11390E (www.agr.gc.ca/fruit-industry)
[4]Source: Canada Brand - Canadian Blueberries (www.marquecanadabrand.agr.gc.ca/tools-utils/5318-eng.htm accessed March 29, 2012)

Production Regions

Lowbush blueberries are produced commercially in eastern Canada, in the provinces of Nova Scotia, New Brunswick, Prince Edward Island, Newfoundland and Labrador and Quebec (refer Table 2).

Table 2. Distribution of blueberry production in Canada, 2011[1,2]

Production regions	Cultivated area (hectares)[3]	Bearing area (hectares)	Percent national production (based on bearing area)
British Columbia	7,653	7,133	19%
Ontario	277	226	1%
Quebec	27,911	15,146	39%
New Brunswick	11,301	5,674	15%
Nova Scotia	17,562	7,672	20%
Prince Edward Island	4,899	2,398	6%
Newfoundland and Labrador	372	–	–
Canada	69,974	38,413	100%

[1]Source: Statistics Canada, *Fruit and Vegetable Production*, February 2012, Catalogue no. 22-003 X, vol. 80, no. 2
[2]Includes highbush and lowbush blueberries
[3]Cultivated area includes bearing and non-bearing areas

The major and minor crop field trial regions were developed following extensive stakeholder consultation and have been harmonized between the Pest Management Regulatory Agency (PMRA) and the Environmental Protection Agency of the USA. The identified regions are used for experimental studies in support of residue chemistry data requirements for the registration of new pesticide uses. The regions are based on soil type and climate and do not correspond to plant hardiness zones. For additional information, please consult the PMRA Regulatory Directive 2010-05 Revisions to the Residue Chemistry Crop field Trial Requirements (www.hc-sc.gc.ca/cps-spc/pubs/pest/_pol-guide/dir2010-05/index-eng.php).

Cultural Requirements

Lowbush blueberries are a perennial succession crop. The plants grow wild in areas of sandy, gravelly, well drained soils with acidity levels of 4.2-5.5 that are generally unsuitable for other types of agriculture. The blueberry bush spreads through slow-growing, underground stems called rhizomes.

Blueberries grow faster if the ground is undisturbed, so producers manage fields only by pruning, fertilizing, reducing weeds and controlling pests and diseases. Pruning by mowing or burning encourages the growth of vigorous new stems from underground rhizomes. Generally, blueberry fields are completely pruned every two years. This eliminates all above ground vegetation and gives the blueberry plants a competitive advantage during re-growth due to their extensive root system. The crop is usually pruned after harvest, late in the fall or in the early spring and then allowed to re-grow during the “sprout” year. This enables the crop to regenerate in the absence of competition. Flower buds are set in the fall of the sprout year. The crop bears fruit the following year or “crop year”. Thus, only half of the acreage is harvested in any one year. In Quebec, a three year cropping system is often used - one sprout or vegetative year and two harvest years. Thus fields are divided into 3 sections with two thirds of the acreage being harvested in a year.

Until the mid-1980s, the entire crop was harvested by hand or by raking. Today, fields in rough terrain and in forested areas are still hand raked, but most of the crop is mechanically harvested (up to 80% in some areas), an innovation that has revolutionized the lowbush blueberry industry. In established fields, modern practices yield between 0.5 and 10 tonnes per hectare.

The following table (table 3) describes production practices and worker activities for lowbush blueberry throughout the season.

Table 3. General lowbush blueberry production schedule in Canada

Time of Year	Activity	Action
April	Plant care	Pruning (prune year (PY))
	Weed management	Pruning (PY)
May	Plant care	Pollination and fertilization (PY)
	Disease management	Monitoring and spraying if necessary (crop year (CY))
	Insect & mite management	Monitoring and spraying if necessary (CY & PY)
	Weed management	Pre-emergent herbicides (PY)
June	Plant care	Pollination (CY) and fertilization (PY)
	Disease management	Monitoring and spraying if necessary (CY)
	Insect & mite management	Monitoring and spraying if necessary (CY & PY)
	Weed management	Post-emergent herbicides and spot applications (CY & PY)
July	Plant care	Leaf tissue sampling (tip dieback) (PY)
	Soil care	Soil sampling (same time as leaf sampling) (PY)
	Disease management	Monitoring and spraying if necessary (PY)
	Insect & mite management	Monitoring and spraying if necessary (CY)
	Weed management	Spot herbicide applications and physical control options (PY)
August	Plant care	Harvest (prune later in season or in spring) (CY) Leaf tissue sampling (tip dieback – prune year) (PY)
	Soil care	Soil sampling (same time as leaf sampling) (PY)
	Disease management	Limited
	Insect & mite management	Limited
	Weed management	Limited

Abiotic Factors Limiting Production

Pollination

Pollination is critical for successful blueberry production. Poor pollination may result from adverse weather conditions or a low number of pollinators. Many native bee species (eg. bumble bees) pollinate lowbush blueberries; however in most years their populations are low and growers need to use rented pollinators (e.g. honeybees, alfalfa leaf cutter bees). In some areas, sufficient numbers of managed pollinators are unavailable.

Temperature extremes

Frost and cold temperatures during bloom (June) and prior to harvest later in the summer, can cause yield losses. Cold and windy conditions during the pollination season can also impact yields. During winter and spring, upper parts of plants can become desiccated due to cold temperatures, drying winds and insufficient snow cover. Wind breaks can be planted and snow fencing can be used to reduce wind and keep snow from blowing off fields. Dry, hot summers can also reduce yields by as much as 50% and affect the quality of the remaining fruit. Recently, irrigation has been explored as a possible solution to this problem.

General Production Issues

1) Pest management in lowbush blueberry has undergone major changes in the last 10 years. There is a great need for additional basic research to refine pest management inputs, to develop management tools for new pests and to implement reduced risk programs.

2) More research is required to develop robust forecasting models and to commercialize these forecasting tools for blueberry producers.

3) Research is required to measure the response to pesticide inputs in a multi-component system that concurrently adjusts levels of other inputs such as pollination, fertility and pruning method. Evaluation of pesticide inputs must be done in multi-year trials covering both sprout year and crop year inputs.

4) Basic research is required on alternative methods of field sanitation or alternative strategies to reduce the need for pruning production fields by burning.

5) Continued work is required for the evaluation and registration of reduced risk pesticides on lowbush blueberry. The registration of new reduced risk pesticides is required to meet export requirements in both established and new markets and also will support other programs aimed at reducing the use of organophosphate insecticides and other older pesticide chemistries.

Diseases

Key Issues

- There is concern over the wide host range of *Botrytis cinerea* and implications for management, given the significant yield losses that this pathogen can cause.
- Further research is required on biological controls for botrytis blight and the use of bees as delivery agents.
- There is a need for the refinement of forecasting models for diseases such as monilinia and botrytis blights.
- The evaluation and registration of fungicides with different modes of action from those currently registered, are required for diseases including monilinia.
- Further research on the biology, yield impact and benefits of disease management is required for diseases such as red leaf, leaf rust and septoria leaf spot. Yield benefits must be evaluated in relation to pruning method, fertility inputs, pollinator services and other components of the production system.

Table 4. Occurrence of diseases in lowbush blueberry production in Canada by province[1, 2]

Disease	Québec	Nova Scotia	New Brunswick	Prince Edward Island
Botrytis blight				
Godronia canker				
Phomopsis canker				
Leaf rust				
Septoria leaf spot				
Valdensinia leaf spot				
Monilinia blight				
Powdery mildew				
Red leaf				
Witches' broom				

Widespread yearly occurrence with high pest pressure.

Widespread yearly occurrence with moderate pest pressure, OR localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure.

Widespread yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with moderate pressure OR sporadic localized occurrence with high pressure.

Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low pressure OR localized sporadic occurrence with low to moderate pest pressure OR pest not of concern.

Pest not present.

Data not reported.

[1]Source: Lowbush blueberry stakeholders in reporting provinces.

[2]Please refer to Appendix 1, for a detailed explanation of colour coding of occurrence data.

Table 5. Adoption of disease management practices for lowbush blueberry in Canada[1]

Practice / Pest		Botrytis blight	Monilinia blight	Septoria leaf spot	Valdensinia leaf spot	Leaf rust	Godronia canker	Powdery mildew
Avoidance	resistant varieties							
	planting / harvest date adjustment							
	crop rotation							
	choice of planting site							
	optimizing fertilization							
	reducing mechanical damage or insect damage							
	thinning / pruning							
	use of disease-free seed, transplants							
Prevention	equipment sanitation							
	mowing / mulching / flaming							
	modification of plant density (row or plant spacing; seeding rate)							
	seeding / planting depth							
	water / irrigation management							
	end of season crop residue removal / management							
	pruning out / elimination of infected crop residues							
	tillage / cultivation							
	removal of other hosts (weeds / volunteers / wild plants)							
Monitoring	scouting - trapping							
	records to track diseases							
	soil analysis							
	weather monitoring for disease forecasting							
	grading out infected produce							
Decision making tools	economic threshold							
	weather / weather-based forecast / predictive model							
	recommendation from crop specialist							
	first appearance of pest or pest life stage							
	observed crop damage							
	crop stage							
	calendar spray							
Suppression	pesticide rotation for resistance management							
	soil amendments							
	biological pesticides							
	controlled atmosphere storage							

Practice / Pest		Botrytis blight	Monilinia blight	Septoria leaf spot	Valdensinia leaf spot	Leaf rust	Godronia canker	Powdery mildew
Crop specific practices	pruning by mowing or burning (lowbush blueberry)	(green)	(green)	(green)	(green)	(green)	(green)	(green)
New Practices (province)	GPS precision agriculture (New Brunswick)	(green)	(green)	(green)	(green)	(green)	(red)	(red)
	Sickle bar mowing pre-burn treatment (Prince Edward Island)	(green)	(green)	(green)	(green)	(green)	(green)	(green)

This practice is used to manage this pest by at least some growers in the province. (green)

This practice is not used by growers in the province to manage this pest. (red)

This practice is not applicable for the management of this pest. (white)

Information regarding the practice for this pest is unknown. (grey)

[1]Source: Lowbush blueberry stakeholders in producing provinces (Quebec, Nova Scotia, New Brunswick and Prince Edward Island).

Table 6. Fungicides and bactericides registered for disease management in lowbush blueberry production in Canada

Active ingredient[1,2]	Classification[3]	Mode of action[3]	Target site[3]	Resistance group[3]	Re-evaluation status[4]	Targeted pests[5]
Agrobacterium radiobacter	biological	unknown	unknown	N/A	R	crown gall
Bacillus subtilis	Bacillus subtilis and the fungicidal lipopeptides they produce	F6: lipids and membrane synthesis	microbial disrupters of pathogen cell membranes	44	R	grey mould, mummy berry, bacterial blight
boscalid	pyridine carboxamide	C2. respiration	complex II: succinate-dehydro-genase	7	R	grey mould, anthracnose (*Colletotrichum* spp.)
boscalid + pyraclostrobin	pyridine carboxamide + methoxy-carbamate	C2. respiration + C3. respiration	complex II: succinate-dehydro-genase + complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene	7 + 11	R	valdensinia leaf spot (suppression), septoria leaf spot (suppression)
captan	phthalimide	multi-site contact activity	multi-site contact activity	M4	R	fruit rot, mummy berry *Monilinia vaccinii-corymbosa*
chlorothalonil	chloronitrile (phthalonitrile)	multi-site contact activity	multi-site contact activity	M5	R	alternaria fruit rot, anthracnose fruit rot, phomopsis canker
chlorothalonil (sprout year)	chloronitrile (phthalonitrile)	multi-site contact activity	multi-site contact activity	M5	R	phomopsis canker; leafspot diseases (suppression only) including: septoria leaf spot, rust (*Naohidemyces vaccinii*), valdensinia leaf spot

Active ingredient[1,2]	Classification[3]	Mode of action[3]	Target site[3]	Resistance group[3]	Re-evaluation status[4]	Targeted pests[5]
cyprodinil + fludioxonil	anilino-pyrimidine + phenylpyrrole	D1: amino acids and protein synthesis + E2: signal transduction	methionine biosynthesis (proposed) (cgs gene) + MAP/ histidine-kinase in osmotic signal transduction (os-2,HOG1)	9 + 12	R	anthracnose (*Colletotrichum acutatum*), botrytis fruit rot
fenhexamid	hydroxyanilide	G3: sterol biosynthesis in membranes	3-keto reductase, C4-demethylation (erg27)	17	R	grey mould
ferbam	dithio-carbamate and relatives	multi-site contact activity	multi-site contact activity	M3	R	blossom blight, *Botrytis* spp. (general), twig blight
fluazinam	2,6-dinitroaniline	C5. respiration	uncouplers of oxidative phos-phorylation	29	R	fruit anthracnose (*Colletotrichum gloeosporioides* and *C. acutatum*), phomopsis fruit rot, mummy berry (suppression)
fludioxonil + cyprodinil (see above)						
propiconazole	triazole	G1: sterol biosynthesis in membranes	C14- demethylase in sterol biosynthesis (erg11/cyp51)	3	R	monilinia blight

Active ingredient[1,2]	Classification[3]	Mode of action[3]	Target site[3]	Resistance group[3]	Re-evaluation status[4]	Targeted pests[5]
prothioconazole	triazole	G1: sterol biosynthesis in membranes	C14- demethylase in sterol biosynthesis (erg11/cyp51)	3	R	blueberry leaf rust (*Thekopsora minima*) (suppression), septoria leaf spot (suppression)
pyraclostrobin	methoxy-carbamate	C3. respiration	complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	11	R	anthracnose
pyraclostrobin + boscalid (see above)						
thiophanate-methyl	thiophanate	B1: mitosis and cell division	ß-tubulin assembly in mitosis	1	RE	blossom blight, twig blight
triforine	piperazine	G1: sterol biosynthesis in membranes	C14- demethylase in sterol biosynthesis (erg11/cyp51)	3	R	mummy berry

[1]Registrations confirmed on the PMRA Registered Products Database (www.hc-sc.gc.ca/cps-spc/pest/index-eng.php) March 13, 2012.

[2] Not all end use products containing this active ingredient may be registered for use on this crop. The information in these tables should not be relied upon for pesticide application decisions. Individual product labels must be consulted for up to date, accurate information concerning the use of these pesticides and specific registration details.

[3]Source: FRAC Code List: Fungicides sorted by mode of action (including FRAC code numbering) published by the Fungicide Resistance Action Committee (February 2011) (www.frac.info/frac/index.htm).

[4]PMRA re-evaluation status as of **March 31, 2011**: R – full registration, RE (yellow) – under re-evaluation, DI (red) – discontinued by registrant, PO (red) – being phased out as a result of re-evaluation.

[5] Please consult the pesticide label for a detailed listing of pests controlled by products containing each active ingredient. Information on registered pesticide uses is also available from the PMRA Registered Products Database (www.hc-sc.gc.ca/cps-spc/pest/index-eng.php).

Botrytis blight (*Botrytis cinerea*)

Pest information

Damage: Botrytis blight can be a serious problem during bloom. Although botrytis is a sporadic pest, yield loss can be severe in some seasons. The pathogen attacks blossoms, fruit and leaves and causes symptoms similar to monilinia blight.

Life cycle: The fungus overwinters on infected weeds. In the spring, the pathogen produces spores that are blown by wind to blueberry blossoms. Infected tissues turn brown and become covered with a gray mold and spores. Spores are blown by wind to other susceptible tissues where they cause infection. The number of disease cycles and the severity of infection is associated with the number of wet periods during bloom and shortly thereafter. Later, infected petals may drop and establish new infection sites. Infected leaves change colour and develop gray mould that contaminates fruit through direct contact. Early-blooming blueberry clones are the first to be infected and they are the source of spores for later flowering clones. Spore populations reach a peak during spring and remain high throughout the summer, even though blueberry tissues are no longer susceptible. Few spores are produced on blueberry debris from the previous year, making weeds an important source of initial inoculum. Frost and herbicide damage increase the susceptibility of the weeds and the blueberry bushes to the disease.

Pest management

Cultural controls: Pruning by burning every second or third crop cycle may reduce some overwintering inoculum of *B. cinerea*. Weeds within and around blueberry fields should be controlled. Potential host weeds include bunchberry, sheep sorrel, goldenrod, pearly everlasting, *Potentilla* spp. and some grasses. Monitoring of early flowering clones for infections of *B. cinerea* helps determine if sprays are necessary. Changes in weather patterns in recent years have resulted in changes in the distribution of botrytis blight and a need to expand the monitoring and controls for this disease outside of traditional botrytis areas. Additional management practices for botrytis blight are listed in table 5.

Resistant cultivars: Not applicable.

Chemical controls: There are several registered products and some that have a reduced risk profile. Fungicides are applied if the disease is evident at mid bloom and wet conditions are predicted. Sprays are conducted at 7-10 day intervals if damp weather persists through the bloom period.

Issues for botrytis blight

1. There is concern over the wide host range of *Botrytis cinerea* and implications for management, given the significant yield losses that this pathogen can cause.
2. The biopesticide currently registered on blueberry for botrytis management is not economically effective. More research is required on biological control agents applied alone or in combination. Bee delivery of bio-control agents for this disease has potential benefits and needs to be commercialized.
3. Additional refinement of the forecasting model for botrytis is required. The model needs to include pre-bloom variables and the forecasting model, including hardware, needs to be commercialized for grower use. For maximum benefit this unit should also include forecasting for other blueberry pests including; monilinia blight, septoria leaf spot, leaf rust, flea beetle, blueberry fruit fly and spanworms.

Godronia canker (*Godronia cassandrae*)

Pest information

Damage: Infections by *Godronia cassandrae* during late May to early June cause tip dieback, stem lesions and dieback of stem parts above the lesion. This is a yield reducing disease and it is believed that there is a direct correlation between the percentage of infected stems and crop losses. Infections during mid-summer (July) lead to the production of undersized fruits.

Life cycle: The fungus overwinters in cankers on stems and crowns of infected plants as pycnidia. Conidia, produced in the pycnidia, are released and splashed onto healthy stems by rain. The disease cycle starts at about bud-break in the spring and new infections continue to occur throughout the growing season each time it rains, until the fall. Conidia infect current year stems as well as 2-year old stems. Lesions of godronia canker grow larger year by year and may ultimately girdle the stems.

Pest management

Cultural controls: Pruning and destroying infected branches is the main control for godronia canker. Monitoring of fruiting fields is done in early July. Burning as a pruning method destroys diseased stems that are sources for new infections. Mowing should not be done before burning. Additional management practices for godronia canker are listed in table 5.

Resistant cultivars: Not applicable.

Chemical controls: None available.

Issues for godronia canker

1. There are no chemical treatments available for godronia canker.

Leaf rust (*Naohidemyces vaccinii*)

Pest information

Damage: Leaf rust is a very common disease of lowbush blueberry. Severe outbreaks can cause extensive defoliation in sprout fields. Leaves develop small, reddish spots on the upper leaf surface that may coalesce into larger spots. Small, water-soaked spots appear on the lower leaf surface, with yellow-orange pustules appearing in these lesions. Premature defoliation from rust impacts fruit bud development. Leaves begin to fall in response to rust infection in late summer and early fall.

Life cycle: Hemlock (*Tsuga* spp.) serves as an alternate host for this fungus. Leaf rust probably also cycles on blueberry alone since the fungus has been found on blueberry when hemlock has been absent from the area. Symptoms of leaf rust can be observed in sprout fields from late July through September.

Pest management

Cultural controls: None identified.

Resistant cultivars: Not applicable, although there is clonal variation in susceptibility.

Chemical controls: Fungicides are currently used for the control of leaf rust in the sprout year (refer to table 6). Disease suppression is achieved with a single application and good control is possible with multiple applications.

Issues for leaf rust

1. The yield benefit of leaf rust control has not been adequately quantified, especially when considered in relation to other production inputs.
2. The impact of current production practices such as pruning and fertilization on leaf rust is unknown.

Monilinia blight (*Monilinia vaccinii-corymbosi*)

Pest information

Damage: Monilinia blight is common in many production areas and can be destructive in seasons with extended wet periods. Fields with heavy soil or poor drainage are prone to the disease. The pathogen infects leaves, blossoms and fruit, causing leaves to wilt and blossom clusters to shrivel. Infected fruit shrivel and harden several weeks before harvest, developing into black fungal masses known as mummy berries.

Life cycle: The fungus overwinters in the form of mummy berries. Field frost, even for an hour, dramatically increases the susceptibility of buds to infection. During bud break, mummy berries germinate to produce apothecia, structures that develop primary spores (ascospores). Under cool and wet conditions, these spores infect the vegetative and floral buds, with symptoms appearing in 10-20 days. Secondary spores (conidia) produced on the diseased tissues are then carried by wind or pollinating insects to infect new plants. Fruits remain symptom-less until they are almost mature, at which time they drop to the ground and the fungus completes its life cycle.

Pest management

Cultural controls: Pruning by burning helps destroy mummy berries. Flail mowing does not destroy the mummies and may result in increased levels of the disease. A strategy has been developed based on air temperature and leaf wetness that rates the likelihood of infection during different periods of time. Monitoring temperature and leaf wetness and spraying only when the risk of infection is high is recommended.

Resistant cultivars: Not applicable.

Chemical controls: The decision to spray depends almost entirely on the past history of the disease in a particular field. If growers have experienced a problem with monilinia blight in the past, they monitor for the disease and apply chemical controls if required. Spray programs target ascospore infections which reduces the production of conidia and secondary spread.

Issues for monilinia blight

1. Further refinement of the forecasting model for monilinia is needed. The model needs to include pre-bud break variables and it needs to be commercialized for grower use.
2. All economically effective fungicides registered for management of monilinia blight on blueberry utilize a similar mode of action (DMI, demethlyation inhibitors). The evaluation and registration of new fungicides with a different mode of action is required for effective resistance management. Label expansion for products used in the crop year will also require the development of MRLs in export markets.

Phomopsis canker (*Phomopsis vaccinii*)

Pest information

Damage: Phomopsis canker is found in sprout fields from late July until the end of September. Disease lesions appear as elongated, flattened cankers on stem bases and cause the stems to drop off. Phomopsis can be devastating to bushes in low areas where winter injury and spring frosts are a problem. However, the disease is not as common in fruiting fields, where it might be confused with godronia canker.

Life cycle: Conidia are spread by splashing rain throughout the growing season from bud break through September. Injuries from mechanical damage, winter stresses or spring frost are necessary for phomopsis infection because wounded tissues serve as entry points for conidia. Wounds from mechanical harvesting or pruning may also facilitate infections. Stems infected in the growing season wilt during the summer months.

Pest management

Cultural controls: Monitoring of fields for phomopsis is done in early September of the sprout year. Pruning by burning is assumed to reduce disease incidence. Careless pruning, cultivating and fertilization late in the summer should be avoided to minimize mechanical injury to the plants. Keeping the plants well watered through prolonged periods of dry weather in the summer and avoiding stress also helps to prevent this disease.

Resistant cultivars: Not applicable.

Chemical controls: Fungicides registered for the control of phomopsis canker are listed in table 6.

Issues for phomopsis canker

1. The proper timing of fungicide applications to manage phomopsis canker in lowbush blueberry is not well known

Powdery mildew (*Microsphaera penicillata var. vaccinii*)

Pest information

Damage: Powdery mildew is very common and may cause premature leaf drop in both crop and sprout fields. Some clones show irregular, reddish patches on the leaves, while others show abundant, white, mycelial growth. Early leaf drop may cause poor fruit bud development in sprouts and reduced yields in crop fields.

Life cycle: The fungus probably overwinters in infected leaves. First symptoms appear in early July, resulting from infections that took place 2-3 weeks previously. Further infections occur as the season progresses. Powdery mildew tends to be more serious on light, sandy and gravelly soils and during hot, dry summers. Phosphorous deficiency may increase powdery mildew severity.

Pest management

Cultural controls: Pruning by burning may reduce inoculum.

Resistant cultivars: Not applicable. There is clonal variation in susceptibility to powdery mildew.

Chemical controls: Powdery mildew is suppressed by fungicide applications for leaf rust and septoria leafspot. At this time, specific fungicide sprays for powdery mildew control are not applied.

Issues for powdery mildew

None identified.

Red leaf (*Exobasidium vacinii*)

Pest information

Damage: Red leaf has a systemic distribution within the plant tissues and results in reduced plant vigour and yield. Infected plants may fail to flower and do not produce much fruit. By midsummer, infected leaves drop and the disease becomes inconspicuous. Symptoms re-appear on the same plants each year until the plants weaken and die.

Life cycle: The fungus overwinters in the shoots and rhizomes of blueberry plants, infecting new sprouts as they arise from the mother plant. Infected leaves turn red and the fungus develops spore-bearing structures on their lower surface. The role of the spores in spreading the disease is unknown. It is assumed that field infections through spores only take place under extended wet conditions.

Pest management

Cultural controls: The practice of burn pruning does not control rhizome infections but may destroy new infections in the shoots that have not yet progressed into the rhizome.

Resistant cultivars: Not applicable.

Chemical controls: In fields where red leaf is a problem, diseased plants should be eradicated by spot spraying with a recommended herbicide in the sprout year. Even a low incidence of red leaf is often sufficient for the spread of the disease throughout the field.

Issues for red leaf

1. There are no known effective treatments for red leaf. The industry-wide impact of this disease is minor, but yield reduction does occur in some production regions. More research on the biology and yield impact of this disease is required.
2. Information on the potential for fungicides for the management of red leaf is required.

Septoria leaf spot (*Septoria* sp.)

Pest information

Damage: Symptoms develop on the lower leaf surface and appear as small water-soaked lesions similar to early rust symptoms. The lesions later coalesce to produce irregular, brown blotches on leaf surfaces. Septoria may cause defoliation in both crop and sprout fields. This affects fruit bud development in the sprout year and reduces yield in the crop year.

Life cycle: The fungus overwinters on infected leaves and twigs. Spores are released from late May to the end of June (in Nova Scotia). Septoria leaf spot severity is dependent upon the number of wet periods that occur during this time. There may be more than one species involved with this disease.

Pest management

Cultural controls: Pruning by burning reduces inoculum.

Resistant cultivars: Not applicable, although there is clonal variation in susceptibility to septoria leaf spot.
Chemical controls: Fungicides are available for use in the sprout year for disease suppression only.

Issues for septoria leaf spot

1. More research is required on the yield benefit resulting from controlling septoria leaf spot in both the sprout and cropping years. In addition, the yield benefit must be evaluated in a production system that includes pruning method, fertility inputs, pollinator services and leaf rust control.

Valdensinia leaf spot (*Valdensinia heterodoxa*)

Pest information

Damage: This leaf spot has recently been identified in Nova Scotia and PEI. It is relatively common and during very wet seasons, may cause severe defoliation in both crop and sprout fields. The fungus produces large, reddish-brown spots up to 1cm or more in diameter. Infected leaves drop soon after symptom development.
Life cycle: The fungus overwinters as sclerotia in infected leaves. In the spring, tiny apothecial cups form on infected leaves and release ascospores during wet conditions. Infected leaves drop quickly. Secondary infections are caused by large conidia that spread to the foliage canopy from fallen, infected leaves. Often a single spore can be seen in the middle of a necrotic spot. This fungus can be spread from field to field on equipment, boots, etc. Other hosts of valdensinia have been found around blueberry fields. These include wild raspberry, birch saplings, bunchberry, maple saplings and wild strawberry.

Pest management

Cultural controls: Pruning by burning will reduce inoculum. Cleaning equipment and boots between fields will help reduce spread.
Resistant cultivars: There has been no clonal variation in susceptibility observed.
Chemical controls: Fungicides are available for use in the sprout year for disease suppression only.

Issues for valdensinia leaf spot

1. The impact of current production practices including pruning by mowing, fertilization and sanitation on valdensinia leaf spot incidence and spread requires further research.

Witches' broom (*Pucciniastrum goeppertianum*)

Pest information

Damage: Infected plants develop broom-like masses of shoots with few or no leaves and do not produce fruit. Symptoms appear the year following infection and persist for many years. New, infected growth is produced each spring.
Life cycle: From mid-May to late June, rust spores (teliospores) develop on infected shoots and germinate to produce another type of spore (basidiospore). These spores are carried by wind to balsam fir trees that serve as alternate hosts and where another type of spore (aeciospore)

is formed. These spores are then wind-blown back to the blueberry plants where they germinate on leaves and stems, stimulating the production of lateral buds that develop into the characteristic, broom-like swollen shoots. This phase takes place during mid to late summer. Finally, teliospores are formed on the swollen, broom-like shoots of blueberry plants and overwinter there. The brooms are perennial and produce new growth each spring, serving as sources of the fungus for many years. As infected plants have been reported in areas remote from balsam fir, basidiospores produced on blueberry may directly infect other blueberry plants without the need for an alternate host. However, this hypothesis is yet to be confirmed.

Pest management

Cultural controls: Infected blueberry plants are removed. Due to the systemic nature of the disease in crowns and rhizomes, burning or flail mowing does not eliminate the disease. Removal of the alternate host (balsam fir) within 400-500 yards of blueberry fields may be effective, but may not be practical as yield losses from the disease are very small.

Resistant cultivars: Not applicable.

Chemical controls: Infected blueberry plants are killed with a systemic herbicide to prevent the spread of the disease.

Issues for witches' broom

None identified.

Insects and Mites

Key Issues

- In some regions, blueberry flea beetle is the most damaging insect pest of lowbush blueberry. More research is required on the reduced risk management of this pest. The evaluation and registration of reduced risk, pollinator friendly, insecticides is required. The current predictive emergence model for blueberry flea beetle adults requires additional verification.
- Blueberry fruit fly is the major insect pest of lowbush blueberry. Control is important because this pest is a quarantinable insect in some export markets. In addition, as "direct to consumer" sales increase, the tolerance for insect infestation in the fruit declines to near zero tolerance.
- Blueberry fruit fly management is difficult with conventional insecticides, due in part to the difficulties in exporting the crop to foreign markets that have specific national residue import tolerances. The development of new resistance management tools is important, but must be done in conjunction with the development of export tolerances by the registrant.
- There are insufficient alternative controls for the blueberry sawfly.
- Emerging technologies such as light traps are showing promising results and may reduce the need for chemical controls for blueberry spanworm. Research is required to establish thresholds and to develop alternative monitoring methods.
- Blueberry stem gall wasp is a minor pest industry-wide, but galls can be a problem for processors. Field infestations can be high in production areas that are near processing plants or in fields which have been exclusively mechanically pruned for an extended number of years.
- Blueberry thrips are an increasing problem in some regions. The current recommended spray timing interval is very narrow and research is required to see if this interval can be extended with the newer chemistries now available to blueberry producers.
- There is a lack of pollinator friendly, reduced risk products registered for the control of the chainspotted geometer.
- Additional reduced risk alternatives are required for the whitemarked tussock moth.
- The red striped fireworm is an emerging problem as growers move away from burning to pruning by mowing.

Table 7. Occurrence of insect and mite pests in lowbush blueberry production in Canada by province[1, 2]

Pest	Québec	Nova Scotia	New Brunswick	Prince Edward Island
Blueberry case beetle				
Blueberry flea beetle				
Blueberry gall midge				
Blueberry leaftier				
Blueberry maggot				
Blueberry sawfly				
Blueberry spanworm and other spanworms				
Blueberry stem gall wasp				
Blueberry thrips (*Catinathrips kainos*)				
Blueberry thrips (*Frankliniella vaccinii*)				
Chainspotted geometer				
Gypsy moth				
Heath spittlebug				
Redstriped fireworm				
Whitemarked tussock moth				

Widespread yearly occurrence with high pest pressure.

Widespread yearly occurrence with moderate pest pressure, OR localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure.

Widespread yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with moderate pressure OR sporadic localized occurrence with high pressure.

Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low pressure OR localized sporadic occurrence with low to moderate pest pressure OR pest not of concern.

Pest is present and of concern, however little is known of its distribution, frequency and importance.

Pest not present.

Data not reported.

[1]Source: Lowbush blueberry stakeholders in reporting provinces.

[2]Please refer to Appendix 1 for a detailed explanation of colour coding of occurrence data.

Table 8. Adoption of insect and mite pest management practices for lowbush blueberry in Canada[1]

	Practice / Pest	Blueberry flea beetle	Blueberry gall midge	Blueberry leaftier	Blueberry maggot	Blueberry sawflies	Blueberry spanworms	Blueberry thrips	Heath spittle bug
Avoidance	resistant varieties								
	planting / harvest date adjustment								
	crop rotation								
	choice of planting site								
	optimizing fertilization								
	reducing mechanical damage								
	thinning / pruning								
	trap crops / perimeter spraying								
	physical barriers								
Prevention	equipment sanitation								
	mowing / mulching / flaming								
	modification of plant density (row or plant spacing; seeding rate)								
	seeding depth								
	water / irrigation management								
	crop residue removal / management								
	pruning out / removal of infested material								
	tillage / cultivation								
	removal of other hosts (weeds / volunteers / wild plants)								
Monitoring	scouting - trapping								
	records to track pests								
	soil analysis								
	weather monitoring for degree day modelling								
	grading out infected produce								
Decision making tools	economic threshold								
	weather / weather-based forecast / predictive model (eg. degree day modelling)								
	recommendation from crop specialist								
	first appearance of pest or pest life stage								
	observed crop damage								
	crop stage								
	calendar spray								

	Practice / Pest	Blueberry flea beetle	Blueberry gall midge	Blueberry leaftier	Blueberry maggot	Blueberry sawflies	Blueberry spanworms	Blueberry thrips	Heath spittle bug
Suppression	pesticide rotation for resistance management	green	green	green	green	green	green	green	green
	soil amendments	red	red	red	red	red	red	red	red
	biological pesticides	green	red	red	green	red	green	red	red
	arthropod biological control agents	red	red	red	red	red	red	red	red
	beneficial organisms and habitat management	green	green	green	green	green	green	green	green
	ground cover / physical barriers	red	red	red	red	red	red	red	red
	pheromones (eg. mating disruption)	red	red	red	red	red	red	red	red
	sterile mating technique	red	red	red	red	red	red	red	red
	trapping	red	red	red	green	red	green	red	red
Crop specific practices	pruning by mowing or burning (lowbush blueberry)	green	green	green	green	green	green	green	green
New practices (province)	Use of light traps for detection/control of spanworm adults (Prince Edward Island)						green		
	Sprout year monitoring for leaf tier (not susceptible), spray in spring of crop year when susceptible Prince Edward Island)			green					

This practice is used to manage this pest by at least some growers in the province. (green)

This practice is not used by growers in the province to manage this pest. (red)

This practice is not applicable for the management of this pest. (white)

Information regarding the practice for this pest is unknown. (grey)

[1]Source: Lowbush blueberry stakeholders in producing provinces (Quebec, Nova Scotia, New Brunswick and Prince Edward Island).

Table 9. Insecticides and miticides registered for pest management in lowbush blueberry in Canada

Active ingredient[1,2]	Classification[3]	Mode of action[3]	Resistance group[3]	Re-evaluation status[4]	Targeted pests[5]
acetamiprid	neonicotinoid	nicotinic acetylcholine receptor (nAChR) agonists	4A	R	blueberry maggot, blueberry spanworm (suppression only), blueberry flea beetle, cherry fruitworm, cranberry fruitworm, strawberry rootworm (adults), thrips
acetamiprid (bushberry group 13-07B)	neonicotinoid	nicotinic acetylcholine receptor (nAChR) agonists	4A	R	aphids
Bacillus thuringiensis subsp. *Kurstaki*	*Bacillus thuringiensis* or *Bacillus sphaericus* and the insecticidal proteins they produce	microbial disruptors of insect midgut membranes	11	R	blueberry spanworm (*Itame argillacearia*), chainspotted geometer, Rannoch looper (*Itame brunneata*), fruit-tree leafroller, European leafroller, obliquebanded leaf roller, three-lined leafroller
carbaryl	carbamate	acetylcholinesterase inhibitors	1A	R	blueberry maggot, Bruce spanworm, cranberry fruitworm, lecanium scale, leafrollers
deltamethrin	pyrethroid, pyrethrin	sodium channel modulators	3A	R	leaftier, Bruce spanworm
deltamethrin + imidacloprid	pyrethroid, pyrethrin + neonicotinoid	sodium channel modulators + nicotinic acetylcholine receptor (nAChR) agonists	3A + 4A	R	blueberry aphid
dimethoate	organophosphate	acetylcholinesterase inhibitors	1B	RE	blueberry maggot
imidacloprid + deltamethrin (see above)					

Active ingredient[1,2]	Classification[3]	Mode of action[3]	Resistance group[3]	Re-evaluation status[4]	Targeted pests[5]
malathion	organophosphate	acetylcholinesterase inhibitors	1B	R	aphids, blueberry maggot, cherry fruitworm, cranberry fruitworm, leafhoppers, leafrollers, rose chafer, thrips, spider mites, strawberry root weevil adults (BC only)
novaluron (crop group 13-07B bushberries)	benzoylurea	inhibitors of chitin biosynthesis, type 0	15	R	cherry fruitworm, cranberry fruitworm
permethrin (vegetative year only)	pyrethroid, pyrethrin	sodium channel modulators	3A	R	thrips
phosmet	organophosphate	acetylcholinesterase inhibitors	1B	RE	blueberry maggot, blueberry spanworm
spinetoram	spinosyn	nicotinic acetylcholine receptor (nAChR) allosteric activators	5	R	blueberry flea beetle, blueberry spanworm (suppression)
spinosad	spinosyn	nicotinic acetylcholine receptor (nAChR) allosteric activators	5	R	blueberry maggot, oblique banded leafroller, spanworm, winter moth, cabbage looper,blueberry flea beetle (suppression)
thiamethoxam	neonicotinoid	nicotinic acetylcholine receptor (nAChR) agonists	4A	R	weevils (*Otiorhyncus sulcatus*), weevils (*Sciopithes obscurus*)
trichlorfon	organophosphate	acetylcholinesterase inhibitors	1B	R	blueberry case beetle, blueberry flea beetle, blueberry sawfly, blueberry spanworm, currant spanworm, whitemarked tussock moth

[1]Registrations confirmed on the PMRA Registered Products Database (www.hc-sc.gc.ca/cps-spc/pest/index-eng.php) March 13, 2012.

[2] Not all end use products containing this active ingredient may be registered for use on this crop. The information in these tables should not be relied upon for pesticide application decisions. Individual product labels must be consulted for up to date, accurate information concerning the use of these pesticides and specific registration details.

[3]Source: IRAC MoA Classification Scheme (Volume 7.1, issued June 2011) published by the Insecticide Resistance Action Committee (IRAC) International MoA Working Group (www.irac-online.org).
[4]PMRA re-evaluation status as of **March 31, 2011**: R – full registration, RE (yellow) – under re-evaluation, DI (red) – discontinued by registrant, PO (red) – being phased out as a result of re-evaluation.
[5]Please consult the pesticide label for a detailed listing of pests controlled by products containing each active ingredient. Information on registered pesticide uses is also available from the PMRA Registered Products Database (www.hc-sc.gc.ca/cps-spc/pest/index-eng.php).

Blueberry case beetle (*Neochlamisus cribripennis*)

Pest information

Damage: The blueberry case beetle can cause considerable damage to lowbush blueberry fields. Both adults and larvae feed on leaves and if present in large numbers can cause severe defoliation. Adults feeding on the bark of stems cause the most serious damage, resulting in drying and winter kill. Damage is most serious in sprout fields or second crop fields, where a major portion of the crop can be lost during large outbreaks. Damage is not serious during the crop year in a two-year rotation, as plants are pruned.

Life cycle: The pest overwinters as adults in leaf litter under blueberry plants. Adult beetles emerge in May and lay eggs in mid-June. The eggs hatch in about 10 days and emerging larvae feed mostly on the leaves of blueberries. Larvae go through three instars and pupate from late July to early August. The egg, larva and pupa are each enclosed in a bell-shaped case. The pupal stage lasts from 4 to 5 weeks and emerging adults of the second generation remain active until November.

Pest management

Cultural controls: Pruning by burning may reduce populations. Several species of wasp are parasites of the pest. Usually, pest populations are kept low by the parasites and control is not necessary. Weekly sampling with an insect sweep net is most important in sprout fields, where adult activity in the fall can cause severe damage. Although action thresholds have not been established, a level of 20 larvae per sample should prompt control measures.

Resistant cultivars: Not applicable.

Chemical controls: None available.

Issues for blueberry case beetle

None identified.

Blueberry flea beetle (*Altica sylvia*)

Pest information

Damage: The blueberry flea beetle can cause severe defoliation if it is present in large numbers. Both adults and larvae feed on blueberry foliage. Outbreaks develop in late May or early June and can occur in the crop or sprout year. If not controlled, these outbreaks can cause severe losses in plant emergence in the sprout year and growth, affecting plant height.

Life cycle: The eggs of the flea beetle overwinter in leaf litter and hatch in May when the leaves begin to unfold. The larvae go through three instars before pupating in the soil. Adults emerge from pupae in late June, lay eggs in late July and are present until late August.

Pest management

Cultural controls: Fall or spring burning will help control the flea beetle population, as the eggs overwinter in the leaf litter. Most outbreaks occur in mechanically pruned fields. In both crop and sprout fields, weekly samplings using a sweep net should be done. Although an action threshold has not been established, 3-5 larvae per sweep should prompt a subsequent check for signs of defoliation and may signal the need for control measures.

Resistant cultivars: Not applicable.

Chemical controls: Refer to table 9 for insecticides registered for blueberry flea beetle. As most outbreaks occur during the bloom period, the safety of pollinators must be taken into account and sprays need to be timed so that beneficial insects are not harmed.

Issues for blueberry flea beetle

1. In some regions, blueberry flea beetle is the most damaging insect pest of lowbush blueberry. More research is required on the reduced risk management of this pest.
2. The evaluation and registration of reduced risk, pollinator friendly, insecticides is required. The work that has been done on sprout year control should be continued and communicated to producers.
3. The current predictive emergence model for blueberry flea beetle adults requires additional verification. Pest forecasting models including hardware need to be commercialized for use by producers.

Blueberry fruit fly (maggot) (*Rhagoletis mendax*)

Pest information

Damage: The blueberry fruit fly is recognized as the most important insect pest of lowbush blueberry. Although direct losses of fruit are of minimal economic importance, there is a zero tolerance for fruit fly larvae in some export markets. The presence of larvae at low levels in harvested fruit greatly reduces the commercial value of the crop. The pest consumes the inner parts of the berry, resulting in shrivelling and premature dropping from the plant.

Life cycle: Adult flies emerge from soil from late June to early August, and live for approximately 30 days. Females can each lay up to 100 eggs, usually leaving only one egg per berry. Larvae develop inside fruits, causing them to shrivel and drop prematurely. A small portion of the infested berries remain on the plant and are harvested. The pupa is formed in the soil and typically emerges the following year, with some emerging 2-4 years later.

Pest management

Cultural controls: Dividing fields into crop and non-crop sections should be avoided as the majority of adult flies emerge during the non-crop year in a two-year cropping system. Debris from winnowing piles should be destroyed or buried, especially if field cleaning is done. Heavily infested berries should not be left unpicked, but disposed of to reduce re-infestation. Weed control around the outer edges of the field forces the fruit fly to lay eggs away from the field and decreases the overall fly population. Monitoring is done using yellow coloured sticky traps placed in the outer margin of the field. Traps should be checked three times a week and records should be kept throughout the season. The action threshold has been set at one captured fly due to the intolerance for the pest in export markets. Monitoring should continue after the threshold has been reached to allow for the evaluation of the effectiveness of the insecticide spray and to determine the need for a second spray application.

Resistant cultivars: Not applicable.

Chemical controls: Insecticides are applied within 7-10 days, once the action threshold is reached. A second spray is occasionally necessary.

Issues for blueberry fruit fly

1. There is a need for research on alternatives to conventional insecticide management for the blueberry fruit fly. This research can build on some of the alternatives already evaluated including perimeter spraying, improved GF-120 formulation, pheromones and sprout year control.
2. Blueberry fruit fly is the major insect pest of lowbush blueberry. Control is important because this pest is a quarantinable insect in some export markets. In addition, as "direct to consumer" sales increase, the tolerance for insect infestation in the fruit declines to near zero tolerance.
3. Blueberry fruit fly management is difficult with conventional insecticides, given the timing of sprays late in the production cycle. This increases the difficulties in exporting the crop to foreign markets that have specific national residue import tolerances. The development of new resistance management tools is important, but must be done in conjunction with the development of export tolerances by the registrant.
4. There is concern about the potential loss of currently registered products. However, many older chemistries lack import tolerances in blueberry export markets and therefore cannot be used in production even if currently registered in Canada. In any efforts to extend the registration of older chemistries, export tolerances should be considered along with other considerations such as occupational exposure of blueberry workers.

Blueberry leaftier (*Croesia curvalana*)

Pest information

Damage: Young larvae of the blueberry leaftier can cause severe damage by feeding on developing flower buds, with up to 20% of the buds being affected. Older larvae cause damage by feeding on leaves and flowers. Defoliation can be close to 100% if the outbreak is severe. Blueberry leaftier is an insect of increasing concern.

Life cycle: The pest overwinters as eggs on leaf litter around blueberry plants. Eggs hatch from April to May. Larvae feed on buds, young leaves and flowers and form a protective shelter of leaves and silk when molting. Larvae pupate within these shelters during June. Adult moths emerge from the pupae in early to late July and lay eggs on the leaf litter from late July to early August.

Pest management

Cultural controls: Burning can help reduce moth numbers in the sprout year. Pheromone traps for adults have been developed to determine if a field requires a spray to control larvae the following spring. However, this pheromone is not available commercially.

Resistant cultivars: Not applicable.

Chemical controls: Refer to table 9 for insecticides registered for leaftier. Applications are directed at the larval stages with timing based on flower bud development stage, which corresponds to egg hatch in the field. The timing of controls is critical to the management of this pest.

Issues for blueberry leaftier

None identified.

Blueberry gall midge (cranberry tipworm) (*Dasineura oxycoccana*)

Pest information

Damage: Blueberry gall midge larvae feed on the terminal growth of vegetative shoots, causing premature budbreak and excessive branching. Plants may recover from early feeding with greater potential for damage due to feeding later in the year.

Life Cycle: The blueberry gall midge overwinters in the soil. First generation females emerge in the spring, mate and lay eggs in buds. Following hatching, larvae feed within buds for up to 10 days. Larvae develop through three instars and, when mature, drop to the ground to pupate. The next generation adults emerge soon after. There are multiple generations per year.

Pest Management

Cultural Controls: This insect prefers lush growth so the application of high nitrogen fertilizers should be avoided.

Resistant Cultivars: Not applicable.

Chemical Controls: None available.

Issues for blueberry gall midge

1. There is insufficient information available on the biology, distribution and potential impact of the blueberry gall midge in lowbush blueberry.
2. There is a need for further research on pest management approaches and the registration of reduced risk insecticides.

Blueberry sawfly (*Neopareophora litura*)

Pest information

Damage: Blueberry sawfly larvae feed on leaves and may cause defoliation if present in large numbers. Infestations are usually confined to isolated areas within a field.

Life cycle: Adult sawflies lay eggs in May inside developing leaf whorls. Larvae feed on young and mature foliage until late June. Then they move to the ground litter, spin cocoons and overwinter. Pupation takes place the next spring and adults emerge within two weeks.

Pest management

Cultural controls: Pruning by burning will not have a huge effect on sawfly as pupae are often deeper in the soil than other insect pests and are thus more protected. Several parasitic wasps (Ichneumonid) are active in blueberry fields and help to keep the populations of sawfly low. Parasites may not control an outbreak early enough to reduce economic damage. Weekly sampling in crop fields using a sweep net should be done. Although no action threshold has been established, 3-5 larvae per sweep should prompt a check for signs of defoliation and may indicate that control measures are needed.

Resistant cultivars: Not applicable.

Chemical controls: Refer to table 9 for insecticides registered for leaftier. Trichlorfon is registered to control the blueberry sawfly, but generally not used as there is no MRL established for the US. As most outbreaks occur during the bloom period, safety of pollinators must be taken into account and sprays need to be timed to avoid harm to beneficial insects.

Issues for blueberry sawfly

1. There are insufficient alternative controls for the blueberry sawfly.

Blueberry spanworm (*Itame argillacearia*) and other spanworms

Pest information

Damage: Caterpillars of several species of spanworm moths feed on the foliage of lowbush blueberry. Plants can be completely defoliated if the outbreak is severe. In fields that are sprouting, the pest can consume the new growth. In the past, these insects have been kept under control as the overwintering eggs were destroyed by burning. In recent years, mowing has replaced burning and the number of spanworm outbreaks has increased.

Life cycle: The pest overwinters as eggs in the litter around the base of plants. The eggs hatch and larvae emerge when the new sprouts begin to grow in late May. The larvae feed most actively on leaves and buds at night. During the day, the larvae drop to the ground and hide in leaf litter. Feeding continues until late June or early July at which time the larvae pupate in the soil. Adult moths emerge in late July and lay eggs on leaves or on the ground.

Pest management

Cultural controls: Burning can reduce the number of spanworms in the field. Several species of parasitic wasp attack the blueberry spanworm and help to control the population. Weekly monitoring is done during May and June using a sweep net. Action thresholds have been set at 7 spanworms per 25 sweeps on sprout fields and 12 spanworms per 25 sweeps on crop fields.

Resistant cultivars: Not applicable.

Chemical controls: Insecticide treatments are necessary when the level of spanworms exceeds the action threshold. Insecticides registered for the control of spanworms are listed in table 9.

Issues for blueberry spanworm

1. Emerging technologies such as light traps are showing promising results and may reduce the need for chemical controls for blueberry spanworm. Research is required to establish thresholds and to develop alternative monitoring methods.

Blueberry stem gall wasp (*Hemadas nubilipennis*)

Pest information

Damage: Blueberry stem gall is caused by the reaction of the plant to egg laying and larval feeding of a chalcid wasp. Galls appear as irregular growths on the stems of the plant. Tissue at the tip of the stem is destroyed, stopping the formation of fruit buds on affected stems. If this damage occurs during the vegetative year, yield can be reduced the following year. The mechanism of the effect of galls on yield is not well understood. Galls can also break off the stem during harvesting, pass through the processing line and end up as foreign objects in the finished product. This type of damage has become more of a concern in recent years. The buildup of galls over several years can lead to a more serious impact. Blueberry stem gall wasp is a minor pest industry-wide, but galls can be a problem for processors. Field infestations can be high in production areas that are near processing plants or in fields which have been exclusively mechanically pruned for an extended number of years.

Life cycle: Adults are almost all females. They emerge from galls from May to June before the buds break and lay eggs in developing shoots. The process of egg laying induces abnormal tissue growth, resulting in a chamber being formed around each egg. Eggs hatch in two weeks and larvae feed inside the chamber, further stimulating the growth of the plant tissue. Eventually a gall is formed around several feeding larvae. The larvae overwinter inside the gall, pupate the following spring and emerge from the galls as adults. Most of the galls (up to 70%) are found on stems within the leaf litter and only a few of them are formed on stems above the surface.

Pest management

Cultural controls: Burning of the plants may have some effect. There are a number of species of wasps, including parasitic wasps, which use the galls formed by the blueberry stem gall wasp. The effect of these wasps on stem gall wasp populations is not known, although high levels of parasitism (more than 50%) have been recorded.

Resistant cultivars: Not applicable.

Chemical controls: None available.

Issues for blueberry stem gall

None identified.

Blueberry thrips (*Frankliniella vaccinii* and *Catinathrips kainos*)

Pest information

Damage: Thrips feed on leaves, causing them to curl tightly and wrap around the stem. In sprout fields, damage is only visible the following spring on leaves that remain attached to the plant. In crop fields, growing leaves do not unfold normally and resemble enlarged buds. Most infestations are localized, but sometimes large infestations of several hectares can occur. Infested plants are more susceptible to winter injury and produce less fruit. Yields may be reduced by 50% or more.

Life cycle: The two species attacking lowbush blueberries have a similar appearance and life cycle. The adult females of the second generation overwinter in the soil and emerge from the ground in April and May. Females lay eggs in leaf tissues from May to June. Emerging larvae and adults feed on blueberry leaves by sucking sap, causing the leaves to curl. These curled leaves provide shelter for the thrips population. The pre-pupal and pupal stages are inactive. Adults of the first generation appear in late July and a second generation starts two weeks later.

Pest management

Cultural controls: It is recommended that curled leaves be burned as soon as they are noticed in the spring. Burning later in the summer is less effective as the thrips may have left the plants. Inspections for the presence of thrips and damage should begin in early June. Infested areas should be treated the following spring, when the plants are small and the overwintered adults first appear.

Resistant cultivars: Not applicable.

Chemical controls: Pesticides registered for the control of thrips are listed in table 9. The timing of application is very important.

Issues for thrips

1. Blueberry thrips are an increasing problem in some regions. The current recommended spray timing interval is very narrow and research is required to see if this interval can be extended with the newer chemistries now available to blueberry producers.

Chainspotted geometer (*Cingilia catenaria*)

Pest information

Damage: The chainspotted geometer feeds on a wide variety of plants including blueberry and cranberry. Most of the damage is done by the later instar larvae which consume both leaves and fruit. When larvae are numerous, large areas may be completely defoliated. Outbreak levels are rare and tend to be quite patchy in distribution throughout the field.

Life cycle: The adult moths emerge in early September and are present until mid-October. They begin egg laying shortly after they emerge. The eggs are loosely attached to the underside of leaves of the host plant. In blueberry fields, sweet fern (*Comptonia peregrina*) is the preferred host plant, but other plants are utilized if sweet fern is not present. The eggs overwinter and begin hatching in early June. The newly hatched larvae skeletonize the leaves. As the larvae become larger, the entire leaf is eaten. There are five larval instars. Pupation takes place in the leaf litter from August to early September and takes between 32 and 48 days to complete.

Pest management

Cultural controls: Weed control in the field and field margins, especially of sweet fern, may help reduce the attractiveness of the site for egg laying. Several natural parasites have been recorded for the chainspotted geometer. These include flies of the family Tachinidae, and wasps in the families, Braconidae, Chalcididae and Ichneumonidae. The fungal disease *Entomophthora aulicae* and a multi-cupsid nuclear-polyhedrosis virus (MVPV) have also been noted as natural controls.

Resistant cultivars: Not applicable.

Chemical controls: Insecticides registered for the control of this pest are listed in table 9.

Issues for chainspotted geometer

1. There is a lack of pollinator friendly, reduced risk products registered for the control of the chainspotted geometer.

Whitemarked tussock moth (*Orgyia leucostigma*)

Pest information

Damage: The whitemarked tussock moth is primarily a forest pest, but is a general feeder and can attack any type of vegetation. Larvae feed on the foliage of lowbush blueberry and can completely defoliate large portions of a field. The damage can take place at a critical time of development in the growth of both crop and sprout fields. Outbreaks are sporadic, with a history of outbreaks every 20 years that last from 2 to 3 years at a time in Nova Scotia. The caterpillars are covered with easily dislodged hairs that can cause irritation and possible allergic reactions in humans when they come in contact with the skin. In addition, the hairs can become airborne and may cause problems if inhaled.

Life cycle: The pest overwinters in egg masses and hatches from late June to mid-July. First instar caterpillars feed on the upper surface of leaves and can easily be dispersed by wind. After six weeks of feeding, the caterpillar pupates in a loosely spun cocoon on the host plant or in cracks and crevices. The pupal stage lasts for about 2 weeks and adults emerge from mid-August to September. Females lay eggs in masses of 50-100 which are protected by a coating of white foam. Eggs are normally laid on or near the cocoon from which the female emerged. Since the females are wingless, the dispersal of the infestation by adults is limited.

Pest management

Cultural controls: The population of the moth is normally kept in check by several parasites and a viral disease. Monitoring for the hatching of caterpillars must be conducted in both crop and sprout fields in early July to time spray applications. The potential for caterpillar populations in the following year can be estimated by scouting in late September and October for egg masses in field and in wooded field margins. There are no formal thresholds established for the whitemarked tussock moth. Monitoring of the feeding patterns should be conducted and immediate action is recommended when apparent feeding damage is observed. The bacterium *Bacillus thuringiensis* subspecies *kurstaki*, strain HD-1 is registered as a biological control for this pest. Workers in fields heavily infested with the caterpillars need to be cautious and wear protective clothing and dust filters to avoid contact with hairs that are easily dislodged from the body of the insect.

Resistant cultivars: Not applicable.

Chemical controls: Spraying should be delayed until larval dispersal is complete. Registered chemicals are listed in table 9.

Issues for whitemarked tussock moth

1. Additional reduced risk alternatives are required for the whitemarked tussock moth.

Gypsy moth (*Lymantria dispar*)

Pest Information

Damage: Gypsy moths feed on a wide variety of plants including oak, apple, hawthorn, birch and willow. Gypsy moth larvae feed on foliage and buds of lowbush blueberry in the spring, resulting in fruit losses.

Life cycle: Gypsy moths overwinter as eggs which hatch in the early spring. Young larvae may also blow into blueberry fields on silken threads from neighbouring forested areas. Larvae feed on stems, leaves and blossoms until early July. At maturity, the larvae pupate in protected sites in the blueberry field. Adults emerge in 1- 2 weeks and following mating, the female moth lays eggs back on the blueberry plants. Female moths are flightless so eggs are often laid in the vicinity of the pupation site. There is one generation per year.

Pest management

Cultural controls: None identified.

Resistant cultivars: Not applicable.

Chemical controls: None available.

Issues for gypsy moth

None identified.

Redstriped fireworm (*Aroga trialbamaculella*)

Pest information

Damage: The redstriped fireworm occasionally causes severe damage in some fields. This insect is more prevalent in sprout fields but will also be found in crop fields. The larvae web leaves together and feed within the webbed leaves. They may also web together fruit, which may affect fruit size and interfere with harvest.

Life cycle: The redstriped fireworm overwinters as mature larvae in the leaf litter. Pupation and adult emergence occurs in the spring, with adults being present into the summer, when eggs are laid on the blueberry plants.

Pest management

Cultural controls: None identified.
Resistant cultivars: Not applicable.
Chemical controls: None available.

Issues for fireworms

1. The red striped fireworm is an emerging problem as growers move away from burning to pruning by mowing.

Weeds

Key Issues

- Annual broadleaf weeds are becoming more of a problem in lowbush blueberry. The impact of fertilization on the vigour of these weeds is not well understood.
- The development of a broader range of reduced risk broadleaf weed control products would allow for more precise herbicide applications and decrease the need for broad spectrum pre-emergent herbicides.
- Witch grass is becoming more of a problem in lowbush blueberry.
- There are insufficient post-emergent grass herbicides available. The registration of reduced risk products with shorter PHI's and resistance management tools would be of benefit.
- Perennial grasses are an increasing problem. The registration of additional reduced risk products would allow for product rotation and reduce the chances of resistance development. Fescue species (*Festuca* spp.) are a particular concern.

Table 10. Occurrence of weeds in lowbush blueberry production in Canada by province[1, 2]

Weeds	Quebec	Nova Scotia	New Brunswick	Prince Edward Island
Annual broadleaf weeds				
Annual grass weeds				
Perennial broadleaf weeds				
Perennial grass weeds				
Woody plants				
Widespread yearly occurrence with high pest pressure.				
Widespread yearly occurrence with moderate pest pressure OR localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure.				
Widespread yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with moderate pressure OR sporadic localized occurrence with high pressure.				
Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low pressure OR localized sporadic occurrence with low to moderate pest pressure OR pest not of concern.				
Pest not present.				
Data not reported.				

[1]Source: Lowbush blueberry stakeholders in reporting provinces.

[2]Please refer to Appendix 1, for a detailed explanation of colour coding of occurrence data.

Table 11. Adoption of weed management practices for lowbush blueberry in Canada[1]

Practice / Pest		Annual broadleaf weeds	Annual grass weeds	Perennial broadleaf weeds	Perennial grass weeds	Woody plant species
Avoidance	use of weed-free seed					
	planting / harvest date adjustment					
	crop rotation					
	choice of planting site					
	optimizing fertilization					
Prevention	equipment sanitation					
	mowing / mulching / flaming					
	modification of plant density (row or plant spacing; seeding)					
	seeding / planting depth					
	water / irrigation management					
	weed management in non-crop lands					
	weed management in non-crop years					
	tillage / cultivation					
Monitoring	scouting - field inspection					
	field mapping of weeds / record of resistant weeds					
	soil analysis					
	grading of grain / produce for weed contamination					
Decision making tools	economic threshold					
	weather / weather-based forecast / predictive model					
	recommendation from crop specialist					
	first appearance of weed or weed growth stage					
	observed crop damage					
	crop stage					
	calendar spray					
Suppression	pesticide rotation for resistance management					
	soil amendments					
	biological pesticides					
	arthropod biological control agents					
	habitat / environment management					
	ground cover / physical barriers					
	mechanical weed control					
Crop specific practices	pruning by mowing or burning (lowbush blueberry)					

This practice is used to manage this pest by at least some growers in the province.

This practice is not used by growers in the province to manage this pest.

This practice is not applicable for the management of this pest.

Information regarding the practice for this pest is unknown.

[1]Source: Lowbush blueberry stakeholders in producing provinces (Quebec, Nova Scotia, New Brunswick and Prince Edward Island).

Table 12. Herbicides registered for weed management in lowbush blueberry in Canada

Active ingredient[1,2]	Classification[3]	Mode of action[3]	Resistance group[3]	Re-evaluation status[4]	Targeted pests[5]
bentazon	benzothiadiazinone	Inhibition of photosynthesis at photosystem II	6	R	yellow nutsedge (directed spray only)
carfentrazone-ethyl	triazolinone	Inhibition of protoporphyrinogen oxidase (PPO)	14	R	lamb's-quarters, morning glory, eastern black nightshade, redroot pigweed, velvetleaf, tall waterhemp, round-leaved mallow, hairy nightshade, field pennycress, prostrate pigweed, smooth pigweed, tumble pigweed, common purslane, Pennsylvania smartweed (seedling), tansy mustard, carpetweed, cocklebur, jimsonweed, kochia, volunteer canola, glyphosate-tolerant volunteer canola, burclover, prickly lettuce, Venice mallow, corn spurry
clopyralid	pyridine carboxylic acid	Action like indole acetic acid (synthetic auxins)	4	RE	tufted vetch
dicamba	benzoic acid	Action like indole acetic acid (synthetic auxins)	4	R	lambkill (sheep laurel), sweet fern, other broadleaf weeds
fluazifop-P-butyl	Aryloxyphenoxy-propionate 'FOP'	Inhibition of acetyl CoA carboxylase (ACCase)	1	RE	grasses, volunteer corn, Johnson grass, Persian darnel, barnyard grass, volunteer spring wheat and spring barley, wild oats, wild proso millet, crabgrass, fall panicum, old witchgrass, foxtail (green, yellow and giant), quackgrass (suppression), wirestem muhly
flumioxazin	N-phenylphthalimide	Inhibition of protoporphyrinogen oxidase (PPO)	14	R	redroot pigweed, green pigweed, common ragweed, lamb's-quarters, green foxtail, hairy nightshade, dandelion, eastern black nightshade, moss (suppressed)

Active ingredient[1,2]	Classification[3]	Mode of action[3]	Resistance group[3]	Re-evaluation status[4]	Targeted pests[5]
Glyphosate (directed spray, non-bearing year only)	glycine herbicide	Inhibition of EPSP synthase	9	R	woody brush
hexazinone	triazinone	Inhibition of photosynthesis at photosystem II	5	R	most common grasses, perennial broadleaf weeds, woody weeds, colonial bent grass, poverty oat grass, blue grass, sheep fescue, timothy, boreal panic-grass, yellow rattle, goldenrod, aster, yarrow, cinquefoil, wild strawberry, hawkweed, fireweed, pearly everlasting, ox-eye daisy, black medic, trailing blackberry, hardhack, lambkill, wild red raspberry, poplar
mesotrione	triketone	Bleaching: inhibition of 4-hydroxyphenyl-pyruvate-dioxygenase (4-HPPD)	27	R	annual weeds, lamb's-quarters, redroot pigweed, velvetleaf, wild mustard, common ragweed (suppression), eastern black nightshade
napropamide	acetamide	Inhibition of cell division (inhibition of very long chain fatty acids)	15	R	annual grasses: annual bluegrass, barnyard grass, foxtail, large crabgrass, sandbur, wild oats annual broadleaf weeds: chickweed, prostrate knotweed, small-flowered mallow (from seed), purslane, annual sow-thistle, stork's-bill, groundsel, lamb's-quarters, pineapple weed, prickly lettuce, redroot pigweed
nicosulfuron + rimsulfuron	sulfonylurea	Inhibition of acetolactate synthase ALS (acetohydroxyacid synthase AHAS)	B	R	black bulrush

Active ingredient[1,2]	Classification[3]	Mode of action[3]	Resistance group[3]	Re-evaluation status[4]	Targeted pests[5]
propyzamide (pronamide)	benzamide	Microtubule assembly inhibition	15	R	annual and perennial grasses including quackgrass
rimsulfuron (see nicosulfuron + rimsulfuron above)					
sethoxydim	cyclohexanedione 'DIM'	Inhibition of acetyl CoA carboxylase (ACCase)	1	R	barnyard grass, large crabgrass, fall panicum, foxtail (green/yellow; wild millet), proso millet, volunteer corn, witchgrass, quackgrass, foxtail barley (suppression), Persian darnel
simazine	triazine	Inhibition of photosynthesis at photosystem II	5	R	lady's-thumb, volunteer clovers, lamb's-quarters (susceptible biotypes), barnyard grass, purslane, crabgrass, ragweed (susceptible biotypes), wild oats, wild buckwheat, yellow foxtail, smartweed, perennial species starting from seed
terbacil	uracil	Inhibition of photosynthesis at photosystem II	5	R	germinating annual broadleaf weeds and grasses
tribenuron-methyl	sulfonylurea	Inhibition of acetolactate synthase ALS (acetohydroxyacid synthase AHAS)	2	RE	bunchberry, yellow loosestrife, speckled alder, wild rose, bracken fern
triclopyr	pyridine carboxylic acid	Action like indole acetic acid (synthetic auxins)	4	R	non-selective brush control during site preparation, alder, ash, birch, chokecherry, maples, poplar

[1]Registrations confirmed on the PMRA Registered Products Database (www.hc-sc.gc.ca/cps-spc/pest/index-eng.php) March 14, 2012.

[2] Not all end use products containing this active ingredient may be registered for use on this crop. The information in these tables should not be relied upon for pesticide application decisions. Individual product labels must be consulted for up to date, accurate information concerning the use of these pesticides and specific registration details.

[3]Source: Herbicide Resistance Action Committee, Classification of Herbicides According to Site of Action (January 2005) at: www.hracglobal.com/

[4]PMRA re-evaluation status as of **March 31, 2011**: R – full registration, RE (yellow) – under re-evaluation, DI (red) – discontinued by registrant, PO (red) – being phased out as a result of re-evaluation.

[5]Please consult the pesticide label for a detailed listing of pests controlled by products containing each active ingredient. Information on registered pesticide uses is also available from the PMRA Registered Products Database (www.hc-sc.gc.ca/cps-spc/pest/index-eng.php).

Annual broadleaf weeds

The majority of weeds in lowbush blueberry fields are species of the native flora that are promoted by the production methods used and include herbaceous annuals and perennials and woody plants. Weeds that prefer low pH soils and a similar habitat to that of blueberries thrive when not controlled.

Pest information

Damage: Annual broadleaf weeds are an increasing problem. Lamb's quarters (*Chenopodium album*), pigweed (*Amaranthus* sp.) and hempnettle (*Galeopsis tetrahit*) are causing increasing problems. Competition for space and nutrients reduces blueberry plant vigour. These weeds can also cause harvesting challenges.

Life cycle: These weeds are generally summer annuals and tend to germinate in late June. This delayed emergence allows them to escape most of the pre-emergent herbicides, especially in wet years. They are prolific seed producers and can spread quickly in a field.

Pest management

Cultural controls: Pruning by burning can have some effect on these weeds. Field and equipment sanitation are important to prevent seed spread. Weed pulling and cutting can prevent seed dispersal. Fertility management is critical, as these weeds require high amounts of nitrogen. Soil pH adjustment (decreasing soil pH) may help control these weeds.

Chemical controls: The efficacy of pre-emergent herbicides is variable depending on weed pressure, weather conditions after application and soil conditions. Herbicides registered for annual broadleaf weed control in lowbush blueberry are listed in table 12.

Issues for annual broadleaf weeds

1. The impact of fertilization on the vigour of annual broadleaf weeds is not well understood.

Perennial broadleaf and woody weeds

Pest information

Damage: Perennial weeds represent the largest group of weeds in the lowbush blueberry production system. Most are forest succession plants that grow naturally with lowbush blueberry. The perennial broadleaf weeds sheep sorrel (*Rumex acetosella*), hawkweed (*Hieracium* spp.), goldenrod (*Solidago* spp.), are a major concern in established fields. Lambkill and sweet fern are concerns in newly cleared land. If allowed to grow, most of these weeds would out-compete the lowbush blueberry for space, reducing yields and ease of harvest of the crop.

Life cycle: Perennial and woody weeds vary in their life cycle, but all plants can exist for more than two years if left unmanaged.

Pest management

Cultural controls: Cutting and pulling of weeds can help reduce the influence of weeds. Fertility management is important.

Chemical controls: There are several post-emergent herbicides and several pre-emergent herbicides that have an effect on many weeds in this group (refer to table 12). Wick wiping with glyphosate is a common practice that helps to control many of these species.

Issues for perennial broadleaf and woody weeds

1. The perennial broadleaf weeds sheep sorrel (*Rumex acetosella*), hawkweed (*Hieracium* spp.) and goldenrod (*Solidago* spp.) are a major concern in established fields. Lambkill and sweet fern are concerns in newly cleared land.
2. The development of a broader range of reduced risk products would allow for more precise herbicide applications and decrease the need for broad spectrum pre-emergent herbicides.
3. St. John's wort (*Hypericum perforatum*), spreading dogbane (*Apocynum androsaemifolium*), barrenberry (*Photinia* spp.) and spreading blackberry (*Rubus* spp.) are weed species that are particularly challenging to control.
4. The availability of reduced risk, crop year control products is limited.

Annual grasses

Pest information

Damage: Annual grasses can cause significant problems in lowbush blueberry production as a result of their fast growth and ability to compete for necessary resources. Crop losses in terms of growth and yield can be very high if annual grasses are not controlled. Annual grasses can often shade the crop causing poor bud formation in the sprout year and low harvesting efficiency in the crop year.

Life cycle: Witch grass (*Panicum capillare*) is the main annual grass weed for this crop. This is a late germinating grass which emerges in late June or early July. Witch grass does not mature until early fall. At maturity it releases its' panicle, which can act like a tumble weed and spread seed.

Pest management

Cultural controls: Pruning by burning can have some effect. Harvester and mower sanitation between fields can help to reduce weed spread.

Chemical controls: Post-emergent chemical controls are difficult to use in the cropping year as the days to harvest for the only graminicide is too short. Also, due to late emergence in the spring, the efficacy of pre-emergent herbicides that could have an effect on weeds tends to be reduced, especially in wet years. Herbicides registered for annual grass control are listed in table 12.

Issues for annual grasses

1. Witch grass is becoming more of a problem in lowbush blueberry.
2. There are insufficient post-emergent grass herbicides available. The registration of reduced risk products with shorter PHI's and resistance management tools would be of benefit.

Perennial grasses

Pest information

Damage: Grasses compete with blueberry plants for resources and space. They can also cause harvesting difficulties in the cropping year.

Life cycle: Perennial grasses are common in most blueberry fields. Most of these grasses can act as annuals but will re-grow from their root systems. Poverty oat grass (*Danthonia spicata*), fescues, (*Festuca* spp.), rough hair grass and bluegrasses (*Poa* spp.) are the main species. Not all species emerge at the same time and more than one species may be present in a field. This is critical to know when applying a post-emergent grass herbicide.

Pest management

Cultural controls: Pruning by burning can have some effect on perennial grasses. Field and equipment sanitation are important to prevent seed spread. Fertility management is important to minimize grass expansion.

Chemical controls: There is only one post-emergent herbicide but there are several pre-emergent herbicides available that have varying efficacy on different grass species. Fescues are tolerant of post-emergent grass herbicides and several species appear to be developing tolerances to pre-emergent herbicides. Herbicides registered for control of perennial grasses are listed in table 12.

Issues for perennial grasses

1. Perennial grasses are an increasing problem. The registration of additional reduced risk products would allow for product rotation and reduce the chances of resistance development. Fescue species (*Festuca* spp.) are a particular concern.

Vertebrate Pests

Birds

Birds feed on ripening fruit and are an increasing concern. Their feeding can significantly reduce crop yield before harvest. The most important birds include seagulls, crows, robins and blackbirds, with gulls being of particular concern. Many producers use propane bangers, electronic noisemakers, balloons or other noise making devices to reduce fruit damage from birds. Some species become accustomed to these deterrents and will still cause significant reductions in crops. Small acreage producers with heavy bird pressure can use netting to stop birds from reaching the plants.

Bear

Bears cause most of their damage during the bloom period in June. Honeybee hives that are used to increase pollination in the fields can attract bears. Bears can severely damage or destroy hives and colonies. This damage can be very costly to both the blueberry grower and the beekeeper. Bears also feed on mature fruit and destroy plants when sitting or lying in fields.

Fencing of beehives is a must in most fields to reduce the damage from bears. Properly installed fencing systems are usually very effective.

Coyote

When populations are high, coyotes can consume significant quantities of blueberry fruits. The presence of coyote will reduce the damage caused by deer.

Deer

Deer can cause significant crop losses where populations are high and blueberry fields are small and isolated. Deer feed on leaves throughout the summer and on fruits as they mature. Most importantly, in the early spring of the fruiting year, deer migrate to the center of the fields where snow has disappeared and graze on the blueberry twigs, chewing off the tops of the vines that carry most of the fruit buds that would otherwise develop into the current year's crop.

As an attempt to deter deer, some products are sprayed around the perimeters of fields. However, success is spotty at best. In a very few cases fences have been erected, but this is expensive and in most fields not practical. Often, growers live with the damage and crop loss.

Resources

IPM/ ICM Resources for production of lowbush blueberry in Canada

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Wild Blueberry Factsheets, General Production http://nsac.ns.ca/wildblue/facts/

Wild Blueberry Network Information Centre
http://nsac.ca/wildblue/

Provincial Lowbush Blueberry Crop Specialists and Provincial Minor Use Coordinators

Province	Ministry	Crop Specialist	Minor Use Coordinator
Ontario	Ontario Ministry of Agriculture and Food	Pam Fisher pam.fisher@ontario.ca	Jim Chaput jim.chaput@ontario.ca
Quebec	Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec www.mapaq.gouv.qc.ca	André Gagnon andre.gagnon@mapaq.gouv.qc.ca Andrée Tremblay andree.tremblay@mapaq.gouv.qc.ca	Luc Urbain luc.urbain@mapaq.gouv.qc.ca
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National and Provincial Lowbush Blueberry Grower Organizations

Wild Blueberry Association of North America
www.wildblueberries.com/

Wild Blueberry Producers Association of Nova Scotia (www.nswildblueberries.com)

Wild Blueberry Producers of New Brunswick (www.nbwildblue.ca)

PEI Wild Blueberry Growers Association Inc.

Appendix 1

Definition of terms and colour coding for pest occurrence tables of the crop profiles

Information on the occurrence of disease, insect and mite and weed pests in each province is provided in Tables 4, 7 and 10 of the crop profile, respectively. The colour coding of the cells in these tables is based on three pieces of information, namely pest distribution, frequency and importance in each province as presented in the following chart.

<table>
<tr><th>Presence</th><th colspan="4">Occurrence information</th><th rowspan="2">Colour Code</th></tr>
<tr><th></th><th></th><th>Frequency</th><th>Distribution</th><th>Importance</th></tr>
<tr><td rowspan="14">Present</td><td rowspan="12">Data available</td><td rowspan="6">Yearly - Pest is present 2 or more years out of 3 in a given region of the province.</td><td rowspan="3">widespread - The pest population is generally distributed throughout crop growing regions of the province. In a given year, outbreaks may occur in any region.</td><td>High - If present, potential for spread and crop loss is high and controls must be implemented even for small populations</td><td>Red</td></tr>
<tr><td>Moderate - If present, potential for spread and crop loss is moderate: pest situation must be monitored and controls may be implemented.</td><td>Orange</td></tr>
<tr><td>Low - If present, the pest causes low or negligible crop damage and controls need not be implemented</td><td>Yellow</td></tr>
<tr><td rowspan="3">localized - The pest is established as localized populations and is found only in scattered or limited areas of the province.</td><td>High - see above</td><td>Orange</td></tr>
<tr><td>Moderate - see above</td><td>White</td></tr>
<tr><td>Low - see above</td><td>White</td></tr>
<tr><td rowspan="6">Sporadic - Pest is present 1 year out of 3 in a given region of the province.</td><td rowspan="3">widespread - as above</td><td>High - see above</td><td>Orange</td></tr>
<tr><td>Moderate - see above</td><td>Yellow</td></tr>
<tr><td>Low - see above</td><td>White</td></tr>
<tr><td rowspan="3">localized - as above</td><td>High - see above</td><td>Yellow</td></tr>
<tr><td>Moderate -see above</td><td>White</td></tr>
<tr><td>Low - see above</td><td>White</td></tr>
<tr><td rowspan="2">Data not available</td><td colspan="3">Not of concern: The pest is present in commercial crop growing areas of the province but is causing no significant damage. Little is known about its population distribution and frequency in this province; however, it is not of concern.</td><td>White</td></tr>
<tr><td colspan="3">Is of concern: The pest is present in commercial crop growing areas of the province. Little is known about its population distribution and frequency of outbreaks in this province and due to its potential to cause economic damage, is of concern.</td><td></td></tr>
<tr><td>Not present</td><td colspan="4">The pest is not present in commercial crop growing areas of the province, to the best of your knowledge.</td><td>black</td></tr>
<tr><td>Data not reported</td><td colspan="4">Information on the pest in this province is unknown. No data is being reported for this pest.</td><td>grey</td></tr>
</table>

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