Vegetative Buffers

FOR INTENSIVE AGRICULTURAL OPERATIONS IN BRITISH COLUMBIA

BENEFICIAL MANAGEMENT PRACTICES GUIDE: 2ND EDITION





Companion document to the

CANADA – BRITISH COLUMBIA ENVIRONMENTAL FARM PLAN PROGRAM

CANADIAN AGRICULTURAL PARTNERSHIP

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BRITISH COLUMBIA

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Vegetative Buffers for Intensive Agricultural Operations in British Columbia

Beneficial Management Practices Guide
2nd Edition

COMPANION DOCUMENT TO THE

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Aura Rose	Karin Rempel
Dan Kampen	Molly and Matt Thurston
Dale Krahn	Richard Quiring
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PREFACE

The purpose of this supplemental Environmental Farm Plan publication is to help farmers and ranchers increase their understanding of vegetative buffers and what they mean to their operations. The guide provides a definition of vegetative buffers, highlights the importance of vegetative buffers for local farms, lists the main principles in using and establishing vegetative buffers, and provides a template for developing a Vegetative Buffer Plan for farms in British Columbia.

LIMITS OF LIABILITY

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INTRODUCTION

This guide is designed for agricultural producers, qualified landscapers, and Environmental Farm Plan (EFP) Planning Advisors who wish to increase their understanding of how vegetative buffers can be used as a Beneficial Management Practice (BMP) to address environmental concerns and improve neighbour relations at intensive agricultural operations. The use of vegetative buffers can meet multiple objectives if properly planned. Buffers are used for a variety of reasons. There is no fixed approach to solving problems with buffers. The guide provides information on how to properly select tree species and how to design, install, and maintain effective buffers for a variety of situations in British Columbia.

Note: This guide may be revised in the future.

How was this guide developed?

A vegetative buffer meteorological model, ENVI-met, was used to simulate interactions between surfaces, buildings, vegetation, and the atmosphere. The results simulated various buffer layouts and attributes (density, width, height, and setback distances) in order to evaluate their relative effect on air dispersion. This information, in addition to other research from across North America, was used to guide buffer design at eight demonstration sites and generate the technical information for this guide.

Is it mandatory to plant buffers?

Planting buffers is voluntary in British Columbia; there is no regulated requirement. However, the use of vegetative buffers is encouraged as a sustainable farm practice that can benefit both producers and their neighbours.

What is an environmental farm plan?

The **Environmental Farm Plan** is a voluntary process to help producers identify areas where environmental improvements could be made on the farm. The *Canada – British Columbia Environmental Farm Plan: Reference Guide* provides information on various environmental regulations and makes suggestions about the use of environmentally sound practices. It is the primary reference for completing the worksheets in the *Canada – British Columbia Environmental Farm Plan: Planning Workbook.*

The *EFP Planning Workbook* asks some basic questions about the opportunities to incorporate vegetative buffers on your farm. If you have already completed an Environmental Farm Plan, you may have identified action items or areas of improvement related to the installation of a vegetative buffer. Where appropriate, developing a Vegetative Buffer Plan can help mitigate interface concerns on your farm.

This *Vegetative Buffers BMP Guide* is a companion document to the *EFP Reference Guide and Planning Workbook*. It outlines a method for conducting a vegetative buffer assessment and provides information for producers and EFP Planning Advisors on how to design a Vegetative Buffer Plan based on concerns identified in the EFP.

How do I use this guide?

This guide provides a step-by-step approach to planning, designing, installing, and maintaining a vegetative buffer. By working through this guide, you will enhance your understanding of vegetative buffers and how they may be incorporated into your own operation.

The guide includes 10 sections:

Section 1 | Overview of Vegetative Buffers: This section defines what a vegetative buffer is and identifies the variety of benefits they offer. It further describes potential risks to an agricultural operation caused by a vegetative buffer and alternative solutions.

Section 2 | Principles of Vegetative Buffers: This section introduces the principles of vegetative buffer design by explaining the underlying mechanics.

Sections 3–5 | Buffer Design: These sections introduce the four components of vegetative buffer design:

- buffer placement
- buffer dimensions
- tree and shrub selection
- planting configuration

Guidelines for each design component are discussed for three types of agricultural operation based on primary objectives (Table 1):

LONG-TERM INVESTMENT

Keep in mind that planting a vegetative buffer is a long-term investment. It will take a decade or longer for a vegetative buffer to grow large enough to provide full benefits. Careful planning and proper planting and care will ensure the best chance of success.

Table 1: Design objectives based on type of agricultural operation

Agricultural Operation	Source of Issue (examples)	Primary Objective
Section 3 | Livestock - indoor housing	Poultry barn Hog barn Dairy	Dust and odour mitigation
Section 4 | Livestock - outdoor	Cattle feedlot Grazing pasture Manure storage Manure spreading	Dust and odour mitigation
Section 5 | Outdoor crops	Orchard Vineyard Berry Vegetables	Pesticide drift

Determine which buffer design section best suits your needs by considering the **source** of the issue being addressed and the **impacted area** that will benefit from the establishment of a vegetative buffer. For example, in the case of a berry field (impacted area) that is affected by dust from a poultry barn (source), the section on "Livestock - indoor housing" would provide the appropriate information for dust mitigation.

Section 6 | Tree and Shrub Gallery: This section provides a list of tree and shrub species that are suitable for the climates of the South Coast and Southern Interior regions of British Columbia.

Section 7 | Implementation Guide for Producers: This section provides an overview of installation considerations and basic care and maintenance for vegetative buffers. It is intended to provide you with an overview of what to expect when creating a vegetative buffer and to support your collaboration with nursery and landscape professionals.

Section 8 | Plan Requirements for EFP Planning Advisors: This section provides an overview of the steps involved in the vegetative buffer planning process. In order to apply for EFP Beneficial Management Practices Program funding (BMP Categories 19 and 34), a vegetative buffer plan must be submitted. A checklist of items required in a plan is provided. Two **sample plans** are given as examples of the outcome of working through the planning process outlined in this guide.

Section 9 | Site Assessment Field Forms: This section provides a series of forms for producers and EFP Planning Advisors to use when conducting a site assessment to develop a vegetative buffer plan. The forms are organized into checklists of factors that should be considered during the planning process.

Section 10 | Appendices: The appendices for this guide provide the following information:

- glossary
- additional resources and sources of information related to vegetative buffers
- biosecurity considerations for landscape professionals who work on agricultural operations

Figure 1: Newly planted vegetative buffers at poultry operations to address dust and odour concerns.

1 OVERVIEW

What is a vegetative buffer?

A vegetative buffer is a single or multiple-row planting of suitable tree and shrub species around an agricultural operation (e.g., livestock barn, pasture, food crop) which is installed and maintained to address environmental concerns and improve neighbour relations.

How effective are vegetative buffers?

This guide focuses on three common issues, termed **primary objectives,** for vegetative buffers: dust, odour, and pesticide drift mitigation. However, it also outlines a number of **secondary objectives** that may be addressed by creating a vegetative buffer.

Vegetative buffers address some issues better than others. The potential effectiveness of properly designed, healthy vegetative buffers to address various objectives is compared in Table 2.

Table 2: Relative effectiveness of vegetative buffers

Objective (issue being addressed)		Relative Efficacy
Primary objective	Pesticide drift mitigation Dust mitigation Odour mitigation	High Moderate – high Low – moderate
Secondary objective	Visual screening/aesthetics Energy efficiency Noise and light reduction Biodiversity/riparian enhancement	High Moderate Low Low

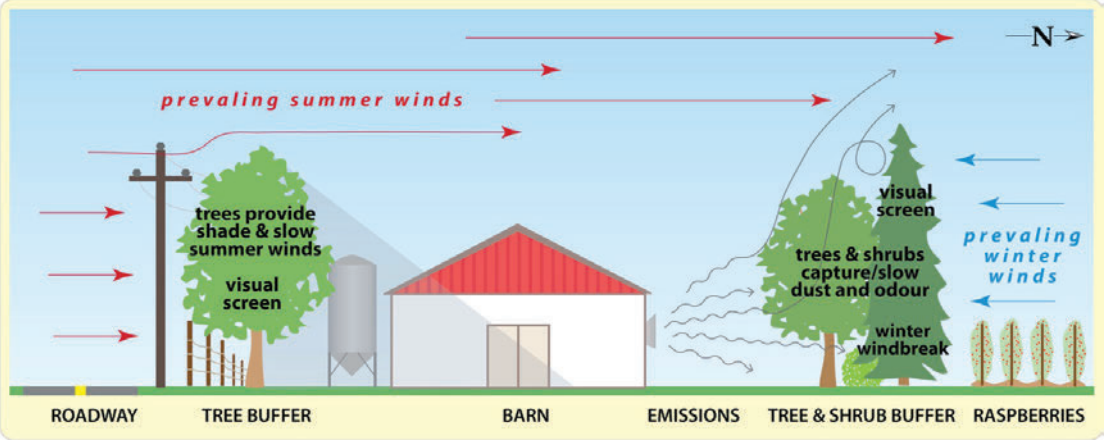


Figure 2: Example vegetative buffer objectives.

Primary objectives

Pesticide drift mitigation: Spray drift occurs when spray droplets are transported by air currents during pesticide application. Vegetative buffers intercept and capture spray droplets. Research has shown that with a proper design, a vegetative buffer can reduce pesticide drift by 50-90%.

Dust mitigation: Vegetative buffers act as a filter by collecting dust on the surface of leaves and needles. Buffers also change airflow patterns, which can reduce the amount of dust blowing onto neighbouring properties.

Odour mitigation: Odour plumes typically occur at ground level and often are absorbed or carried on airborne particulates. Vegetative buffers can reduce odours in the same way as they reduce dust levels: by capturing particles and changing airflow patterns, which reduce particle travel and improve dilution in the atmosphere. Visual screening reduces the perception of odour[1], which is an important aspect of odour mitigation.

Secondary objectives

Visual screening/aesthetics: Out of sight is out of mind; vegetative buffers block unsightly structures or operational practices and improve aesthetics, which contributes to good neighbour relations.

Energy efficiency: Energy savings can be achieved by strategically planting trees to lower heating and cooling costs. During the summer, shade from trees reduces air temperatures, which can lower indoor cooling costs. Windbreaks can also block harsh winter winds, which can lower indoor heating costs, and can limit the potential for farm structures to be damaged. Shelter from summer sun and winter winds helps moderate the environment around farm operations for both people and livestock.

Noise and light reduction: Increased density of branches and leaves results in greater scattering of sound waves and shading of artificial light.

Biodiversity and riparian enhancement: Vegetative buffers can be designed to enhance biodiversity and riparian values. Refer to the applicable Environmental Farm Plan companion documents[2] for further information.

1 Gottfied and Dolan. 2003. The Nose Smells What the Eye Sees. Neuron: Volume 39, Issue 2, P375-386, July 17, 2003
2 Environmental Farm Plan Biodiversity Guide and Riparian Assessments

Potential risks

Although vegetative buffers provide many benefits, they can interfere with operational requirements and create hazards. A careful site assessment will ensure that the location and mature size of the buffer will not create problems in the future. Factors that could be negatively affected by a vegetative buffer include:

- building ventilation
- operational access
- snow distribution
- frost accumulation
- visibility
- light availability for crops (due to shading)
- wildfire risk (within the wildland–urban interface)
- crop health (due to pest and disease vectors)

Alternatives to vegetative buffers

Vegetative buffers on agricultural operations are not the only option for addressing environmental concerns and improving neighbour relations. In some cases it may be necessary to seek an alternative solution. Vegetative buffers may be used with or instead of other mitigation measures, such as:

- fences
- berms
- siting
- fan placement
- emission control technology (e.g., electrostatic precipitators)
- pesticide application BMPs

Figure 3: A four-year-old vegetative buffer at a poultry operation in Abbotsford planted to address dust drift onto the adjacent blueberry operation and odour drift towards neighbours across the street.

NOTES

2 PRINCIPLES OF VEGETATIVE BUFFERS

TERMINOLOGY

SOURCE: the origin of dust, odour, or pesticide drift (e.g., barn emission fans, pesticide spray applicator)

IMPACTED AREA: zone that will benefit from the vegetative buffer (e.g., neighbour's property)

UPWIND: in the direction from which the wind blows

DOWNWIND: in the direction in which the wind blows

Vegetative buffers on farms can be used to reduce dust, odour, and pesticide drift by modifying airflow and capturing particles through filtration. The buffers are most effective when they are properly designed. Three factors improve their effectiveness:

- **Filter effect:** the buffer acts as a filter for air passing through the vegetation.
- **Chimney effect:** the buffer acts as a chimney to divert and dilute airflow.
- **Windbreak:** the buffer acts as a windbreak to reduce wind speed.

If the buffer is designed properly, the filter and chimney effects will work together to maximize reduction of dust, odour, or pesticide drift in the downwind impacted area. The windbreak effect should be used only on sites where reducing wind speed is beneficial. Windbreaks are not appropriate on sites where an increase in wind speed is desired to ensure contaminants (odour, dust, or pesticide drift) are blown away or where they may exacerbate frost pockets. Always take into account how reducing wind speed will affect your site before planting a windbreak.

Filter effect

Vegetative buffers act as a filter (Figure 4). As air flows through the buffer, large or small particles of dust or spray droplets collect on the vegetation's leaves and needles. The air travelling though the buffer comes out the other side with fewer dust or odour particles or fewer pesticide droplets. There is also some limited evidence that odours can be caught in vegetation.

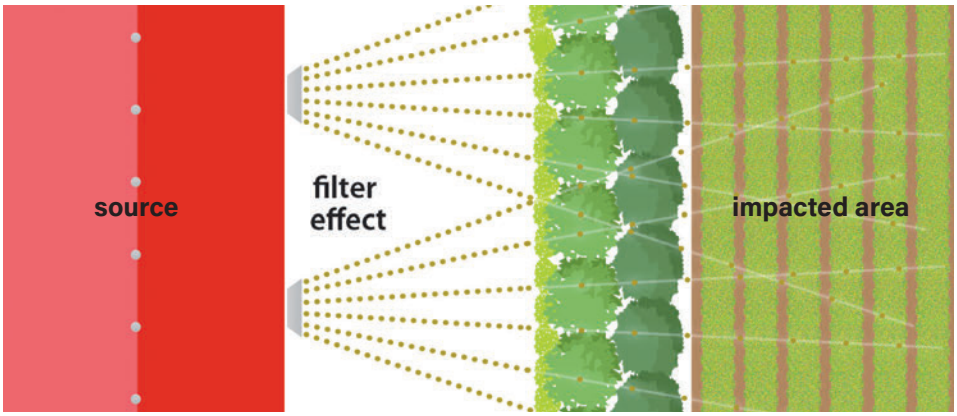


Figure 4: Filter effect of a vegetative buffer

The filter effect requires the vegetation to be somewhat porous. If the vegetation is too dense, most of the air will be diverted around or over the buffer. As a result, more contaminants may reach the impacted area. The buffer reduces air speed at ground level directly before the buffer, which causes dust, odour, or pesticides to settle out on the source property.

Chimney effect

Buffers can change airflow patterns over the source property, which can reduce the amount of dust that blows onto neighbouring properties (the impacted area). A vegetative buffer in the path of the airflow will create a restriction and cause air to either flow through the buffer or over and around it. The chimney effect occurs when air is diverted up and over the vegetation creating a stack of air that promotes vertical mixing and dispersion (Figure 5). The contaminants (pesticide drift, dust, and odour) in the airstream are (1) diluted to lower concentrations and (2) sent higher up and deposited further downwind beyond the impacted area. The air around the buffer is turbulent, which further promotes mixing and causes air to rise and mix with the prevailing wind.

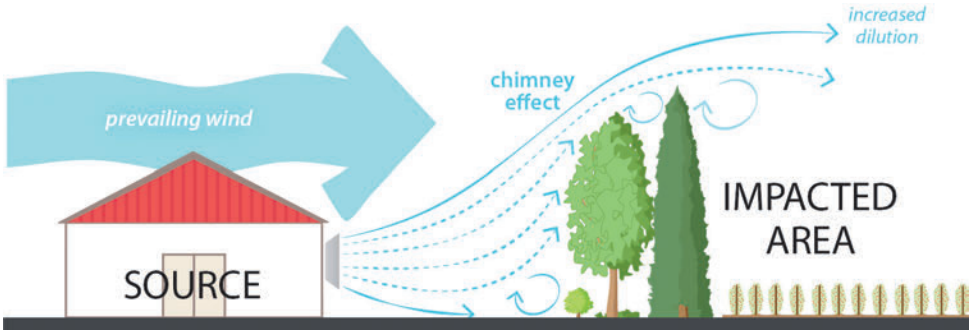


Figure 5: Chimney effect of a vegetative buffer

If the vegetation is too dense (has little to no canopy porosity), the air will flow over the top and be pulled down directly beyond the buffer. This is called downwash. In this case, an air cavity forms (up to three times the height of the buffer) in which contaminant-laden air can recirculate (Figure 6). If the impacted area is within the cavity zone, contaminant levels will increase and build up over time. Allowing some air to flow through the buffer will reduce the amount of downwash, which will allow any recirculated air to be blown away.

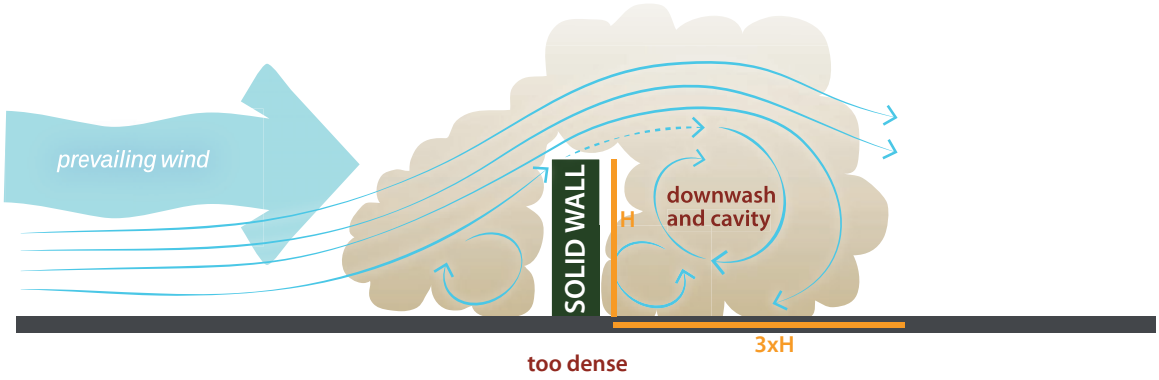


Figure 6: Effect when buffer vegetation is too dense (low canopy porosity)

Windbreaks and wind speed

A vegetative buffer can act as a windbreak to slow air speed in the area directly before and after the buffer. This causes contaminants (pesticide drift, dust, and odour) to "fall" out of the air more rapidly and form larger deposits.

A fully closed buffer, in which buffer structures exist upwind and downwind of the barn, is most effective in reducing wind speed because it shelters the air inside the buffer.

Windbreaks can reduce wind speed for a distance up to 10 times the tree height on the downwind side. Maximum wind speed reductions occur when windbreaks are located at distances that are five times the tree height (Figure 7). However, consider a windbreak's effect on reducing wind speed.

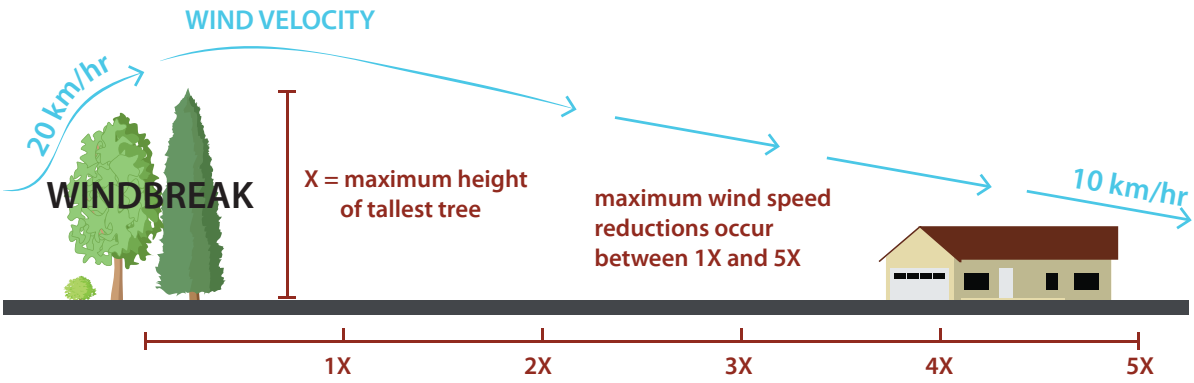


Figure 7: Estimated wind speed reductions from windbreaks

Wind patterns and topography

The topography of the landscape can significantly influence site-specific wind patterns and affect how air moves to neighbouring properties (the impacted area). Prevailing winds should always be considered when designing a buffer, but local, site-specific winds should also be considered because they may differ from prevailing winds due to local topography (refer to Appendix 2 for information on how to obtain local wind information).

Local topography affects the movement of the plume and can cause wind direction changes from day to night as temperature changes. As air temperature decreases, winds typically flow down valleys. During daylight hours, wind direction typically reverses and air moves up valleys. If there is very little variation in temperature, as is common in summer, a plume in a valley may circulate back and forth, resulting in minimal dispersal of contaminants.

Large hills can alter normal wind patterns. If the prevailing wind is blowing up a hill from the barn or field, the plume could follow the natural topography to an uphill impacted area. During low, steady, or calm winds, this can cause higher concentrations of contaminants to collect in the impacted area. In this situation, the best method to disperse the contaminants is to increase the height of the plume as high as possible using a vegetation buffer and ensure there is no structure (such as a windbreak) that reduces wind speed before the source property. For plumes that will travel uphill, the buffer must be as tall as possible to force air high enough to pass over the uphill impacted area.

If the barn or field is downhill from the prevailing winds, the plume will be lower to the ground. When the impacted area is downhill from the source property, planting a vegetative buffer downwind will capture and disperse the contaminants before they reach the impacted area. In this case, a buffer does not need to be as tall as that described in the uphill scenario.

Odour from open areas

In open fields, odour is likely to be generated at ground level and to travel in wafts of air along the ground toward the impacted area. In this case, the primary recommendation is to reduce odour and dust at the source property, if possible, using techniques such as proper manure management, composting, or proper livestock stocking densities. Vegetative buffers have low to medium effectiveness, but if designed properly, are a great secondary technique for reducing odour and dust contamination. Buffers filter the airflow and deflect the remaining airflow up and away from the impacted area. Reducing airflow before the source property is a concern, though, because a greater concentration of odorous air will build up on the source property and eventually be carried to the impacted area with a new waft of air. A windbreak should be used with caution in this case.

Open areas with ground-level plumes require a high-density (low porosity) buffer at or near ground level. In addition, taller buffer species increase plume lifting and thus can reduce downstream plume deposition on impacted areas.

Pesticide drift and particle size

Pesticide spray drift is composed of relatively larger particles (droplets) than dust particles that originate from livestock farms; therefore, the distance that droplets travel is significantly less than of dust particles. Figure 5 show the distance a droplet will travel depending on droplet size and wind speed. This figure shows a range of spray droplets size (100 to 500 microns) whereas dust particles are typically less than 10 microns.

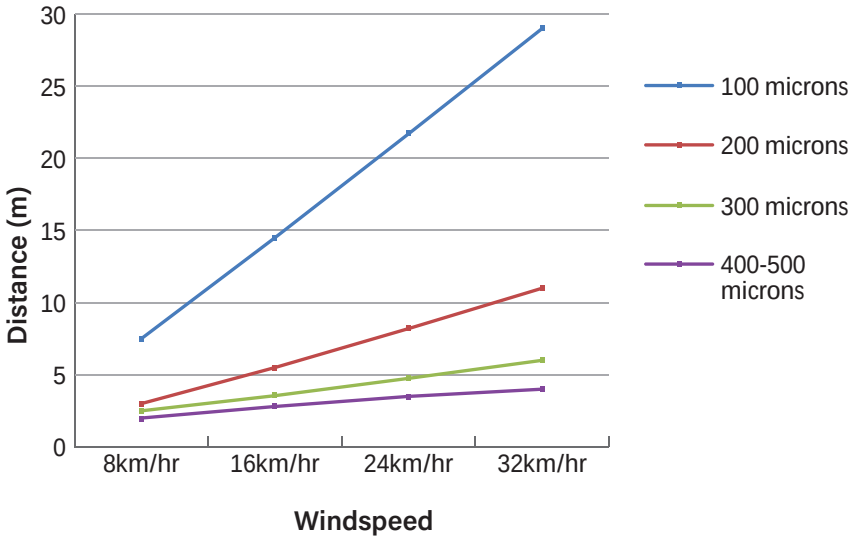


Figure 8: Spray droplet movement based on wind speed and droplet size[3]

Due to their relative size, pesticide droplets are intercepted by vegetation much more readily than dust particles; consequently, filtration is very effective.

Wind and air currents can drastically affect spray droplet drift. Most operators spray pesticide during light, stable wind conditions. Spraying during high winds should be avoided. An upwind buffer can be used as a windbreak to reduce the wind speed on the site being sprayed in order to reduce drift off site and improve spray effectiveness.

For large particles, like pesticide spray drift, moderately dense tree canopies (50-70%) provide the greatest filtration capacity. Some degree of canopy porosity is required in the buffer vegetation to allow filtration to occur and to ensure that air is not diverted around the buffer. If the buffer is too dense, it will act like a wall, forcing air up and over the buffer rather than allowing it to filter through the buffer. This leads to downwash, which traps pesticide drift on the opposite side of the buffer. However, if the buffer is not dense enough, such as when very porous species like fir are used, minimal filtration will occur. Canopy density is the most important determinant in creating an effective pesticide drift mitigation buffer.

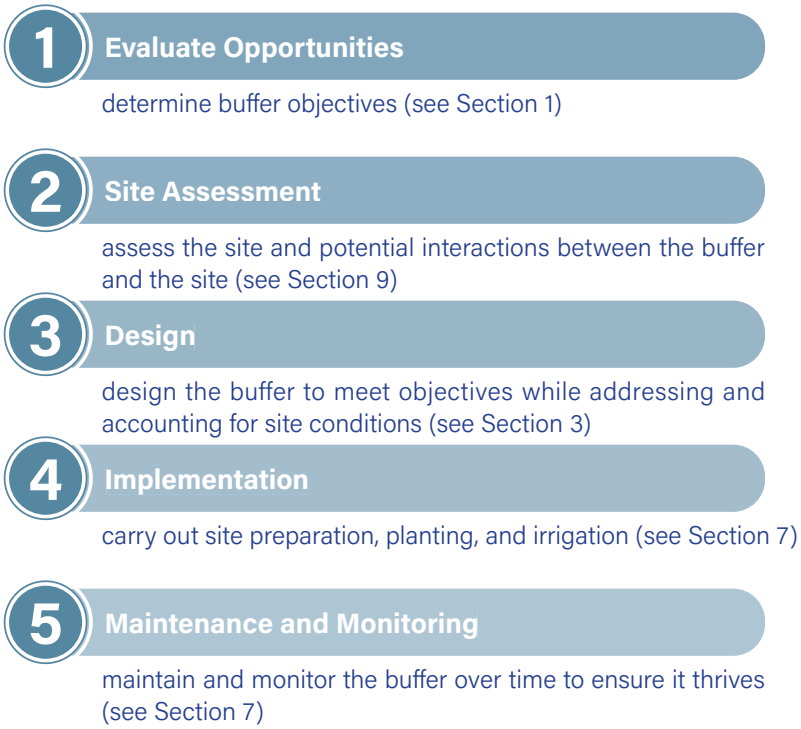
The second most important design factor for a pesticide drift mitigation buffer is height. The tree buffer should be at least 1-2 metres taller than the height of the sprayed crop, and should not grow to a height that will shade an adjacent crop. Some tree canopies naturally thin out as the tree grows in height. Ensure that tree height is not given priority over canopy density.

3 Source: Tom Wolfe, Saskatchewan Agriculture. Based on spray height 0.9 m or 3 ft.

3 BUFFER DESIGN: LIVESTOCK – INDOOR HOUSING

PLANNING OVERVIEW

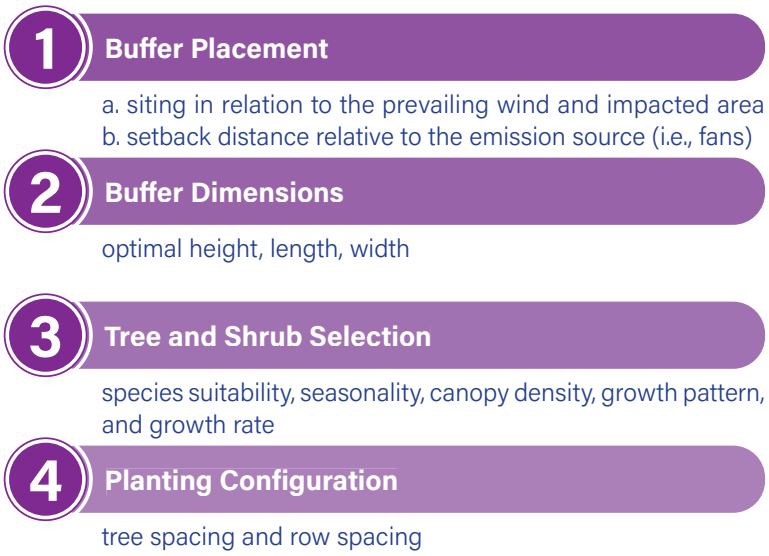
Five steps are involved in planning and establishing a vegetative buffer:



BUFFER DESIGN

Prior to designing a vegetative buffer, ensure that the first two planning steps have been completed: evaluate opportunities and conduct a site assessment using the forms in Section 9. Review the principles of vegetative buffers in Section 2.

The design process can be divided into four sequential components:



Primary objectives

This section describes optimal vegetative buffer design to address dust and odour emanating from indoor housing (e.g., poultry, hog, or dairy barns). Vegetative buffers can provide two key benefits in mitigating common negative impacts from indoor housing operations:

Dust mitigation: Vegetative buffers act as a filter by collecting dust on the surface of leaves and needles. They also change airflow patterns, which can reduce the amount of dust blowing onto neighbouring properties.

Odour mitigation: Odour plumes typically occur at ground level and often are absorbed or carried on airborne particulates. Vegetative buffers can reduce odours in the same way that they reduce dust levels: by capturing particles and by changing airflow patterns, which reduces particle travel and improves dilution in the atmosphere. Visual screening has been shown to reduce the perception of odour[4], which is an important aspect of odour mitigation.

The following summary provides recommendations and rationale for designing vegetative buffers for indoor housing operations. Figure 10 illustrates these design components.

Figure 9: A four year old vegetative buffer at a poultry operation in Chilliwack planted to address dust and drift onto an adjacent residential neighbourhood

PLANNING TIP

Consider this key question throughout the buffer design process: **How will a vegetative buffer affect my agricultural operation and my neighbours?**

4 Gottfied and Dolan. 2003. The Nose Smells What the Eye Sees. Neuron: Volume 39, Issue 2

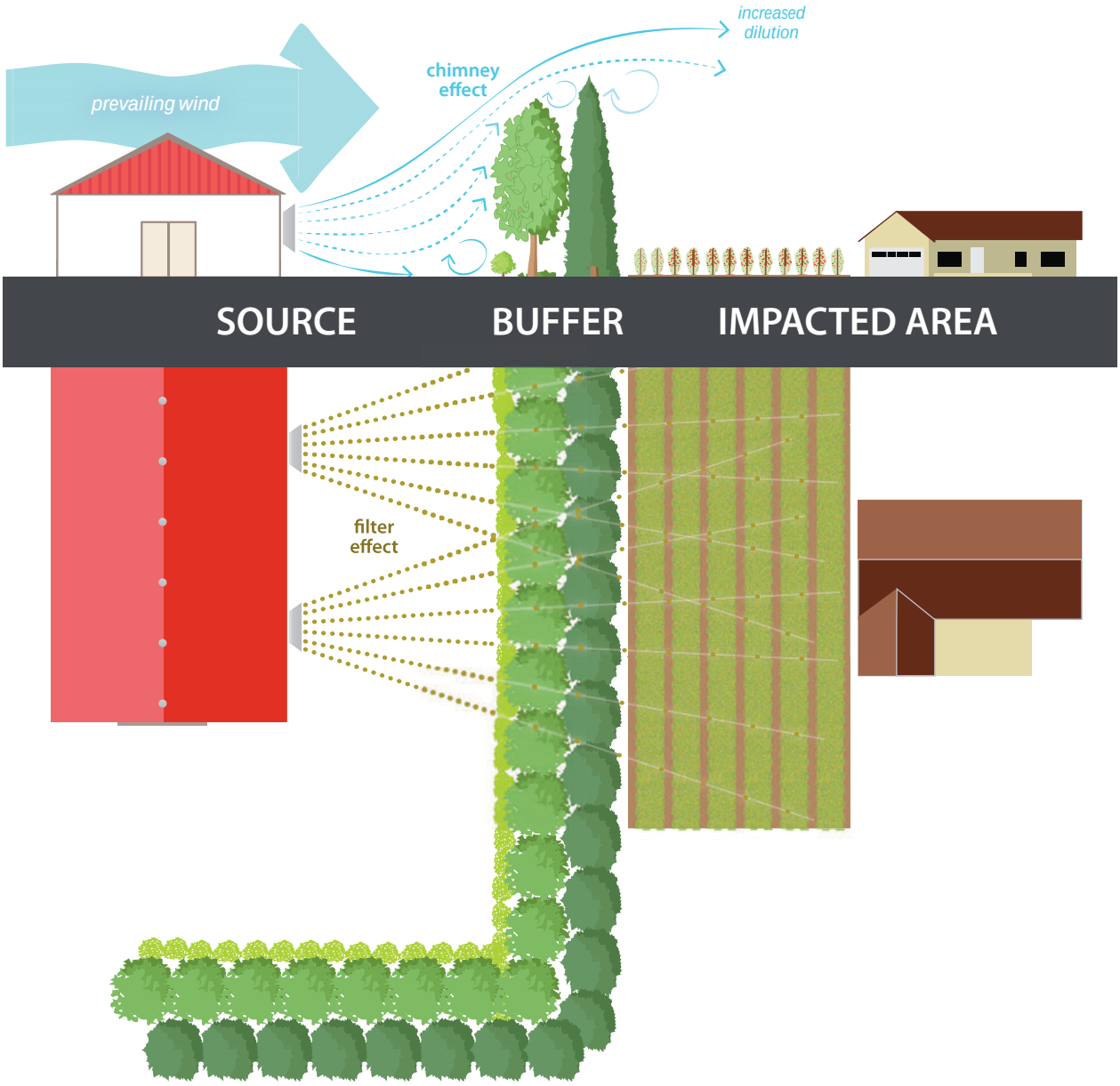


Figure 10: Vegetative buffer design concepts: Livestock – indoor housing

BUFFER DESIGN COMPONENTS | Livestock – indoor housing | Dust and odour mitigation		
BUFFER PLACEMENT		
Siting	**Determine Wind Direction:** Optimal buffer placement is dictated by the direction of the prevailing wind during the season or time of day when dust and odour are of greatest concern. Typically, prevailing winds reverse with season. If dust and odour are a concern during more than one season, plan for a buffer placement that addresses multiple wind directions. The direction and speed of prevailing winds should be determined as the first step of the buffer design process (refer to Appendix 2 for information on how to obtain local wind data). In some cases, the area of concern (impacted area) is not in the direction of the prevailing wind. Rather, it may be affected solely because it is close to the emission source. In this situation, creating a buffer between the source and the impacted area, regardless of the direction of prevailing winds, may be beneficial.	
	Recommendation: Establish a buffer downwind of the emission source. Where proximity of the source to the impacted area has greater influence than the wind, establish the buffer between the source and impacted area, regardless of the wind direction.	**Rationale:** A buffer planted downwind of the emission source will reduce dust and odour by the filter and chimney effects, which result in dilution. The filter and chimney effects can dilute contaminants where proximity of the source and to the impacted area has greater influence than the wind.
	Recommendation: Extend the buffer to create a corner to improve the buffer's effectiveness.	**Rationale:** Incorporating a corner will intercept air that would otherwise escape around the straight edge of a linear buffer. Air funnelled into the corner will be forced through or over the buffer by the filter and chimney effects. Corner buffers provide further benefit when wind direction changes.
	Recommendation: Create an additional buffer upwind of the emission source to provide further benefit. Extending the buffer around the entire barn will further improve effectiveness. Implement only if space and budget allows because the benefit may not be significant.	**Rationale:** A buffer planted upwind of the emission source will act as a windbreak to reduce wind speed on the source property. This will allow more dust and odour to settle on the ground between the source and the buffer.

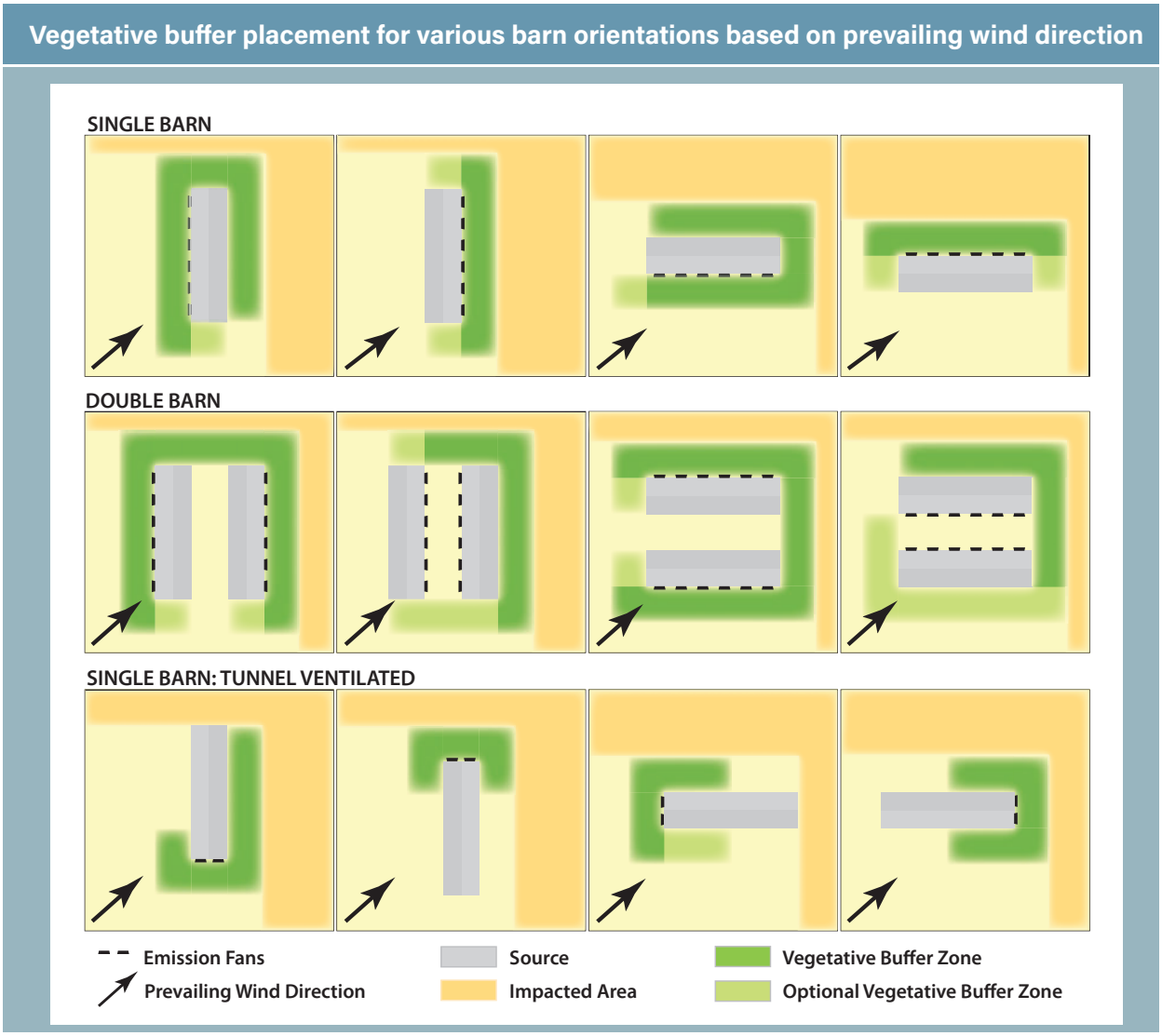
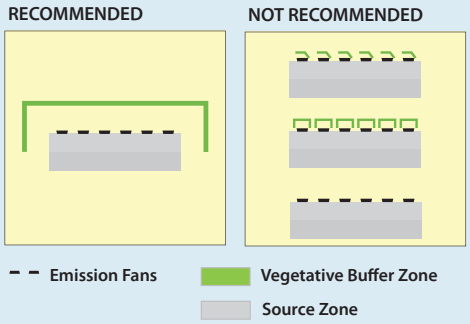
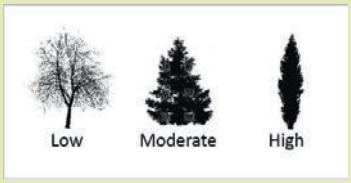
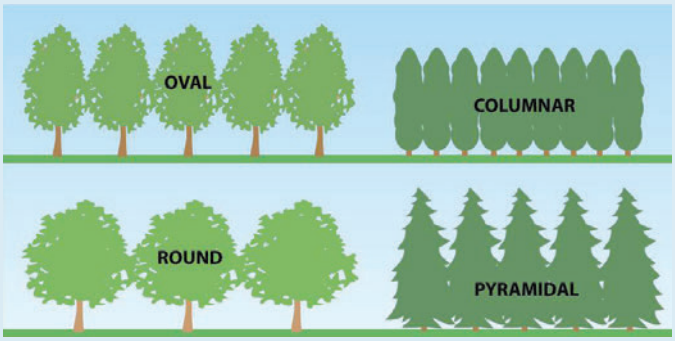
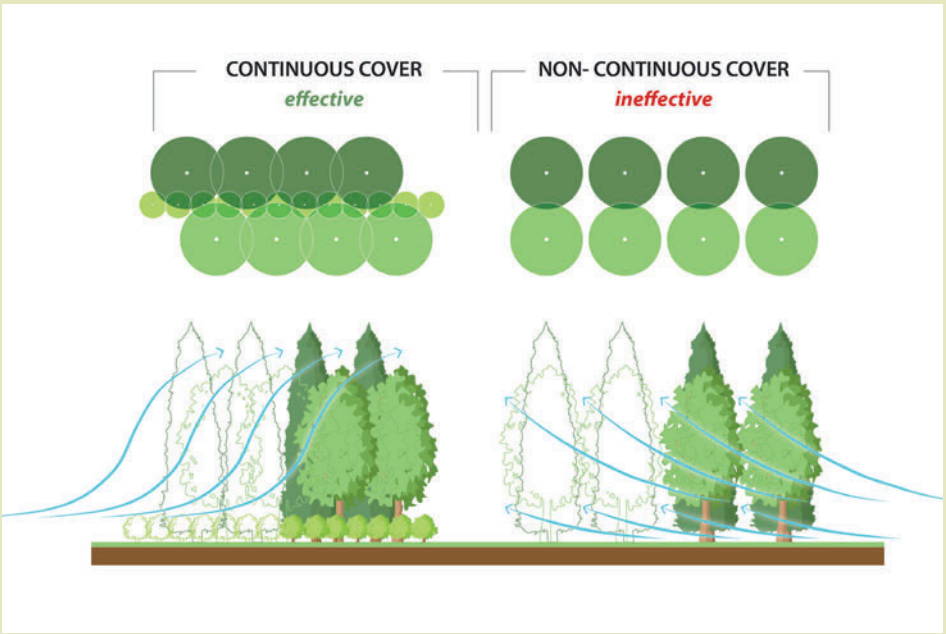


Figure 11: Vegetative buffer placement for various barn orientation based on prevailing wind direction

Setback distance	**Recommendation:** Determine the most effective setback distance that space allows, and on a case-by-case basis. Do not plant the buffer directly in front of the barn or short-segment buffers in front of each fan. These two practices will: ▪ diminish buffer effectiveness and possibly worsen the problem; ▪ compromise barn ventilation (they may cause back pressure on the fans); and ▪ negatively impact tree health (they may cause tree decline due to excessive dust accumulation and constant temperature changes).  	**Rationale:** The setback distance is the distance between the emission source and the buffer. Modelling research conducted for this project indicated that buffer effectiveness increased with increasing setback distance; however, the optimal setback distance is very site specific. As setback distance increases, the filter effect diminishes and the buffer primarily provides the chimney effect (dilution). Mature tree height must increase with increased setback distance in order for the buffer to intercept the full height of the plume. Buffers planted directly in front of barn fans are less effective. In this case, the plume blows directly onto the buffer, becomes very turbulent, and flows over or around the buffer. Minimal filtering or dilution occurs. In reality, setback distance is often dictated by available space. When space is limited, buffers are best placed along the perimeter of the property to affect wind patterns, reduce overall wind speeds, and increase contaminant deposition on the source property.
BUFFER DIMENSION		
Height	**Recommendation:** Establish a mature buffer height that roughly corresponds to a 45 degree angle or higher from the bottom of the fan or fan hood to the height of the trees at maturity.	**Rationale:** Some air will be forced over the tree buffer. The buffer height should be sufficient to allow the chimney effect to carry emissions as high as possible over the impacted area and mix with prevailing winds, which will dilute the plume.
Length	**Recommendation:** Extend the buffer the full length of the barn to a point roughly 45 degrees to the corner of the barn and then perpendicularly (to create a corner) to at least half the width of the barn. Creation of a one-directional linear buffer is not recommended.	**Rationale:** Buffer length should be sufficient to intercept and capture emissions from all fans. Incorporating a corner will intercept air that would otherwise escape around the straight edge of a linear buffer. Air funnelled into the corner will be forced through or over the buffer by the filter and chimney effects. Corner buffers provide further benefit when wind direction changes.
Width (number of rows)	**Recommendation:** Plant at least one row, preferably with an evergreen species. Ideally, plant more rows with evergreen or deciduous species, and if possible, select a different species for each row. However, if space is limited, plant a single row of evergreens.	**Rationale:** A wider buffer will allow more filtering to occur as air flows through the buffer. The most effective buffers have multiple rows. A three-row buffer, with at least one evergreen row and one taller deciduous row, is ideal. Planting deciduous and evergreen species in two or more rows provides a greater range of canopy density and structural variability, which slows airflow forcing it up through the buffer. Using more than one species enhances filtering capacity, moderates airflow, and reduces losses if one species succumbs to a pest or disease.

TREE AND SHRUB SELECTION		
Site suitability	**Recommendation:** Select tree and shrub species that are suitable to the site conditions. Section 6 – Tree and Shrub Gallery provides further information on selecting species, and includes a list of species that are suitable for the climates of the South Coast and Southern Interior regions of British Columbia.	**Rationale:** Ensuring compatibility between tree species and site conditions is critical for the long-term growth of a healthy buffer. Choose species that: ▪ thrive in the local climate; ▪ have low susceptibility to pests, wildlife, and diseases; ▪ are not toxic to nearby livestock and are not hosts for diseases that could affect nearby crops; and ▪ tolerate the site conditions (e.g., light, moisture, soils, drainage).
Seasonality	**Recommendation:** For situations where the tree canopy of a vegetative buffer is needed year round or specifically during winter months, plant at least one evergreen row. **Recommendation:** For upwind buffers where a winter tree canopy is not required, use either deciduous or evergreen species.	**Rationale:** Evergreen tree canopies provide year-round cover because they do not shed their needles or leaves. Once deciduous trees lose their leaves, the surface area available for air interception is greatly reduced. **Rationale:** In summer, both evergreen and deciduous species provide shading, microclimate, and windbreak benefits.
Canopy density (porosity)	**Recommendation:** Use a species that has a moderate tree canopy density. Avoid species that have a low or very high canopy density. 	**Rationale:** Moderate tree canopy density is optimal because it allows some air passage and filtering to occur. Low-density canopies allow too much air passage, which reduces buffer filtration and overall effectiveness. Very high-density canopies (or solid barriers, such as a wall) are less permeable and force most of the air up and over the buffer. This leads to downwash, which traps dust and odour on the opposite side of the buffer.
	Recommendation: When planting more than one row, incorporate a tall, low canopy density species (deciduous) to provide additional benefits.	**Rationale:** An extra row of trees with low canopy density (e.g., deciduous species) can enhance the buffer's capacity to moderate and filter airflow. Tall, more porous canopies allow more airflow through the upper canopy and mixing with the prevailing winds overhead. This reduces the likelihood of contaminants recirculating in the air cavity on the opposite side of the buffer. Using multiple tree species with varied canopy densities allows more air to pass through the buffer, which enhances filtration capacity.

Growth pattern	**Recommendation:** Use at least one columnar or pyramidal shaped species. If gaps form between the base of the tree and the ground, plant a row of shrubs to close the gap.	**Rationale:** Continuous cover to the ground is important. Low gaps between the ground and the base of the tree allow ground level emissions to pass through without being intercepted. Over time, some tree species naturally shed their lowest branches; therefore, a row of shrubs should be planted to close the gap.
		
Growth rate and longevity	**Recommendation:** Consider planting tree species that have moderate growth rates, which may be preferable to using slow- or fast-growing species.	**Rationale:** Often, fast-growing tree species have shorter lifespans and are prone to weak wood and thus breakage. If you plan to plant a fast-growing species (e.g., poplar), it should be used with a moderate- or slow-growing species (e.g., excelsa cedar) to extend the lifespan of the buffer. If a fast-growing species is planted next to a slow-growing species, plant the slow-growing species along the south or west side of the buffer unless it is shade tolerant. This will ensure that the fast-growing species does not shade out the slow-growing species. Site characteristics such as soil type and flooding or drought can greatly influence growth rates, which is why choosing site-suitable species and appropriate tree spacing is so important.

PLANTING CONFIGURATION		
Tree spacing	**Recommendation:** Space trees according to the guidelines listed in Section 6 – Tree and Shrub Gallery or as recommended by a landscape contractor.	**Rationale:** To maximize effectiveness, buffer vegetation should be planted close enough to form continuous cover when it is mature. Appropriate inter-tree spacing is based on the tree species used. Trees planted too close together will compete for limited resources (i.e., water and light), which will result in thinner canopies, weaker tree structure, branch dieback, and possibly tree mortality. Spacing distances are provided in Section 6 - Tree and Shrub Gallery. It is critical to follow minimum spacing guidelines.
Row spacing	**Recommendation:** Ensure row spacing is sufficient to accommodate the mature width of each tree species while allowing the crowns to overlap somewhat at maturity. Exact row spacing depends on the tree species and site conditions.	**Rationale:** Continuous tree cover provides greater effectiveness by minimizing gaps that would allow air to pass through the buffer without being intercepted.
	Recommendation: Plant trees in a staggered pattern relative to adjacent rows.	**Rationale:** Staggering trees minimizes gaps while the buffer is still immature and ensures continuous cover is achieved once maturity is reached.
		

Secondary objectives

Vegetative buffers can provide numerous auxiliary benefits. Some common secondary objectives and associated design considerations are described in this section.

Visual screening/aesthetics: Out of sight is out of mind; vegetative buffers block unsightly structures or operational practices and improve aesthetics, which contributes to good neighbour relations.

Energy efficiency: Energy savings can be achieved by strategically planting trees to lower heating and cooling costs. During the summer, shade from trees reduces air temperature, which can lower indoor cooling costs. Windbreaks can block harsh winter winds, which can lower indoor heating costs, and can limit the potential for farm structures to be damaged. Shelter from summer sun and winter winds helps moderate the environment around the farm operation for both people and livestock.

Noise and light reduction: Increased density of branches and leaves results in greater scattering of sound waves and shading of artificial light.

Biodiversity and habitat enhancement: Vegetative buffers can be designed to enhance biodiversity values. Refer to the applicable Environmental Farm Plan companion documents for further information.

The following summary provides recommendations and rationale for buffer designs related to the secondary objectives.

VISUAL SCREENING/ ASTHETICS	Walk the property perimeter to determine the best buffer placement to effectively screen the area of concern. Consult adjacent property owners.
ENERGY EFFICIENCY Summer cooling	Plant trees on the south, southeast, and southwest sides of the impacted area (e.g., barn). Appendix 3 provides a shade distance calculator which can be used to determine the setback distance needed between the buffer and impacted area to maximize the shade benefit of the mature trees. Planting trees too close to the impacted area/building may impede airflow and ventilation. Other potential risks to consider include root damage to foundations and branch breakage or tree failure onto buildings. Deciduous trees provide wide, spreading canopies, which maximize shade during warm months.
ENERGY EFFICIENCY Winter shelter	Plant trees upwind (winter prevailing wind) to slow prevailing winds before they reach the impacted area (e.g., barn). Windbreaks provide protection for a distance up to 10 times the tree height on the downwind side. Maximum protection occurs when windbreaks are located at distances that are five times the tree height. Evergreen coniferous trees with moderate to high canopy density are best because they retain their needles all year, which provides year-round shelter.
NOISE REDUCTION	Vegetative noise buffers are effective only when properly designed. Poor design can increase the perception of noise. The buffer should be within 15 m (50 ft) of the noise source (preferably) or within 15 m of the impacted area. Noise reduction will occur only if the buffer is wide enough to completely block the view between the source and the impacted area. Combining a solid barrier (e.g., fence, soil berm) with a vegetative buffer will yield greater results. Tall, evergreen tree species with canopies to the ground and high canopy density are recommended.
LIGHT REDUCTION	Plant trees close to the light source. Multiple rows and a wide, dense tree buffer will provide the greatest benefit. Tall, evergreen tree species with canopies to the ground and high canopy density are recommended.
BIODIVERSITY AND RIPARIAN ENHANCEMENT	Vegetative buffers provide numerous opportunities to increase biodiversity and riparian enhancement. For more information and specific guidelines, refer to the applicable Environmental Farm Plan companion documents. Keep in mind the potential to create habitat for vermin and pests, or to create suitable habitat for disease transmission.

4 BUFFER DESIGN: LIVESTOCK – OUTDOOR

PLANNING OVERVIEW

Five steps are involved in planning and establishing a vegetative buffer:

1. **Evaluate Opportunities**
   determine buffer objectives (see Section 1)
2. **Site Assessment**
   assess the site and potential interactions between the buffer and the site (see Section 9)
3. **Design**
   design the buffer to meet objectives while addressing and accounting for site conditions (see Section 3)
4. **Implementation**
   carry out site preparation, planting and irrigation (see Section 7)
5. **Maintenance and Monitoring**
   maintain and monitor the buffer over time to ensure it thrives (see Section 7)

BUFFER DESIGN

Prior to designing a vegetative buffer, ensure the first two planning steps have been completed: evaluate opportunities and conduct a site assessment using the forms in Section 9. Review the principles of vegetative buffers in Section 2.

The design process can be divided into four sequential components:

1. **Buffer Placement**
   a. siting in relation to the prevailing wind and impacted area
   b. setback distance relative to the emission source
2. **Buffer Dimensions**
   optimal height, length, width
3. **Tree and Shrub Selection**
   species suitability, seasonality, canopy density, growth pattern, and growth rate
4. **Planting Configuration**
   tree spacing and row spacing

Primary objectives

This section describes optimal vegetative buffer design to address dust and odour from cattle feedlots, dairies, livestock grazing pastures, or manure storage facilities. Dust may originate from gravel roads, crop harvesting, feedlots, or pastures with exposed soil.

Vegetative buffers provide two key benefits in mitigating common negative impacts of open containment livestock operations:

Dust mitigation: Vegetative buffers act as a filter by collecting dust on the surface of leaves and needles. They also change airflow patterns, which can reduce the amount of dust that blows onto neighbouring properties due to dilution in the wind.

Odour mitigation: Odour plumes typically occur at ground level and often are absorbed or carried on airborne particulates or in gases. Vegetative buffers can reduce odours in the same way that they reduce dust levels: by capturing particles and changing airflow patterns to reduce emissions and improve dilution in the atmosphere. Visual screening reduces the perception of odour[5], which is an important aspect of odour mitigation.

The following summary provides recommendations and rationale for designing vegetative buffers for outdoor livestock operations. Figure 13 illustrates these design components.

Figure 12: A newly planted vegetative buffer at a pasture raised pork operation in Armstrong to address odour drift towards neighbours as well as provide a visual screen. Wire cages are to protect from deer browse.

PLANNING TIP

Consider this key question throughout the buffer design process: **How will a vegetative buffer affect my agricultural operation and my neighbours?**

TOPOGRAPHY

Take into account local topography when determining buffer placement, height, and canopy density. Airflow uphill or downhill of an outside livestock area can lead to a greater concentration of dust or odour in the impacted area (i.e., your neighbour's property).

5 Gottfied and Dolan. 2003. The Nose Smells What the Eye Sees. Neuron: Volume 39, Issue 2

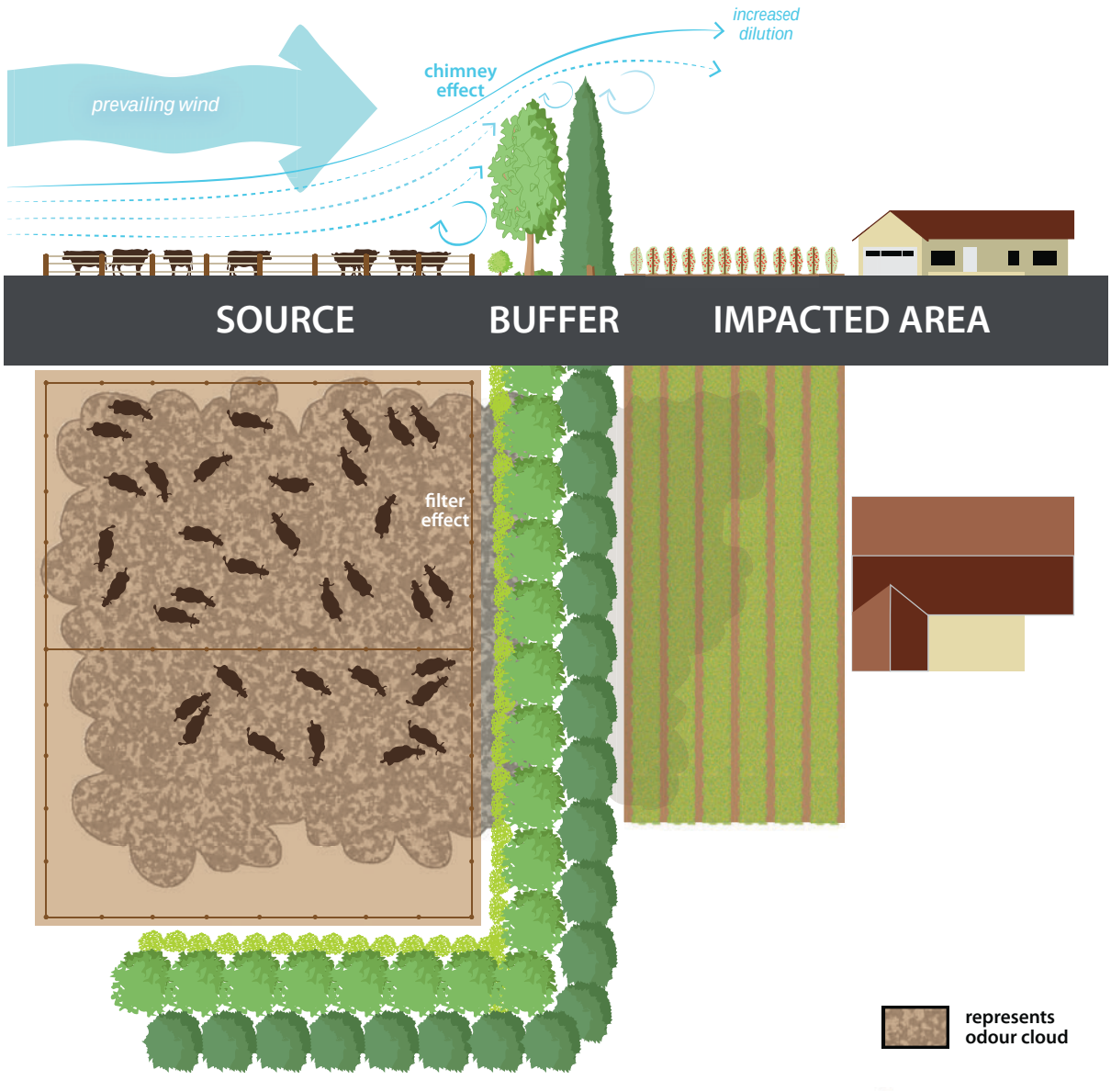
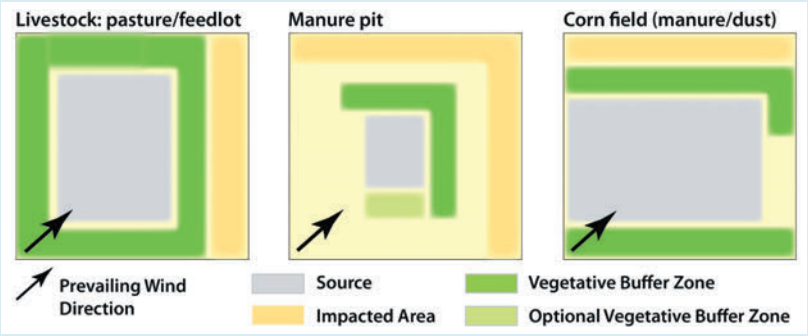
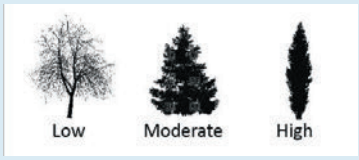
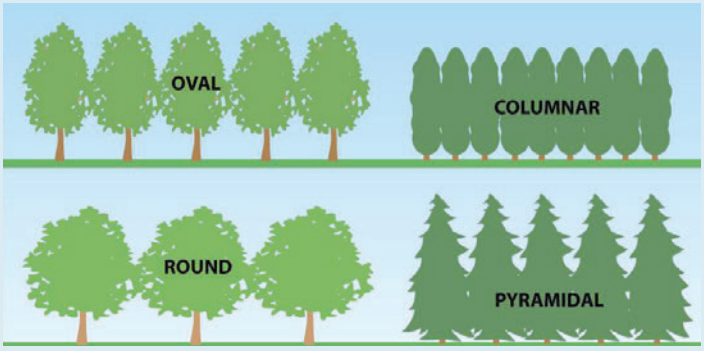
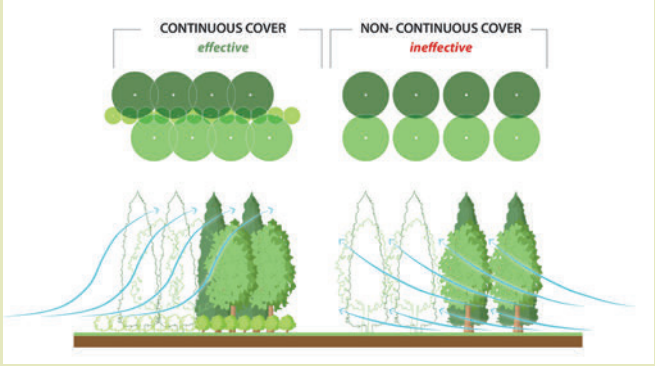


Figure 13: Vegetative buffer design concepts: Livestock – outdoor.

BUFFER DESIGN COMPONENTS | Livestock – outdoor | Dust and odour mitigation		
BUFFER PLACEMENT		
Siting	**Determine Wind Direction:** Optimal buffer placement is dictated by the direction of the prevailing wind during the season or time of day when dust and odour are of greatest concern. Typically, prevailing winds reverse with season. If dust and odour are a concern during more than one season, plan for buffer placement that addresses multiple wind directions. The direction and speed of prevailing winds should be determined as the first step of the buffer design process (refer to Appendix 2 for information on how to obtain local wind data). In some cases, the area of concern (impacted area) is not in the direction of the prevailing wind. Rather, it may be affected solely because it is close to the source of dust and odour. In this situation, creating a buffer between the source and the impacted area, regardless of the direction of the prevailing winds, may be beneficial.	
	Recommendation: Establish a buffer downwind of the emission source.	**Rationale:** A buffer planted downwind of the emission source will reduce dust and odour by the filter and chimney effects, which result in dilution.
	Recommendation: Extend the buffer to create a corner to improve the buffer's effectiveness.	**Rationale:** Incorporating a corner will intercept air that would otherwise escape around the straight edge of a linear buffer. Air funnelled into the corner will be forced through or over the buffer by the filter and chimney effects. Corner buffers provide further benefit when wind direction changes.
	Recommendation: Establish an additional buffer 15-30 m (50-100 ft) upwind of the dust and odour source only if a buffer is also being used on the downwind side. Extending the buffer around the odour source will further improve its effectiveness. Implement only if space and budget allows because the benefit may not be significant.	**Rationale:** A buffer planted upwind of the contaminant source will act as a windbreak to reduce wind speed on the source property. This will allow dust and odour to settle on the source property and become increasingly concentrated over time. If there is no downwind buffer, the concentrated dust and odour may be blown directly to the impacted area (e.g., neighbour) when wind speed eventually increases.
	Recommendation: Avoid planting a windbreak (upwind side of the property) where it may cause greater concentrations of air to build up on the source property.	**Rationale:** When dust or odour accumulates due to a windbreak, there is a risk that the air will be carried to the impacted area in greater concentration during the next wind event.
Visual screening	**Recommendation:** Where space allows, plant a buffer around the entire perimeter of the odour source. If space is limited, position the buffer between the odour source and the impacted area (e.g., neighbour) to provide visual screening.	**Rationale:** Planting between the source and the impacted area increases buffer effectiveness by creating a visual screen, which reduces the perception of odour.

BUFFER DIMENSION		
	Vegetative buffer placement for outdoor livestock scenarios based on prevailing wind direction	
Height	**Recommendation:** Select tree species that will be tall at maturity (ideally > 15 m [50 ft]). **Recommendation:** Consider the influence of local topography in relation to the optimal buffer height.	**Rationale:** Dust and odour particles originating from open areas can be lifted high into the air or travel along topography depending on weather conditions. Taller species will enable greater air interception and filtration. The taller the tree buffer, the higher the plume will be lifted and diluted in the prevailing wind, and it is less likely that dust and odour will be deposited on the impacted area. **Rationale:** Large hills can change normal wind patterns. If the source area is located downhill of the prevailing wind, the plume will be lower to the ground; therefore, less buffer height is needed. If the impacted area is uphill of the source, the plume may follow the natural topography to the impacted area. During periods of minimal wind, dust and odour may not disperse. The buffer must be as tall as possible to force air high enough to pass over the uphill impacted area.
Length	**Recommendation:** Extend the buffer at least the length of the source area or longer if space and budget allows. **Recommendation:** Further extend the buffer at a 90 degree angle to create a corner. Creation of a one-directional linear buffer is not recommended.	**Rationale:** Dust and odour particles originating from open environments can travel significant horizontal distances depending on current weather conditions. **Rationale:** Incorporating a corner will intercept air that would otherwise escape around the straight edge of a linear buffer. Air funnelled into the corner will be forced through or over the buffer by the filter and chimney effects. Corner buffers provide further benefit when wind direction changes.
Width (number of rows)	**Recommendation:** Plant at least one row, preferably an evergreen species. Ideally, plant more rows with evergreen or deciduous species, and if possible, select a different species for each row. However, if space is limited, plant a single row of evergreens.	**Rationale:** A wider buffer allows more filtering to occur as air flows through the buffer. The most effective buffers have multiple rows. A three-row buffer is ideal. Planting deciduous and evergreen species in two or more rows provides a greater range of canopy density and structural variability, which slows down airflow and forces it up through the buffer. Using more than one species enhances filtering capacity, moderates airflow, and reduces losses if one species succumbs to a pest or disease outbreak.
	Recommendation: In the front (or first row), use shrubs or trees with dense canopies that reach the ground.	**Rationale:** Ground-level buffer density must be maximized or else ground-level emissions will pass through the gap below the buffer. Odour and dust in open livestock areas are generated at the ground and travel easily at the ground level. A high canopy density buffer at or near ground level will capture a significant section of the plume and will help control deposition behind the buffer. Trees with very low canopy density or buffers with gaps at the base should be avoided.

TREE AND SHRUB SELECTION		
Site suitability	**Recommendation:** Select tree and shrub species that are suitable to the site conditions. Section 6 – Tree and Shrub Gallery provides further information on selecting species, and includes a list of species that are suitable for the climates of the South Coast and Southern Interior regions of British Columbia.	**Rationale:** Ensuring compatibility between tree species and site conditions is critical for the long-term growth of a healthy buffer. Choose species that: ▪ thrive in the local climate; ▪ have low susceptibility to pests, wildlife, and diseases; ▪ are not toxic to nearby livestock and are not hosts for diseases that could affect nearby crops; and ▪ tolerate site conditions (e.g., light, moisture, soils, drainage)
Seasonality	**Recommendation:** For situations where the tree canopy of a vegetative buffer is needed year round or specifically during winter months, plant at least one evergreen row.	**Rationale:** Evergreen tree canopies provide year-round cover because they do not shed their needles or leaves. After deciduous trees lose their leaves, the surface area available for air interception is greatly reduced.
	Recommendation: For upwind buffers where a winter tree canopy is not required, use either deciduous or evergreen species.	**Rationale:** In summer, both evergreen and deciduous species provide shading, microclimate, and windbreak benefits.
Canopy density (porosity)	**Recommendation:** Use a species that has a moderate to high tree canopy density; 60% canopy density is ideal. Avoid species that have a low or very high canopy density.  	**Rationale:** Moderate to high tree canopy density is optimal because it allows some air passage and filtering to occur. Low-density canopies allow too much air passage, which reduces buffer filtration and overall effectiveness. Very high-density canopies (or solid barriers such as a wall) are less permeable and force most of the air up and over the buffer. This leads to downwash, which traps dust and odour on the opposite side of the buffer.
	Recommendation: When planting more than one row, incorporate a tall species with low canopy density (deciduous) to provide further benefit.	**Rationale:** An extra row of trees with low canopy density (deciduous species) can enhance the buffer's capacity to moderate and filter airflow. Tall, more porous canopies allow more airflow through the upper canopy and mixing with prevailing winds. This reduces the likelihood of contaminants recirculating in the air cavity on the opposite side of the buffer. Using multiple species with varied canopy densities allows more air to pass through the buffer, enhancing filtration capacity.
Growth pattern	**Recommendation:** Use at least one columnar or pyramidal shaped species. If gaps form between the base of the tree and the ground, plant a row of shrubs to close the gap.	**Rationale:** Continuous cover to the ground is important. Low gaps between the ground and the base of the tree allow ground-level emissions to pass through without being intercepted. This is especially important for outdoor livestock operations because the air tends to flow at ground level. Over time, some tree species naturally shed their lowest branches; therefore, a row of shrubs should be planted to close the gap.

Growth pattern		
Growth rate and longevity	**Recommendation:** Consider planting tree species with moderate growth rates, which may be preferable to using slow- or fast-growing species.	Rationale: Often fast-growing tree species have shorter lifespans and are prone to having weak wood and thus breakage. If you plan to plant a fast-growing species (e.g., poplar), it should be used with a moderate- or slow-growing species (e.g., excelsa cedar) to extend the lifespan of the buffer. If a fast-growing species is planted next to a slow-growing species, plant the slow-growing species along the south or west side of the buffer unless it is shade tolerant. This will ensure that the fast-growing species does not shade out the slow-growing species. Site characteristics such as soil type and flooding or drought can greatly influence growth rates, which is why choosing site-suitable species and appropriate tree spacing is so important.
PLANTING CONFIGURATION		
Tree spacing	**Recommendation:** Space trees according to the guidelines listed in Section 6 – Tree and Shrub Gallery or as recommended by a landscape contractor.	**Rationale:** To maximize effectiveness, buffer vegetation should be planted close enough to form continuous cover when it is mature. Appropriate inter-tree spacing is based on the tree species used. Trees planted too close together will compete for limited resources (i.e., water and light), which will result in thinner canopies, weaker tree structure, branch dieback, and possibly tree mortality. Spacing distances are provided in Section 6 - Tree and Shrub Gallery. It is critical to follow minimum spacing guidelines.
Row spacing	**Recommendation:** Ensure row spacing is sufficient to accommodate the mature width of each tree species while allowing the crowns to overlap somewhat at maturity. Exact row spacing depends on the tree species and site conditions.	**Rationale:** Continuous tree cover provides greater effectiveness by minimizing gaps that would allow air to pass through the buffer without being intercepted.
	Recommendation: Plant trees in a staggered pattern relative to adjacent rows.	**Rationale:** Staggering trees minimizes gaps while the buffer is still immature and ensures continuous cover is achieved once maturity is reached.
		

Secondary objectives

Vegetative buffers can provide numerous auxiliary benefits. Some common secondary objectives and associated design considerations are described in this section.

Visual screening/aesthetics: Out of sight is out of mind; vegetative buffers block unsightly structures or operational practices and improve aesthetics, which contributes to good neighbour relations.

Energy efficiency: Energy savings can be achieved by strategically planting trees to lower heating and cooling costs. During the summer, shade from trees reduces air temperature, which can lower indoor cooling costs. Windbreaks can also block harsh winter winds, which can lower indoor heating costs, and can limit the potential for farm structures to be physically damaged. Shelter from summer sun and winter winds helps moderate the environment around the farm operation for both people and livestock.

Noise and light reduction: Increased density of branches and leaves results in greater scattering of sound waves and shading of artificial light.

Biodiversity and habitat enhancement: Vegetative buffers can be designed to enhance biodiversity values. Refer to the applicable Environmental Farm Plan companion documents for further information.

The following summary provides recommendations and rationale for buffer designs related to the secondary objectives.

VISUAL SCREENING/ ASTHETICS	Walk the property perimeter to determine the best buffer placement to effectively screen the area of concern. Consult adjacent property owners.
ENERGY EFFICIENCY Summer cooling	Plant trees on the south, southeast, and southwest sides of the impacted area (e.g., barn). Appendix 3 provides a shade distance calculator which can be used to determine the setback distance needed between the buffer and the impacted area to maximize the shade benefit of the mature tree. Planting trees too close to the impacted area/building may impede airflow and ventilation. Other potential risks to consider include root damage to foundations and branch breakage or tree failure onto buildings. Deciduous trees provide wide, spreading canopies, which maximize shade during warm months.
ENERGY EFFICIENCY Winter shelter	Plant trees upwind (winter prevailing wind) to slow prevailing winds before they reach the impacted area (e.g., barn). Windbreaks provide protection for a distance up to 10 times the tree height on the downwind side. Maximum protection occurs when windbreaks are located at distances that are five times the tree height. Evergreen coniferous trees with moderate to high canopy density are best because they retain their needles in the winter, which provides year-round shelter.
NOISE REDUCTION	Vegetative noise buffers are only effective when they are properly designed. Poor design can increase the perception of noise. The buffer should be within 15 m (50 ft) of the noise source (preferably) or within 15 m of the impacted area. Noise reduction will occur only if the buffer is wide enough to completely block the view between the source and the impacted area. Combining a solid barrier (e.g., fence, soil berm) with a vegetative buffer will yield greater results. Tall, evergreen tree species with canopies to the ground and high canopy density are recommended.
LIGHT REDUCTION	Plant trees close to the light source. Multiple rows and a wide, dense tree buffer will provide the greatest benefit. Tall, evergreen tree species with canopies to the ground and high canopy density are recommended.
BIODIVERSITY AND RIPARIAN ENHANCEMENT	Vegetative buffers provide numerous opportunities to increase biodiversity and riparian enhancement. For more information and specific guidelines, refer to the applicable Environmental Farm Plan companion documents. Keep in mind the potential to create habitat for vermin and pests, or to create suitable habitat for disease transmission.

5 BUFFER DESIGN: OUTDOOR CROPS

PLANNING OVERVIEW

Five steps are involved in planning and establishing a vegetative buffer:

1. **Evaluate Opportunities**
   determine buffer objectives (see Section 1)
2. **Site Assessment**
   assess the site and potential interactions between the buffer and the site (see Section 9)
3. **Design**
   design the buffer to meet objectives while addressing and accounting for site conditions (see Section 5)
4. **Implementation**
   carry out site preparation, planting and irrigation (see Section 7)
5. **Maintenance & Monitoring**
   maintain and monitor the buffer over time to ensure it thrives (see Section 7)

BUFFER DESIGN

Prior to designing a vegetative buffer, ensure the first two planning steps have been completed: evaluate opportunities and conduct a site assessment using the forms in Section 9. Review the principles of vegetative buffers in Section 2.

The design process can be divided into four sequential components: Primary objectives

1. **Buffer Placement**
   a. siting in relation to the prevailing wind and impacted area
   b. setback distance relative to the emission source
2. **Buffer Dimensions**
   optimal height, length, width
3. **Tree and Shrub Selection**
   species suitability, seasonality, canopy density, growth pattern, and growth rate
4. **Planting Configuration**
   tree spacing and row spacing

Primary objectives

This section describes optimal vegetative buffer design to address pesticide drift. Pesticide drift may be a concern where a conventional farm is located near an organic farm or near residential neighbours. Two scenarios may need to be addressed: (1) pesticide drifting off a farm, or (2) pesticide drift being received from a neighbour's farm.

Spray drift occurs when spray droplets are transported by air currents during pesticide application. Vegetative buffers intercept and capture spray droplets. Research has shown that with a proper design, a vegetative buffer can reduce pesticide drift by 50-90%.

Although vegetative buffers can help mitigate pesticide drift, they are no substitute for proper adherence to pesticide application Beneficial Management Practices and regulations. This includes understanding the spray equipment specifications and calibration procedures, pesticide label requirements and application recommendations.

The following summary provides recommendations and rationale for designing vegetative buffers for outdoor crops. Figure 16 illustrates these design components.

Figure 14: A newly planted vegetative buffer at an organic vineyard in Kelowna to address pesticide drift from an adjacent conventional orchard. The wire cages are to protect the trees from deer browse.

PLANNING TIP

Consider this key question throughout the buffer design process: **How will a vegetative buffer affect my agricultural operation and my neighbours?**

Figure 15: Spray card to evaluate pesticide drift

PLANNING TIP

A USEFUL TOOL

Water-sensitive spray cards are useful for determining the degree and extent of pesticide spray drift. Place the cards throughout the area of concern before a spray event.

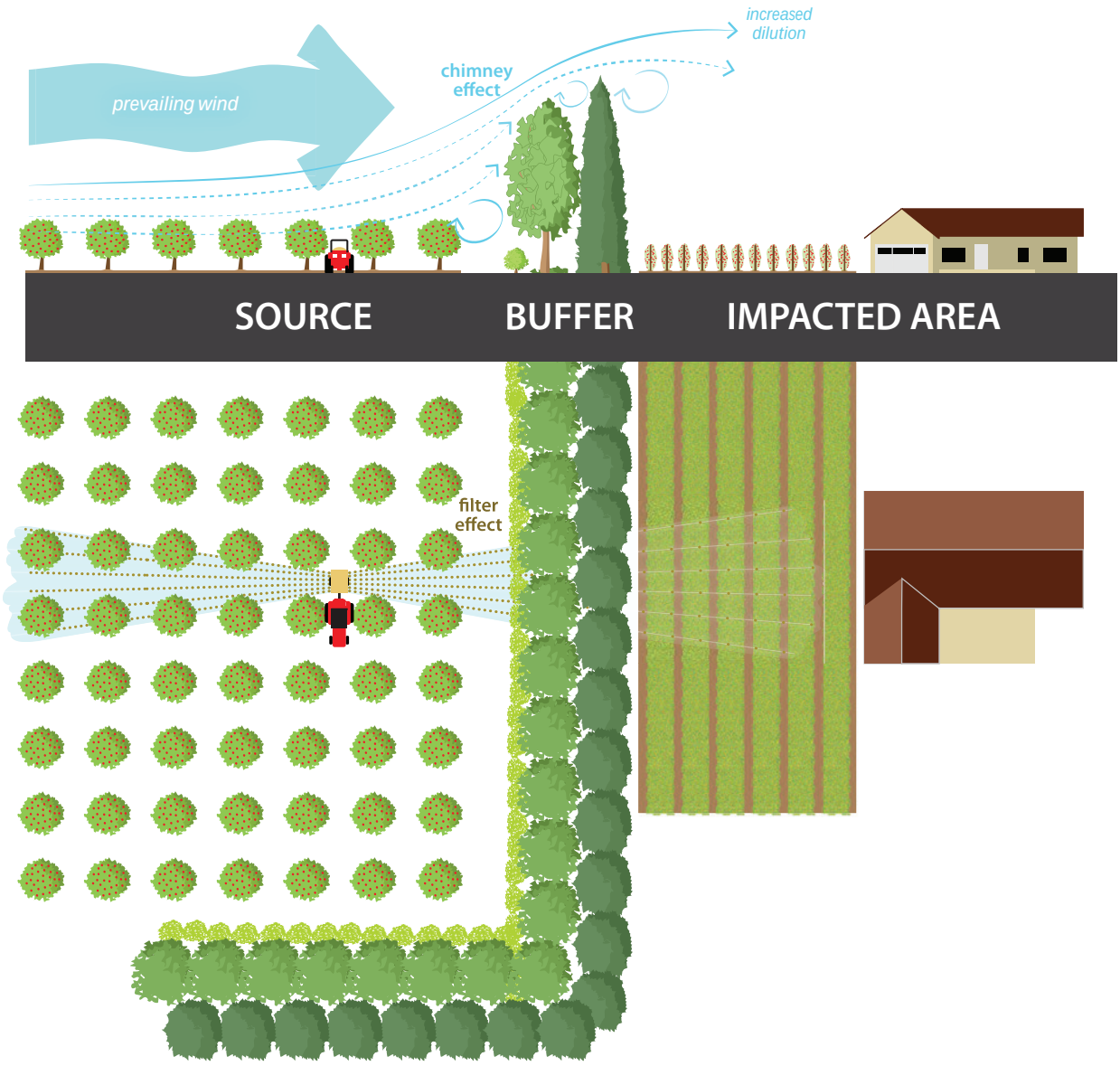
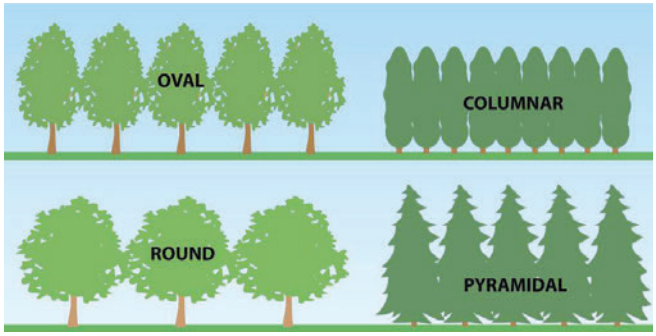


Figure 16: Vegetative buffer design concepts: Outdoor crops

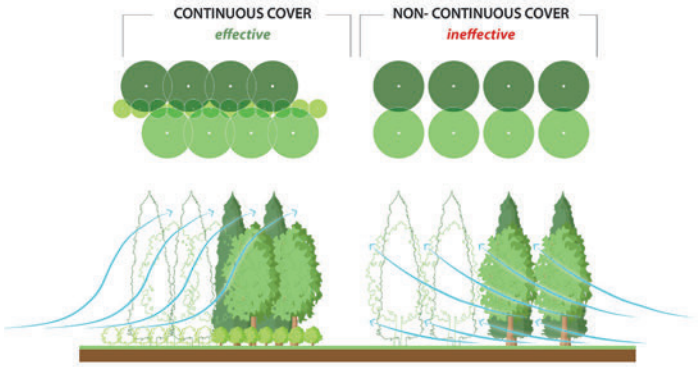
BUFFER DESIGN COMPONENTS | Outdoor crops | Pesticide drift reduction		
BUFFER PLACEMENT		
Siting	**Wind Considerations:** Drift occurs mainly from the normal operation of the sprayer. Most operators spray during light, stable wind conditions. However, if operators typically spray during higher wind speeds, then wind direction and speed need to be considered when determining buffer placement (refer to Appendix 2 for information on how to obtain local wind data).	
	Recommendation: Locate the buffer between the source zone and impacted area.	**Rational:** Trees planted between the source and impacted area reduce drift due to the filter and chimney effects, which results in dilution.
	Recommendation: Use vegetative buffers as a windbreak to reduce wind speed on the site being sprayed. Adding a buffer upwind of the emission source can further reduce concerns.	**Rationale:** Planting a buffer upwind of the spray drift allows more drift to stay on target and settle on the property between the source and the buffer.
	Recommendation: Extend the buffer to create a corner to improve the buffer's effectiveness.	**Rationale:** Incorporating a corner will intercept air that would otherwise escape around the straight edge of a linear buffer. Air funnelled into the corner will be forced through or over the buffer by the filter and chimney effects. Corner buffers provide further benefit when wind direction changes.
Setback distance	**Recommendation:** Plant the buffer as close as possible to the spray source.	**Rationale:** Planting close to the spray source ensures more spray droplets will be captured and fewer will be propelled higher into the air and will drift to the impacted area. As the setback distance increases, a taller buffer is needed to intercept drift. For most fruit and vegetable crops, growing space for the buffer is limited due to small property sizes and nearness to neighbours. Plan the buffer to fit within the limited space.
BUFFER DIMENSION		
Height	**Recommendation:** Ensure that the mature buffer is taller than the height of the crop being sprayed. Optimally, the buffer should be at least 1-2 metres taller than the sprayed crop; however, height may have to be restricted to avoid shading adjacent crops.	**Rationale:** Pesticide spray drift has relatively large particles (droplets); therefore, the height of the plume and the distance the drift travels is less than that of smaller particles like dust. If the buffer is too short, pesticide drift will not be intercepted.
Length	**Recommendation:** Create buffers that extend the length of the area in which pesticides are applied. Observe a spray event in progress or strategically hang water-sensitive paper to determine the length of the impacted area.	**Rationale:** A continuous buffer will reduce the amount of pesticide drift passing directly onto the impacted area.
	Recommendation: Further extend the buffer at a 90 degree angle to create a corner. Creation of a one-directional linear buffer is not recommended.	**Rationale:** Incorporating a corner will intercept air that would otherwise escape around the straight edge of a linear buffer. Air funnelled into the corner will be forced through or over the buffer by the filter and chimney effects. Corner buffers provide further benefit when wind direction changes.

Width (number of rows)	**Recommendation:** Plant at least one row, preferably with an evergreen species. Ideally, plant more rows with evergreen or deciduous species, and if possible, select a different species for each row. However, If space is limited, plant a single row of evergreens.	**Rationale:** A wider buffer allows more filtering to occur as air flows through the buffer. The most effective buffers have multiple rows. Planting deciduous and evergreen species in two or more rows provides a greater range of canopy density and structural variability, which slows down airflow and forces it up through the buffer. Using more than one species enhances filtering capacity, moderates airflow, and reduces losses if one species succumbs to a pest or disease outbreak.
TREE AND SHRUB SELECTION		
Site suitability	**Recommendation:** Select tree and shrub species that are suitable to the site conditions. Section 6 – Tree and Shrub Gallery provides further information on selecting species, and includes a list of species that are suitable for the climates of the South Coast and Southern Interior regions of British Columbia.	**Rationale:** Ensuring compatibility between tree species and site conditions is critical for the long-term growth of a healthy buffer. Choose species that: ▪ thrive in the local climate; ▪ are not hosts for diseases that could affect nearby crops; ▪ have low susceptibility to pests, wildlife, and diseases; ▪ are not toxic to nearby livestock; and ▪ tolerate site conditions (e.g., light, moisture, soils, drainage)
Seasonality	**Recommendation:** For situations where the tree canopy of a vegetative buffer is needed year round or specifically during winter months, plant at least one evergreen row.	**Rationale:** Evergreen tree canopies provide year-round cover because they do not shed their needles or leaves. After deciduous trees lose their leaves, the surface area available for air interception is greatly reduced.
	Recommendation: For upwind buffers where a winter tree canopy is not required, use either deciduous or evergreen species.	**Rationale:** In summer, both evergreen and deciduous species provide shading, microclimate, and windbreak benefits.
Seasonality	**Recommendation:** Plant at least one evergreen row.	**Rationale:** Evergreen coniferous species are two to four times more effective at intercepting pesticide drift than are deciduous trees because needles provide a greater surface capture area. Evergreen coniferous tree canopies provide year-round cover because they do not shed their needles. After deciduous trees lose their leaves, the surface area available for air interception is greatly reduced; therefore, deciduous trees may not provide drift interception during early or late season spraying.

Canopy density (porosity)	**Recommendation:** Use a species that have a moderate to high canopy density (50-70%).  	**Rationale:** Pesticide spray drift has relatively larger particles (droplets) than dust that originates from livestock farms. Larger droplets are intercepted by vegetation much more readily than dust, which results in effective filtration. Moderate to high tree canopy density is optimal because it allows some air passage and filtering to occur. Low-density canopies allow too much air passage, which reduces filtration and overall buffer effectiveness. Very high-density canopies (or solid barriers such as a wall) are less permeable and force most of the air up and over the buffer. This leads to downwash, which traps pesticide drift on the opposite side of the buffer.
Growth pattern	**Recommendation:** Use at least one columnar or pyramidal shaped species.	**Rationale:** Continuous cover in the canopy is important for controlling pesticide drift. Gaps in the canopy allow drift to pass through the buffer without being filtered or diluted.
	Recommendation: Plant shrubs and grasses at the base of the buffer to intercept low-level drift from ground-level sprayers.	**Rationale:** Low gaps between the ground and the base of the tree allow ground-level drift to pass through without being intercepted. This is especially important where crops are sprayed at ground level because the pesticide drift will travel along the ground. Over time, some species naturally shed their lowest branches; therefore, a row of shrubs should be planted to close the gap.



Growth rate and longevity	**Recommendation:** Consider planting tree species with moderate growth rates, which may be preferable to using slow- or fast-growing species.	**Rationale:** Often, fast-growing tree species have shorter lifespans and are prone to having weak wood and thus breakage. If you plan to plant a fast-growing species (e.g., poplar), it should be used with a moderate- or slow-growing species (e.g.,excelsa cedar) to extend the lifespan of the buffer. If a fast-growing species is planted next to a slow-growing species, plant the slow-growing species along the south or west side of the buffer unless it is shade tolerant. This will ensure that the fast-growing species does not shade out the slow- growing species. Site characteristics such as soil type and flooding or drought can greatly influence growth rates, which is why choosing site-suitable species and appropriate tree spacing is so important.
PLANTING CONFIGURATION		
Tree spacing	**Recommendation:** Space trees according to the guidelines listed in Section 6 – Tree and Shrub Gallery or as recommended by a landscape contractor.	**Rationale:** To maximize effectiveness, buffer vegetation should be planted close enough to form continuous cover when it is mature. Appropriate inter-tree spacing is based on the tree species used. Trees planted too close together will compete for limited resources (i.e., water and light), which will result in thinner canopies, weaker tree structure, branch dieback, and possibly tree mortality. Spacing distances are provided in Section 6 - Tree and Shrub Gallery. It is critical to follow minimum spacing guidelines.
Row spacing	**Recommendation:** Ensure row spacing is sufficient to accommodate the mature width of each tree species while allowing the crowns to overlap somewhat at maturity. Exact row spacing depends on the tree species and site conditions.	**Rationale:** Continuous tree cover provides greater effectiveness by minimizing gaps that would allow air to pass through the buffer without being intercepted.
	Recommendation: Plant trees in a staggered pattern relative to adjacent rows.	**Rationale:** Staggering trees minimizes gaps while the buffer is still immature and ensures continuous cover is achieved once maturity is reached.



Secondary objectives

Vegetative buffers can provide numerous auxiliary benefits. Some common secondary objectives and associated design considerations are described in this section.

Visual screening/aesthetics: Out of sight is out of mind; vegetative buffers block unsightly structures or operational practices and improve aesthetics, which contributes to good neighbour relations.

Energy efficiency: Energy savings can be achieved by strategically planting trees to lower heating and cooling costs. During the summer, shade from trees reduces air temperature, which can lower indoor cooling costs. Windbreaks can also block harsh winter winds, which can lower indoor heating costs, and can limit the potential for farm structures to be damaged. Shelter from summer sun and winter winds helps moderate the environment around the farm operation for both people and livestock.

Noise and light reduction: Increased density of branches and leaves results in greater scattering of sound waves and shading of artificial light.

Biodiversity and habitat enhancement: Vegetative buffers can be designed to enhance biodiversity values. Refer to the applicable Environmental Farm Plan companion documents for further information.

The following summary provides recommendations and rationale for the specific buffer design components.

VISUAL SCREENING/ ASTHETICS	Walk the property perimeter to determine the best buffer placement to effectively screen the area of concern. Consult adjacent property owners.
ENERGY EFFICIENCY **Summer cooling**	Plant trees on the south, southeast, and southwest sides of the impacted area (e.g., barn). Appendix 3 provides a shade distance calculator which can be used to determine the setback distance needed between the buffer and the impacted area to maximize the shade benefit of the mature tree. Planting trees too close to the impacted area/building may impede airflow and ventilation. Other potential risks to consider include root damage to foundations and branch breakage or tree failure onto buildings. Deciduous trees provide wide, spreading canopies, which maximize shade during warm months.
ENERGY EFFICIENCY **Winter shelter**	Plant trees upwind (winter prevailing wind) to slow prevailing winds before they reach the impacted area (e.g., barn). Windbreaks provide protection for a distance up to 10 times the tree height on the downwind side. Maximum protection occurs when windbreaks are located at distances that are five times the tree height. Evergreen coniferous trees with moderate to high canopy density are best because they retain their needles in the winter, which provides year-round shelter.
NOISE REDUCTION	Vegetative noise buffers are effective only when properly designed. Poor design can increase the perception of noise. The buffer should be within 15 m (50 ft) of the noise source (preferably) or within 15 m of the impacted area. Noise reduction will occur only if the buffer is wide enough to completely block the view between the source and the impacted area. Combining a solid barrier (e.g., fence, soil berm) with a vegetative buffer will yield greater results. Tall, evergreen tree species with canopies to the ground and high canopy density are recommended.
LIGHT REDUCTION	Plant trees close to the light source. Multiple rows and a wide, dense tree buffer will provide the greatest benefit. Tall, evergreen tree species with canopies to the ground and high canopy density are recommended.
BIODIVERSITY AND RIPARIAN ENHANCEMENT	Vegetative buffers provide numerous opportunities to increase biodiversity and riparian enhancement. For more information and specific guidelines, refer to the applicable Environmental Farm Plan companion documents[11]. Keep in mind the potential to create habitat for vermin and pests, or to create suitable habitat for disease transmission.

6 TREE AND SHRUB GALLERY

Vegetative buffer objectives, combined with the specific site conditions of an agricultural operation, will dictate the appropriate tree species choice. Collaborate with a local nursery or landscape professional early in the planning process to ensure that appropriate species are selected and that plant stock is readily available. Considerations for species selection are further discussed in Sections 3–5: Buffer Design.

How to use the gallery

This section contains a gallery of species that are suitable for the climates of the South Coast and Southern Interior regions of British Columbia. The gallery is organized into three sections:

1. Evergreen trees
2. Deciduous trees
3. Shrubs and vines

Species that are included in the gallery are:

- typically available in large quantities from local suppliers;
- exhibit characteristics that will address common vegetative buffer objectives (dust, odour and/or pesticide drift mitigation);
- do not require unusual or arduous care and maintenance; and
- are not considered invasive species in British Columbia.

The species list in this gallery is not exhaustive. Other species, and particularly other varieties or cultivars of the species listed, may be appropriate for your buffer. Be aware that stock availability varies from year to year, so nursery and landscape professionals may recommend alternatives to the species listed in this gallery.

Not all species listed are suitable to the climates of both the South Coast and Interior regions. Check with a professional to determine whether a species is climatically suitable to your area.

Note that the mature heights and widths provided in the gallery are approximate. They can vary considerably depending on the region of the province, growing conditions (e.g., soil, drainage, site characteristics) and maintenance undertaken.

Canopy density (or tree porosity) is referred to according to three categories: High (very dense, limited air passage), Moderate (moderately dense, some air passage), and Low (many gaps with significant air passage). Determining appropriate canopy density is discussed in detail in Sections 3–5: Buffer Design.

SITE SUITABILITY

Vegetative buffer trees and shrubs should either be native varieties or introduced varieties that are known to succeed in the local climate and have low susceptibility to pests and diseases.

Choose species that will tolerate the site soil conditions, moisture regime (e.g., wet winters, summer drought), light regime (full sun or part shade), and any other conditions that are unique to your site (e.g., seasonal flooding, deep snow load, high salinity, high winds)

Figure 17: Evergreen trees

How to choose between evergreen and deciduous trees

Evergreen trees provide benefit year-round because they do not drop their needles or leaves. Evergreens tend to have denser tree canopies than deciduous trees; therefore, they have a greater surface area for capturing and filtering particles. High density trees result in requiring monitoring so that particles coating the branches don't impact the health of the trees. Evergreen trees are also more likely to maintain branch cover low to the ground, which is desirable for dust and odour capture, but can grow to be excessively large quickly without regular pruning.

Figure 18: Deciduous trees

Deciduous trees typically have faster growth rates than evergreens, so the benefit will be gained sooner. Keep in mind that the more rapid a tree's growth rate, the more likely it will be prone to branch breakage, and it will have a shorter lifespan. Deciduous trees drop their leaves annually, which may be useful in areas of heavy dust accumulation. Many deciduous trees have wide, spreading canopies, which are optimal for creating shade. Ideally, plant a mix of evergreen and deciduous rows to optimize benefits.

Vegetative buffer enhancement using shrubs & vines

Shrubs can be planted to capture low-lying dust, odour, and pesticide drift that may not be captured by the tree canopy. Shrubs may also be valued for their aesthetics, and because they help reduce the area around the base of trees that requires regular mowing. Choose shrubs that have dense forms, establish quickly and out-compete weeds, and maintain cover right to the ground surface.

Vines grown on a suitably durable fence or trellis can enhance the filter effect of a vegetative buffer. They can act as a stand-alone vegetative buffer in circumstances where there is not sufficient space to grow a tree buffer. Fast growing vines can be paired with a tree buffer to provide some degree of filtration for the first few years while the trees grow. The major limitations of vines are that they are constrained to the height of the trellis or fence and their growth habit won't necessarily provide continuous cover. Many vines, by nature, are invasive so be sure to evaluate the amount of maintenance required.

Figure 19: Shrub buffer example

Figure 20: Vine buffer example

Toxic species

Before planting trees or shrubs in the vicinity of livestock (your own or your neighbour's), check that the planned species are not toxic. Common tree species that are known to be toxic to livestock are listed in Table 3; however, the list is not exhaustive. More information can be obtained by searching the internet and consulting a veterinarian

Table 3: Examples of tree species which are toxic to livestock

Common Name	Botanical Name	Issue
Black locust	*Robinia pseudoacacia*	Toxic to all types of livestock
Horse chestnut	*Aesculus* sp.	Toxic to all types of livestock
Kentucky coffeetree	*Gymnocladus dioicus*	Toxic to all types of livestock
Oak (black, red, and white)	*Quercus* sp.	Toxic to all types of livestock
Red chokecherry	*Prunus virginiana*	Toxic to all types of livestock. Other species of cherry may also be toxic.
Red maple	*Acer rubrum*	Fatal to horses. Any hybrid of red maple should be avoided (e.g., *Acer rubrum* × *freemanii*)
Walnuts and bitternuts	*Juglans* sp.	Toxic to horses
Yew	*Taxus* sp.	Fatal to all types of livestock

Pest and disease vectors

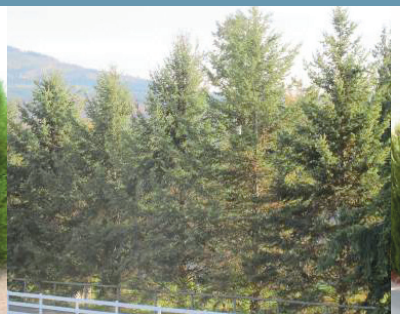
Before planting trees or shrubs in the vicinity of an agricultural crop (your own or your neighbour's), check that the planned species are not known vectors or hosts for pests or diseases that would jeopardize the crop. Common host plants for agricultural diseases are listed in Table 4; however, the list is not exhaustive. More information can be obtained by searching the internet and consulting a Ministry of Agriculture entomologist or pathologist.

Table 4: Common host plants of agricultural diseases

Common Name	Botanical Name	Issue
Juniper	*Juniperis* sp.	Host for pear trellis rust. Do not plant in the vicinity of pear orchards.[6]
Eastern red cedar	*Juniperis virginianae*	Host for cedar-apple rust. Do not plant in the vicinity of apple orchards.[7]

6. A Guide to Managing Tree Fruit Pests in the Home Garden http://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/agriculture-and-seafood/animal-and-crops/plant-health/ph_fruitspray.pdf
7. Cedar-apple rust and quince rust http://www.omafra.gov.on.ca/english/crops/facts/cedarap.htm

	Cedar - Brandon *Thuja occidentalis* **'Brandon'**	**Cedar - Excelsa** *Thuja plicata* **'Excelsa'**	**Cedar - Smaragd** *Thuja occidentalis* **'Smaragd'**	**Cedar - Western redcedar** *Thuja plicata*
				
Height × spread	3–6 m (10–20 ft) × 1.2 m (3–4 ft)	10–12 m (30–40 ft) × 3–6 m (10–20 ft)	3–6 m (10–20 ft) × 1.2 m (3–4 ft)	30–40 m (100–130ft) × 8–10 m (26–30 ft)
Spacing	0.6 m (2 ft)	2–3 m (7–10 ft)	0.6 m (2 ft)	4–5 m (13–16 ft)
Light requirement	Full sun	Full sun to partial shade	Full sun	Full sun to partial shade
Canopy density	High	Moderate	High	Moderate
Shape	Columnar	Pyramidal	Columnar	Pyramidal
Comments		Cultivar of native western redcedar		Native to B.C.

	Port Orford Cedar *Cupressocyparis lawsoniana 'Columnaris'*	**Cypress - Leyland** *Cupressus leylandii*	**Douglas-fir** *Pseudotsuga menziesii*	**Juniper - Spartan** *Juniperis chinesis*
				
Height × spread	3-6 m (10–20 ft) × 1 m (3.2 ft)	10–15 m (35–50 ft) × 4.5–6 m (15–20 ft)	40–70 m (130–230 ft) × 6–10 m (20–30 ft)	5 m (16 ft) × 2 m (6.5 ft)
Spacing	1.5 – 1.8 m (5-6 ft)	1.5–2.5 m (5–8 ft)	4–5 m (13–16 ft)	1.2 m (3–4 ft)
Light requirement	Full sun	Full sun	Full sun to partial shade	Full sun
Canopy density	High	High	Low	High
Shape	Columnar	Pyramidal	Pyramidal	Columnar
Comments	Hardy; drought tolerant; slow growing	Hardy; deer resistant; fast growing (2–3 ft/yr)	Native to B.C.; drought tolerant	Hardy; drought tolerant; fast growth rate

Evergreen tree gallery (cont.)

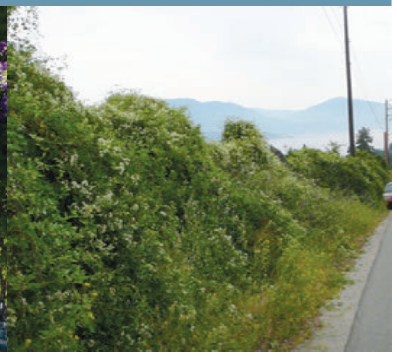
	Juniper - Wichita blue *Juniperis scopulorum* **'Wichita Blue'**	**Pine - Mugo** *Pinus mugo* **'Mughus'**	**Pine - Vanderwolfe's limber pine** *Pinus flexis* **'Vanderwolfe's'**	**Yew - Hick's** *Taxus × media* **'hicksii'**
				
Height × spread	3–6 m (10–20 ft) × 1.2–1.5 m (4–5 ft)	2.5–5 m (8–15 ft) × 1.5–3 m (5–10 ft)	6–9 m (20–30 ft) × 3–5 m (10–15 ft)	1.5–3 m (5–10 ft) × 1.2 m (3–4 ft)
Spacing	1.2 m (3–4 ft)	1–1.5 m (3–5 ft)	1.5–2.5 m (5–8 ft)	0.6 m (2 ft)
Light requirement	Full sun to partial shade	Full sun	Full sun	Full sun to shade
Canopy density	High	Low-moderate	Moderate	High
Shape	Pyramidal	Round	Pyramidal	Columnar
Comments	Drought tolerant; cultivar of native juniper	Hardy; deer resistant; drought tolerant	Drought tolerant; cultivar of native limber pine; slow growth rate	Bark, foliage, fruit are toxic if ingested

	Ash - Patmore green ash *Fraxinus pennsylvanica* **'Patmore'**	**Hornbeam - European** *Carpinus betulus* **'Fastigiata'**	**Katsura** *Cercidiphyllum japonicum*	**Honey locust** *Gleditsia triacanthos*
				
Height × spread	12–15 m (40–50 ft) × 10 m (30 ft)	12 m (40 ft) × 8 m (25 ft)	9–12 m (30–40 ft) × 6 m (20 ft)	12 m (45 ft) × 10 m (30 ft)
Spacing	6–7 m (20–23 ft)	5–6 m (16–20 ft)	3–4 m (10–13 ft)	6–7 m (20–23 ft)
Light requirement	Full sun	Full sun to shade	Full sun to partial shade	Full sun
Canopy density	Low	Low	Low	Low
Shape	Oval	Oval	Pyramidal	Round
Comments	Hardy, disease resistant; seedless variety. Fall colour: yellow	Heat and drought tolerant Fall colour: yellow	Drought tolerant Fall colour: yellow-orange	Fall colour: yellow

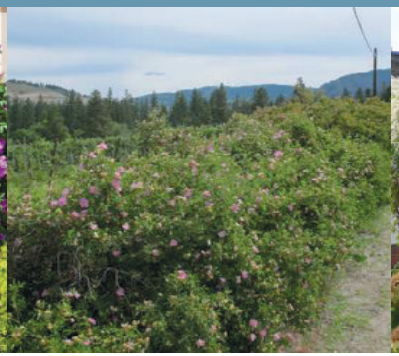
	Maple - Armstrong *Acer rubrum × freemanii* **'Armstrong'**	**Maple - Columnar Norway** *Acer platanoides* **'Columnare'**	**Maple - Conquest Norway** *Acer platanoides* **'Conquest'**	**Maple - Emerald queen** *Acer platanoides*
				
Height × spread	15 m (50 ft) × 3–6m (10–20 ft)	12 m (40 ft) × 8 m (25 ft)	12 m (40 ft) × 6 m (20 ft)	15 m (50 ft) × 12 m (40 ft)
Spacing	2–3 m (7–10 ft)	4–5 m (13–16 ft)	3–4 m (10–13 ft)	7–8 m (23–26 ft)
Light requirement	Full sun to partial shade	Full sun to partial shade	Full sun to partial shade	Full sun to partial shade
Canopy density	Low	Low	Low	Low
Shape	Columnar	Columnar	Narrow oval	Oval
Comments	Fatal to horses. Fall colour: yellow to orange-red		Fall colour: bronze-orange	

Deciduous tree gallery (cont.)

	Oak - Pin *Quercus palustris*	**Poplar - Prairie sky** *Populus* × *canadensis*	**Poplar - Swedish aspen** *Populus tremula* **'Erecta'**	**Poplar - Tristis** *Populus* ×**'Tristis'**
				
Height × spread	16 m (52 ft) × 12 m (40 ft)	9–12 m (30–40 ft) × 1.5–3 m (5–10 ft)	12 m (40 ft) × 3 m (10 ft)	9–12 m (30–40 ft) × 6 m (20 ft)
Spacing	16 m (52 ft) × 12 m (40 ft)	1–2 m (3–6 ft)	1.5–2 m (5–6 ft)	3–4 m (10–13 ft)
Light requirement	Full sun	Full sun	Full sun	Full sun
Canopy density	Low	Low	Low–Moderate	Low
Shape	Pyramidal	Columnar	Columnar	Oval
Comments	Produces acorns. Fall colour: yellow red, then brown, persist over winter			

	Beauty bush *Kolkwitzia amabilis*	**Burning bush** *Euonymus alatus*	**Clematis - jackmanii (VINE)** *Clematis jackmanii*	**Clematis - white (VINE)** *Clematis ligusticifolia*
				
Height × spread	2-3 m (7-10 ft) × 2-3 m (7-10 ft)	3 m (10 ft) × 3 m (10 ft)	3-6 m (12-20 ft) x 1.5-3 m (5-10 ft)	6 m (20 ft) x 6-9 m (20-30 ft)
Spacing	1 m (3 ft)	1 m (3 ft)	1 m (3 ft)	1 m (3 ft)
Light requirement	Full sun to part shade	Full sun to part shade	Full sun	Full sun
Comments	Drought tolerant; tolerates clay soil		Drought tolerant; vigorous, reliable. Prune to 30 cm (1 ft) above ground in spring for compact growth	Drought tolerant; propagates from seed; native to B.C.

	Hardhack *Spiraea douglasii*	**Lilac** *Syringa vulgaris*	**Ninebark - Diabolo** *Physocarpus opulifolius* **'Diabolo'**	**Ocean spray** *Holodiscus discolor*
				
Height × spread	1–2 m (3–7 ft) × 1 m (3 ft)	3-4 m (10-12 ft) x 2.5-4 m (8-12 ft)	2.5-3 m (8-10 ft) x 2 m (6 ft)	3-5 m (10-16 ft) x 2-3 m (7-10 ft)
Spacing	1 m (3 ft)	1 m (3 ft)	1 m (3 ft)	1 m (3 ft)
Light requirement	Full sun	Full sun	Full sun	Full sun to part shade
Comments	Tolerant of wet sites; native to B.C.	Drought tolerant; deer resistant; vigorous; will sucker	Drought tolerant	Drought tolerate; native to B.C.

	Oregon grape *Mahonia aquifolium*	**Rose - Hansa rugosa** *Rosa rugose* **'Hansa'**	**Rose - Prairie** *Rosa woodsii*	**Silver lace vine** *Polygonum aubertii*
				
Height × spread	0.3-2.5 m (1-8 ft) x 1-2 m (3-6 ft)	1-2.5 m (4-8 ft) x 1.8-3 m (6-10 ft)	1.8 m - (6 ft) x 1.2-1.8 m (4-6 ft)	10 m (35 ft) x 6-12 m (20-40 ft)
Spacing	1 m (3 ft)	1 m (3 ft)	1 m (3 ft)	1 m (3 ft)
Light requirement	Full sun to part shade	Full sun	Full sun	Full sun
Comments	Drought tolerate; deer resistant; height will increase with more water	Hardy; drought tolerant; will spread by suckers and seed.	Drought tolerant; will spread by suckers and seed; native to B.C.	Drought tolerant; very vigorous; can grow 3.5 m (12 ft) per year.

	Snowberry *Symphoricarpos albus*	**Spiraea - Goldmound** *Spiraea japonica* **'Goldmound'**	**Willow - Arctic** *Salix purpurea 'Nana'*	**Willow – native varieties** *Salix species*
				
Height × spread	1–2 m (3–7 ft) × 1 m (3 ft)	1 m (3 ft) x 1 m(3 ft)	2 m (7 ft) x 1.5 m (5 ft)	1–12 m (3–40 ft) × 2–3 m (7–10 ft)
Spacing	1 m (3 ft)	1 m (3 ft)	1 m (3 ft)	1 m (3 ft)
Light requirement	Full sun to part shade	Full sun	Full sun to part shade	Full sun to part shade
Comments	Native to B.C.			Tolerant of wet sites; native to B.C.

7 IMPLEMENTATION GUIDE FOR PRODUCERS

Site preparation

Long-term success of a vegetative buffer requires an effective plan, proper installation, and long-term care.

Installation techniques should follow the *Canadian Landscape Standard* (Canadian Landscape and Nursery Association and Canadian Society of Landscape Architects).

This section summarizes basic considerations during the installation of a vegetative buffer. It is not exhaustive. Guidance from a trained professional is strongly advised to ensure proper installation.

Site preparation will save money over the long run by improving tree growth and reducing the possibility of tree mortality. The following are common reasons for conducting site preparation:

- **Soil compaction:** Soil can easily become compacted by machines, vehicles, or repeated foot traffic. Compacted soil prevents proper drainage and inhibits healthy growth of tree roots. You may need to till the soil to loosen prior to planting.
- **Poor drainage:** If you have areas of poor drainage that tend to hold water for long periods, you will need to correct this problem. Trees subjected to long periods of flooding will eventually die due to a lack of oxygen to the tree roots. You may need to improve drainage or bring in soil to raise the ground level.
- **Lack of top soil:** Import soil if the site lacks sufficient top soil.
- **Pre-existing vegetation:** If undesired trees and shrubs are growing within the buffer planting area, remove or relocate them.
- **Berm:** Create a soil berm for the vegetative buffer if it will be in an area with a high or fluctuating water table. This will also provide extra height for your buffer. Berms are not recommended for sites in dry climate regions with sandy, rapidly draining soils.
- **Debris:** Remove debris in the planting zone.
- **Utilities:** Contact your utility providers or a utility marking service to locate buried electrical cables, water mains, and gas pipelines. Find out required setback distances. Mark no-go zones with spray paint or ribbon. Appendix 4 provides BC Hydro guidelines for planting near power lines.
- **Access:** Consider how the nursery delivery truck and other vehicles or equipment needed for planting will access the planting zone.
- **Biosecurity:** Ensure anyone who will be on site is aware of, and complies with, your biosecurity requirements. Appendix 6 provides biosecurity considerations for landscape professionals working on agricultural operations.

Nursery order

Seek the assistance of a nursery or landscaping professional when ordering trees and shrubs. They will be familiar with local plant stock availability and can easily coordinate efficient delivery.

What to know before ordering

To order trees and shrubs from a local nursery, you will need to calculate the quantity required based on tree spacing and length of the buffer. Refer to Section 6 – Tree and Shrub Gallery for recommended tree spacing.

Keep in mind, particularly when ordering large quantities, that availability of some species may be limited. The nursery or landscape professional may provide suggestions about alternative species or varieties.

Stock size

Larger tree stock will provide benefits earlier than smaller stock; however, the stock and planting costs will be higher. Planting tree plugs (sapling trees) is relatively inexpensive, but it will take far longer for the trees to grow to a beneficial size. Larger stock will require greater immediate care and will have a higher risk of transplant stress and mortality until roots become established.

If potted stock is being used ensure that it is not root bound. When trees are grown in pots for too long, the roots grow in a circular pattern around the pot, which could eventually girdle the tree stem.

When to order

Ordering stock in spring or summer ensures a greater choice of stock and better pricing. By the fall, stock supply declines. Delivery and planting during fall (Southern Interior) or late fall to early winter (South Coast) is best, although planting in late winter to early spring is still acceptable. Trees planted during warm months from mid spring to early fall are more likely to experience drought and heat stress, which increases susceptibility to pests and disease, and can result in poor growth and mortality.

Planting

The following describes the steps taken when planting trees and shrubs:

✓ **Protection:** All live material should be planted as quickly as possible after it has been delivered. If there is a delay in planting, protect the plant material by storing it in the shade and covering it with mulch, shade cloth or tarps. Keep the root balls moist. Handle plant material with care.

✓ **Planting time:** Plant on a cool, cloudy day, preferably in late September to October (Southern Interior) or late October to early December (South Coast). Planting can also occur in early spring. Avoid planting on hot, dry days.

✓ **Root preparation**: Plants should be well watered before being unpackaged. Inspect roots of potted plants to ensure they are not circling or girdling the tree stem.

✓ **Soil preparation**: Planting holes should be at least twice the width of the root ball and deep enough so that the top of the root ball is level with the soil surface. Test the drainage by filling the hole with water. If the water does not drain, use methods to improve drainage.

✓ **Planting**: The top of the rootball should be level with the soil surface. Do not plant too deeply; this can lead to mortality. Ensure there are no air pockets around the root ball by tamping down the soil. If the tree settles too deeply, the planting depth must be corrected. All packaging materials (e.g., wire, ties, rope) should be cut and removed out to the perimeter of the root ball to prevent girdling of the roots or tree stem as they grow. Untreated burlap can be left (rolled down) at the base of the planting hole. If burlap is treated (blue or green colour) it must be removed because it contains copper sulphate, which can inhibit root growth. Vinyl burlap should also be removed. Wire baskets should not be removed from rootballs. They can be cut once the tree is in place. The visible portion should be folded down away from the rootball and buried.

✓ **Watering**: Thoroughly water immediately after planting. If a period of dry weather occurs after planting, irrigation will be necessary until sufficient fall/winter precipitation occurs.

✓ **Stabilization**: Any stabilization (tree stakes) should allow free movement of the tree crown while preventing movement of the root system. Avoid damaging the tree or root ball.

DEER PROTECTION

Deer can cause significant browsing damage to young trees and shrubs. Install deer protection if you live in an area where deer browse is a concern. Protection may be in the form of wire cages around each tree or deer fencing around your property. In the photo to the right, 54 inch high 2 inch mesh light fencing material was secured with four 12 inch 'U' shaped pins at the base.

Figure 24: Deer protection

Irrigation

An irrigation system must be installed so that the trees are watered during the establishment period after planting. Trees can take 3-5 years to develop healthy root systems. During this period, it is critical that trees receive adequate water and avoid drought stress.

Consult a trained professional, landscaper, or irrigation supply expert to determine the best irrigation system to use. Keep in mind that an irrigation system will require maintenance in the fall and spring.

Avoid mowing over irrigation lines as mower blades will cut the pipe. Where mowing is necessary the irrigation line should be protected from the mower (e.g., buried below or elevated above the ground surface).

Maintenance and monitoring

A vegetative buffer is a living entity that will require care and a watchful eye over the long term. Getting off to a good start in the first few years is critical to the long-term health of the trees and shrubs. This is accomplished by regular watering and keeping an eye out for early signs of stress.

Obtain a maintenance plan from an EFP Planning Advisor or nursery or landscape planner.

Maintenance should follow the *Canadian Landscape Standard* by the Canadian Landscape and Nursery Association and Canadian Society of Landscape Architects. This section summarizes basic maintenance guidelines.

Watering: Watering is critical for the first 3-5 years after planting while the root systems are becoming established. A drip system should be installed to irrigate the buffer during this period.

Irrigation may be necessary from April or May (weather dependent) through to the end of October. The goal of watering is to penetrate the root zone. The frequency and duration will depend on the time of year and weather conditions. Consult a landscape professional to determine an appropriate watering regime. Irrigation lines require seasonal maintenance and should be checked regularly to ensure the buffer is getting adequate water.

If there is a high water table or seasonal flooding, do not start regular irrigation until the water table has receded.

Watering may also be necessary beyond 5 years during prolonged periods of drought.

Mulching: Mulch helps retain soil moisture, regulate soil temperature, and suppress weeds. Mulch is strongly recommended for dry sites, sites without irrigation, and sites with prolific weed or grass growth that may inhibit buffer growth.

Use a non-composted bark mulch of hemlock and Douglas-fir. Mulch to a depth of 10 cm (4 in). Keep mulch 30 cm (12 in) away from the tree stem. Never mound the mulch around the tree stem. Other types of mulch such as coir (coconut) mats or squares of secured landscape fabric are also effective. Avoid the use of rubber tree mats as they have been found to leach toxins and degrade more quickly than anticipated.

Composted mulches can improve soil fertility. For example, annual leaf litter provides a valuable nutrient input and will help control weeds.

Weed control: Ensure that vegetation surrounding the buffer is regularly removed to reduce competition with the planted stock (especially when the stock is in the seedling stage). However, avoid mowing or weed clipping within 30 cm (12 in) of the tree base to prevent damage. Use mulch where weed competition is an ongoing problem.

Pruning: Do not prune during the first 5 years after planting. After 5 years pruning should be done only to maintain or improve tree structure and to improve tree health or function within the buffer. Pruning must be done in accordance with current acceptable arboriculture practice, as determined by the International Society of Arboriculture, and during the season best suited to the trees in question. Pruning should be carried out under the direction of, or by, a qualified professional.

Pruning should be limited to cuts that are necessary to remove dead, diseased, damaged, and defective branches in order to direct growth and correct structural weaknesses while preserving the natural character and structure of the tree.

Never cut branches flush to the trunk. Always leave a branch collar. Do not cut back the tree top or remove the terminal leader from the tree (topping). Depending on the tree species, topping will encourage lateral growth rather than vertical growth and will leave the tree susceptible to disease and weak branching. Do not remove the lower branches of the trees; they capture dust, odour, and pesticide drift.

Fertilizing: If soils are properly prepared, fertilizer is generally not needed. Fertilizer should be applied under the direction of a landscape professional and only if required to correct symptoms of nutrient deficiency. Consult a nursery or landscape specialist if you observe signs of tree stress or decline.

Wind: Trees may be susceptible to heavy winds for the first few months after planting. If the ground was not sufficiently tamped to remove air pockets or if trees were planted in very wet soils, the trees could shift during strong winds. After windstorms, survey the new buffer to ensure no damage has occurred. If trees have tipped, right them, making sure their root balls are flush with the ground, and firmly tamp the surrounding soil. Do not pile sand or soil at the base of trees to secure them. The root ball must remain flush with the ground surface.

Tree stakes: The use of tree stakes is recommended for deciduous trees > 1.5 m (5 ft) and coniferous trees > 2 m (6.5 ft). Use tree stakes and ties for one full growing season after planting. Every four months, check that the ties are not causing depressions in the bark or girdling the trees. Loosen or repair as necessary. Remove tree stakes and ties in the second growing season. Failure to remove will cause future girdling and eventual mortality as the tree stem widens.

8 PLAN REQUIREMENTS – EFP PLANNING ADVISORS

In order to apply for EFP Beneficial Management Practices Program funding (BMP Categories 19 and 34), a vegetative buffer plan must be submitted. This section provides a checklist to guide EFP Planning Advisors through the process of developing a vegetative buffer plan. Two **sample plans** are provided as examples to show the outcome of working through the planning process outlined in this guide. Site assessment field forms are included in Section 9. The forms are organized into checklists of factors that should be considered during the planning process.

Plan checklist

Table 5: The following components must be included in the vegetative buffer plan:

✔	**INTRODUCTION**	State the objectives and geographic location of the vegetative buffer.
✔	**SITE SUMMARY**	Provide the following details: ▪ Landowner and lessee name (when applicable) ▪ Business name ▪ Address ▪ Assessor and date of site visit ▪ Category and type of operation (e.g., poultry – broiler; orchard – apple) ▪ Metrics of operation (e.g., number of livestock).
✔	**BUFFER OBJECTIVES**	Primary and secondary objectives: for each objective, describe the problem and the source of the problem. Provide a site overview map that shows the location of the source(s) and target(s) (map checklists are included below).
✔	**SITE ASSESSMENT**	Provide a summary table of all relevant considerations determined during the site assessment. Site assessment field forms are provided in Section 9.
✔	**MICROCLIMATE EVALUATION**	Describe how each of the following microclimate characteristics (and any other relevant ones) will influence the design of the buffer: ▪ prevailing wind direction during the warm and cold seasons ▪ average annual precipitation ▪ average first and last dates of frost ▪ Refer to Appendix 2 for information on how to obtain local wind data.
✔	**BUFFER DESIGN**	▪ Provide a summary of the buffer design components that will be used to achieve the buffer objectives. Include the citation for the rationale (e.g., this guide or other sources). ▪ Provide a buffer design map and planting plan (map checklists are included below). ▪ For each tree row, describe the buffer objective(s) and key considerations, the buffer design rationale, and the design plan.

✔	**SITE PHOTOS**	Provide site photos that show the planned locations of the buffer row, and denote the maximum height and width of the available growing space.
✔	**IMPLEMENTATION PLAN**	For each buffer row, provide a task list for site preparation and installation. The implementation plan should detail: ▪ installation requirements (including required materials and supplies, optimal planting date, special installation techniques/strategies, and watering/irrigation) ▪ biosecurity protocol to be followed by anyone installing or maintaining the buffer ▪ planting prescription ▪ maintenance plan.
✔	**COST ESTIMATE**	Provide a table of cost estimates for each item and task required for site preparation and installation. This includes: ▪ quantity ▪ stock size/dimensions ▪ unit price and total cost ▪ source or supplier Include the date of the cost estimate and the plan metrics: total buffer length (sum of all tree/shrub rows) and the cost per foot (total cost divided by total buffer length).

Two maps are required in the vegetative buffer plan: the **site overview map** and **buffer design map**. The buffer design map contains all the information needed for buffer installation and should be provided to the landscape contractor. Map components are summarized in Table 6. Use online imagery as the base layer for both maps. There are free software programs online (e.g., Google Earth Pro) that provide measurement tools and high resolution images for maps and reports.

Table 6: Map requirements for vegetative buffer plans (when applying for EFP funds)

Site Overview Map	Buffer Design Map	Map Element
✔	✔	Legend, north arrow, scale bar
✔		Base information: property lines, fences, roads, structures (homes, barns, outbuildings), land use
✔		Slope direction arrow(s)
✔		Source and target of issue(s) being addressed by the vegetative buffer (include fan direction where applicable)
✔		Photo locations indicating the direction the photo was taken
	✔	Planned buffer rows (labelled and differentiated by line type or colour)
	✔	Additional information for the landscape contractor (e.g., location of trees to remove, above-ground and below-ground utilities/services, no-tree zones, access route(s), road names, biosecurity zone, hose bibs)

SAMPLE PLANS

This section contains two sample vegetative buffer plans. They are intended to provide examples to help the users of this guide complete a vegetative buffer plan.

Plan #1: Organic Fruit Orchard

Addresses pesticide drift and dust issues.

SAMPLE VEGETATIVE BUFFER PLAN – ORGANIC FRUIT ORCHARD

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LIST OF FIGURES

1 INTRODUCTION

This plan is for installation of a vegetative buffer on an organic fruit orchard to mitigate pesticide drift from the neighbouring conventional apple orchard and dust from a shared access road. This project is being funded under Canadian Agricultural Partnership as a vegetative buffer demonstration site.

2 SITE SUMMARY

SITE SUMMARY			
Landowner:		Lessee:	
Business Name:		Address:	
Assessor:		Site Visit Date:	
Category of Operation:	Orchard	Type of Operation:	Organic pear/apple/ peach
Metrics of Operation:	N/A		

3 VEGETATIVE BUFFER OBJECTIVES

OBJECTIVE	High	Medium	Low
Dust mitigation			X
Odour mitigation			
Pesticide drift mitigation	X		
Visual screening/aesthetics			
Energy efficiency: summer cooling			
Energy efficiency: winter shelter			
Noise reduction			
Light reduction			
Biodiversity and riparian enhancement			
Other:			

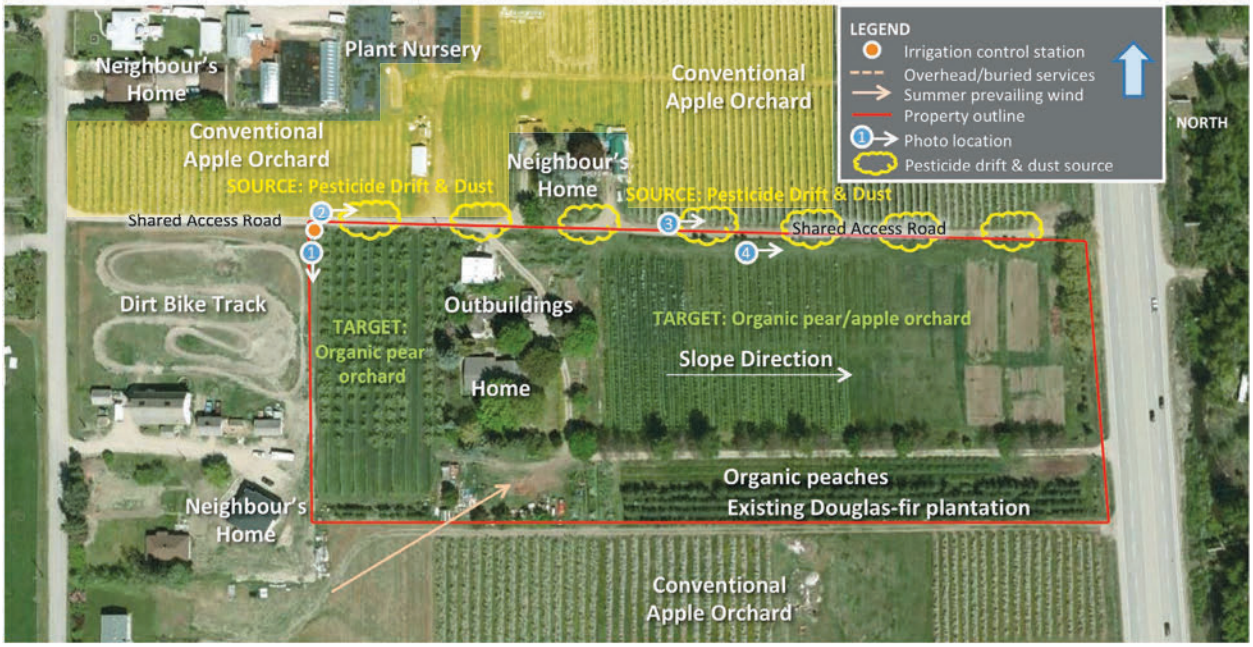

Figure E1-1: Base map

3.1 Primary Objective(s)

Pesticide Drift Mitigation

Problem:

The orchard is certified organic. Most sprays used by conventional orchards are not acceptable on organic orchards. The greatest concern for the organic orchard is the application of Sevin (carbaryl) insecticide in May and several fungicides from April to June. There is no (or minimal) leaf cover during this period, which means there is a greater risk of pesticide drift through the organic orchard. The use of codling moth and leafroller sprays from mid-July to August is also a concern.

Source: Neighbour's conventional orchard

The orchard is experiencing ongoing pesticide drift from the neighbour's conventional apple orchard (immediately to the north). Close proximity to the conventional orchard is the main contributing factor to pesticide drift. Wind is unlikely to be a contributing factor since pesticides are applied during periods of very low wind speeds. A vegetative buffer is proposed as one measure to help mitigate pesticide drift. Other effective mitigation measures include adherence to pesticide application regulations and Beneficial Management Practices.

3.2 Secondary Objective(s)

Dust Mitigation

Problem:

Dust residue on organic fruit can increase susceptibility to pest and disease problems.

Source 1: Shared access road

The shared access road immediately north of the ranch produces dust. Dust is worse in summer during prolonged dry periods.

Source 2: Neighbour's dirt bike track

The neighbour's dirt bike track to the west produces dust when in use. In order to mitigate this dust source, a tree buffer on the western edge of the orchard would have to be quite tall. A buffer row there is not advised, firstly because it would shade the orchard during the afternoon, and secondly because there is not adequate space on the orchard to support a row of mature trees between the orchard edge and the property line.

4 SITE ASSESSMENT

Factors	Description
Utilities/services	There are overhead lines and buried services (gas and irrigation). A utility marking service will be hired to mark buried lines prior to buffer installation. Planting the buffer close to the overhead line is unavoidable. For this reason, a shorter tree species should be selected. The producer has been informed that the buffer trees below the overhead line may require future pruning.
Irrigation control station	Access must be maintained by leaving a 1.5 m (5 ft) clear gap in the buffer on either side of the control station.
Vehicle and machinery access	The producer requires 5 m (16 ft) of clear space for the tractor to turn the corner at the end of each orchard row.
Slope	The property is on an east-facing aspect with a gentle 5-10% slope. Steepness increases toward the base of the property (east edge).
Buffer conflict with existing trees	▪ **Orchard trees**: In order to provide planting space for the buffer in the upper (western) section of the orchard, the producer will remove the outside row of pears (~15 trees). Historically, the producer could not classify fruit from this row as organic due to its proximity to the conventional orchard's spray. ▪ **Non-orchard trees**: There is an incomplete row of Douglas-fir and spruce at the lower (eastern) section of the buffer. The spruce will be removed since it is performing poorly and has been attacked by weevils. The fir will be incorporated into the buffer. The buffer will be designed so that the firs can be removed and replaced with buffer species at the discretion of the producer if they grow too tall.
Regional tree pest and disease concerns	▪ **Pear trellis rust:** The producer has identified pear trellis rust in their orchard and is in the process of removing all junipers (the alternate host) from their property. Juniper species will not be used in the buffer. ▪ **Spruce weevil**: Spruce trees on the property have minor damage from weevils. ▪ **Mountain pine beetle**: is a regional concern; it attacks native pine species (ponderosa and lodgepole). **No juniper, spruce, or native pine species will be used in the buffer.**
Inventory of existing tree species on property	Trees on the property include apple, pear, peach, willow, honey locust, sumac, Douglas-fir, spruce, hazelnut, and maple. No tree health issues were observed other than those noted above.

Factors	Description
Certified organic status	This orchard has certified organic status; therefore, the buffer must comply with Canadian organic standards. Any materials used in the buffer must be free of pesticides.
Deer browse	Although deer are rarely seen on this property, they are regionally common; therefore, tree species that will unduly attract deer should not be used. As a precaution, deer browse protection cages should be placed around planted trees during the years that the buffer is becoming established.
Irrigation	The producer already has a system in place. They will amend their system to ensure full inclusion of the buffer trees.
Drought	The producer is water conscious and would prefer to use species that have low irrigation needs.
Snow loading	The orchard occasionally receives heavy snow loads. The use of tree species that are particularly susceptible to snow damage should be avoided.
Adjacent land uses	▪ **North**: Conventional apple orchard; source of pesticide drift. The shared access road separates the two orchards. It is a source of dust during dry periods. Midway along the north boundary is a residential rental house. ▪ **South**: Conventional apple orchard. Pesticide drift from this orchard does not impact the organic orchard due to an existing fir plantation (owned by the organic producer). ▪ **East**: Highway runs along the east side of the orchard, beyond which is a riparian area. ▪ **West**: Residential neighbour; has a dirt bike track, which occasionally creates dust issues for the orchard.
Neighbour relations	Neighbour relations are neutral. The orchard has not received complaints about their operation.

5 MICRO CLIMATE EVALUATION

Micro climate Factors	Description
Predominate wind direction: warm season	NE
Predominate wind direction: cold season	SW
Average annual precipitation	382 mm (15 in)
Average first and last frost dates	October 9 / April 28

Wind Direction:

Wind direction is not a relevant consideration for the placement of the pesticide drift mitigation buffer because pesticides are applied during periods of very low wind speeds (typically in early morning) to maximize application efficacy. The organic orchard is susceptible to pesticide drift due to its proximity to the conventional orchard rather than due to wind.

Precipitation:

The average annual precipitation is relatively low. May and June have the highest amounts of rainfall (averaging 36 and 38 mm, respectively); however, it is not necessarily enough to sustain healthy plant growth. Irrigation is typically required from May through October.

Frost and Snow:

The first frost can occur in early October; however, snow does not typically fall until early November. Planting is best undertaken from late September to mid-October. Waiting to plant until late October or early November is risky because snow and sustained low temperatures may occur.

Shade:

Trees planted in rows B and D (Figure E1-2) could shade the conventional orchard to the north of the organic orchard. Shadow length is longest December 21 and shortest June 21. Shade on an orchard is considered to be most problematic from early April to early September. A shadow length analysis based on this date range indicated that trees will start to shade the edge of the conventional orchard once they exceed 9 m (30 ft) in height.

6 BUFFER DESIGN

6.1 Buffer Design Characteristics to Accomplish Objectives

All vegetative buffer rows serve the dual purpose of mitigating pesticide drift and dust. As described in the Vegetative Buffer Beneficial Management Practices Guide, the optimal buffer design for pesticide drift mitigation includes the following characteristics:

- Trees are evergreen (rather than deciduous). Evergreen species capture drift year-round and have a greater surface capture area on their needle-like structures.
- Trees have medium canopy porosity (30-50%).
- Trees grow to be taller than the adjacent crops and higher than the spray boom (at minimum). Preferably, trees are much taller than these minimums, provided they will not shade adjacent crops.
- Grasses, herbs, and shrubs beneath the buffer tree canopy contribute to drift mitigation by providing extra surface capture/air interception low to the ground.

Vegetative buffers for pesticide drift mitigation are best used in conjunction with adherence to pesticide application regulations and Best Management Practices.

6.2 Buffer Design Plan

PLANTING PRESCRIPTION

Location	Task	Length(m/ft)	Spacing (m/ft)	Quantity	Comment
ROW A	Install deer fence, plant clematis	9/30	1.5/5	6	Install on property line
ROW B	Install deer fence, plant clematis	50/160	1.5/5	32	Install on property line
	Plant columnar cypress	50/160	1.8/6	27	Plant inside fence; offset from services
ROW C	Plant columnar cypress	47/155	1.8/6	26	Install on property line
ROW D	Plant excelsa cedar	100/320	2.7/9	34	Plant in between firs, ~1.8 m/6 ft from road
	Plant poplar erecta	100/530	2.7/9	60	Plant in between each fir/cedar gap

LEGEND

- Irrigation control station
- Overhead & buried utilities
- Remove 1 row of pear trees
- Remove spruce trees

NORTH

Figure E1-2: Buffer design map and planting plan.

Row	Considerations	Rationale	Design Plan
A	▪ The orchard experiences pesticide drift and dust from shared access road. ▪ The orchard experiences dust from the neighbour's dirt bike track. ▪ Maximum available buffer space: 0.3 m × 2.4 m (1 ft × 8 ft).	▪ Dust capture from the dirt bike tracks would necessitate the creation of a tall tree buffer; however, space limitations and light needs of the orchard preclude a tree buffer. ▪ A fence and vine species would help with pesticide drift capture in the corner of the orchard near the access road and would be narrow enough to fit the available space.	▪ For the first 9 m (30 ft) of row A, install a fence and plant a clematis vine to provide some pesticide drift capture in the corner of the orchard next to access road.
B	▪ The orchard experiences pesticide drift and dust from the shared access road. ▪ The outer row of pears currently acts as a defacto buffer. ▪ Overhead power lines and buried utilities are present. ▪ Clearance requirement for the tractor: 5 m (16 ft). ▪ Maximum available buffer space: 1.5 m × 3 m (5 ft × 10 ft).	▪ The outer row of orchard trees must be removed to create space for the buffer. Since the buffer will take several years to grow and the outer row of pear trees was acting as a buffer, a fence and vine species could be used to provide early drift capture while the conifers fill in. ▪ A row of conifers would intercept pesticide drift and dust. A shorter, narrow species that will require minimal pruning to maintain the height below the power line could be used.	▪ Install a fence and plant a clematis vine on property edge. ▪ Plant one row of columnar cypress inside the fence, maintaining the 5 m (16 ft) clear space for the tractor.
C	▪ The orchard experiences dust from the shared access road. ▪ Clearance requirement for the tractor: 5 m (16 ft). ▪ Maximum available buffer space: 2.4 m (8 ft) × unlimited height.	▪ The outer row of orchard trees must be removed to create space for the buffer. ▪ A row of conifers would intercept dust. A narrow species could be used.	▪ Plant one row of columnar cypress 0.3 m (1 ft) offset from the property line, maintaining the 5 m (16 ft) clear space for the tractor.
D	▪ The orchard experiences pesticide drift and dust from the shared access road. ▪ Clearance requirement for the tractor: 5 m (16 ft). ▪ Incorporate existing row of Douglas-fir trees into the buffer. ▪ Maximum available buffer space: 4.2 m × 9 m (14 ft × 30 ft).	▪ Take advantage of the opportunity to create a wider buffer by planting a conifer in between gaps in the existing fir row. ▪ Greater width and vertical space allows for a second buffer row. A faster growing species could be used to provide early drift capture while the conifers fill in.	▪ Plant excelsa cedar in the gaps of the existing Douglas-fir row. ▪ Plant a complete row of poplar erecta, triangular spaced 0.6 m (2 ft) from the south side of the conifer row.

7 SITE PHOTOS

Photo locations are marked on the base map (Figure E1-1). Arrows represent the maximum available buffer width and height.

Photo 1: Row A looking south.

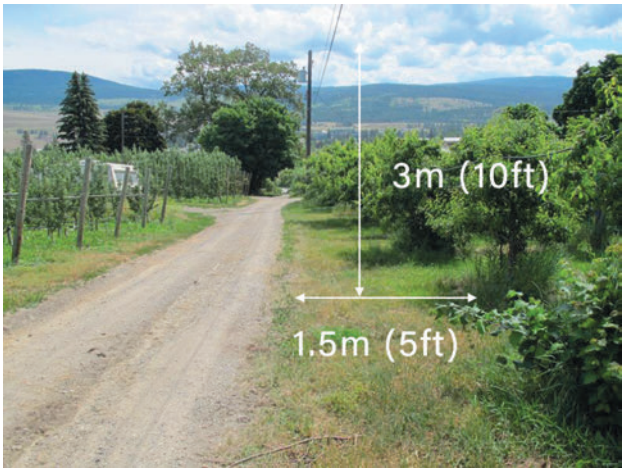

Photo 2: Row B looking east.

Photo 3: Row D (on right) looking east from access road. Note existing Douglas-fir trees.

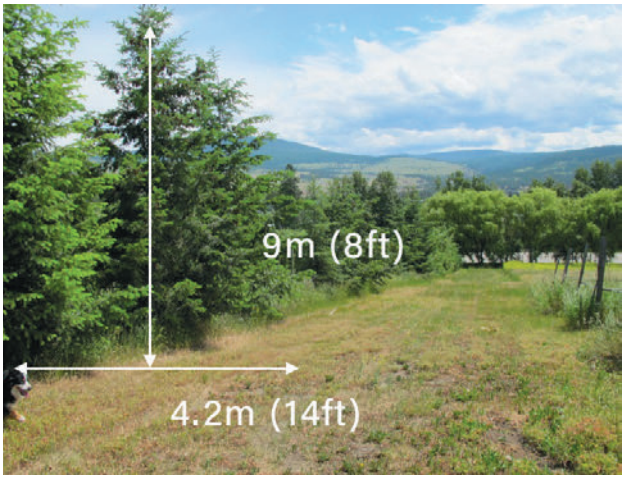

Photo 4: Row D (on left) looking east from organic orchard. Note existing Douglas-fir trees.

Figure E1-3: Site photos

8 IMPLEMENTATION PLAN

TASK	Row A	Row B	Row C	Row D
Site Preparation				
Mark underground utilities/services (including irrigation)	X	X	X	X
Mark clear space required around irrigation control station	X	X		
Mark maximum planting zone width and position	X	X	X	X
Remove outer orchard row		X	X	
Remove spruce trees				X
Installation				
Install fence	X	X		
Plant clematis vine along fence	X	X		
Plant columnar cypress		X	X	
Plant excelsa cedar and poplar erecta				X
Install deer protection cages around planted trees		X	X	X

8.1 Installation Requirements

- All materials used for the deer protection cages and fence must be untreated (no chemicals).
- Deer protection cages are made of 5 cm (2 in) gauge mesh light fencing material. They are 137 cm (54 in) tall × 0.6 m (2 ft) wide (for conifers) or 0.3 m (1 ft) wide (for poplars). They are secured into the ground with two 0.3 m (1 ft) long U-shaped metal pins.
- Deer-style fencing should be used to create the fence for growing vines on rows A and B.
- Planting must be done before the first frost in the fall (to be safe, plant by October 31).
- Trees should be watered in as they are planted. The ranch's irrigation system may be shut off by the time of planting. If this is the case, then trees will require hand watering until significant rain or snow occurs.

8.2 Biosecurity Protocol

Certified organic farm: Any amendments used in installation or maintenance in subsequent years must adhere to the Canadian organic standard. No herbicides can be used.

8.3 Planting Prescription

See the buffer design map (Figure E1-2).

8.4 Maintenance Plan

Maintenance Schedule:

/ = required; o = if necessary

Task	J	F	M	A	M	J	J	A	S	O	N	D	Frequency
Inspection	/	/	/	/	/	/	/	/	/	/	/	/	Monthly
Water					o	/	/	/	/	o			Weather dependent – during all dry periods
Fertilize													Not usually required
Mulch													Not usually required
Prune		o									o		As required

Inspection and General Guidelines:

Inspect vegetative buffers monthly. During the first 2 years, inspect the buffers weekly during hot months.

VISUAL CHECK	Check for signs of stress, mortality, pests, or disease. Seek advice and treatment promptly if required.
TREE LEAN	Straighten any leaning trees after heavy wind storms. Firmly tamp the soil around the tree base to ensure there are no air pockets.
SNOW DAMAGE	Inspect the buffer for snow loading after snow storms. Remove snow if it is accumulating and causing branch or tree lean.
DEER BROWSING	Maintain deer protection cages until trees have grown at least twice the height of the cages. At this point they can be removed. While cages are in place, watch for deer tampering. Immediately repair any cage damage and contact the landscaper to notify them of damage.
MOWING DAMAGE	Avoid damaging the trees and shrubs during mowing and weed trimming. Do not mow or line trim (weed wack) within 0.3 m (1 ft) of the tree base. If weeds are becoming problematic, mulch can be applied. If possible, allow grass and herbs to grow beneath the buffer row because this will enhance pesticide drift mitigation.
CONTAMINATION	Avoid spillage, drift, or runoff of fuel, fertilizer, toxic materials, road salt, and pesticides in the vicinity of the buffer. Any amendment used in installation or maintenance in subsequent years must adhere to the Canadian Organic standard. No unapproved products i.e. herbicides can be used.

Irrigation:

Trees are susceptible to drought stress for the first 3-5 growing seasons after planting while their roots are establishing. Irrigate during the growing seasons of 2020-2023 at a minimum. After 3 years, water can be gradually reduced to the levels used for other trees on the property.

- The goal of watering is to penetrate the depth of the upper root zone (0.3 m/1 ft).
- **From mid-May to the end of October, water twice a week in either the early morning or evening**. If it rains significantly (> 10 mm in 24 hours), a watering can be skipped. During periods of hot weather, increase watering to 3 days/week.
- Take care not to damage the irrigation system during mowing or weed trimming.

Irrigation System Maintenance

SPRING	- Undo the end cap to flush the line of any dirt trapped inside. - Reconnect the timer and replace the batteries. New batteries should last a full watering season. - Thoroughly check for leaks and blocked nozzles. Replace or clean clogged nozzles. Test timer operation. Check that water is flowing through all nozzles.
DURING USE	Once a week, walk along the drip irrigation system when it's on and ensure that water is flowing at each nozzle. If a nozzle is not working, replace it. If an entire section of the circuit is not dripping, look for a kink in the mainline tubing. Look for leaks. It's simple to replace a section of tubing by using two barbed couplers and new tubing.
FALL	Before freezing temperatures occur, remove the end cap and allow water to drain out. Blowing out the system is recommended.

Fertilizer:

Fertilizer should not be necessary except where a professional has determined there is a nutrient deficiency based on either a soil test or visual assessment. If foliage is becoming thin or discoloured, there may be a nutrient imbalance. Consult an expert prior to applying any fertilizer. Soil acidity plays a critical role in a tree's ability to absorb available nutrients. For reference, the optimal pH range for trees and shrubs is 6.0-7.0. At the recommendation of a professional, pH can be adjusted to this optimal range.

Mulch:

Mulch was not installed at the time of planting and is not required since a drip irrigation system is in place. If you are concerned about weed growth or have a particularly dry site, installing mulch may be beneficial.

Use non-composted bark mulch as follows:

- Use mulch composed of chips and fines from hemlock, pine, and/or douglas fir. The mulch should not contain invasive plants, cedar bark, salts, or other contaminants.
- Maximum depth of the mulch should be 10 cm (4 in) when settled.
- Keep mulch a minimum of 10 cm (4 in) away from the tree base. Never mound mulch around tree stem.
- Avoid clogging irrigation nozzles with mulch.

Mulches such as compost, leaf litter, or bark mulch can improve soil fertility. Avoid using impermeable plastic film.

Pruning:

Pruning should be done only to improve tree structure or health within the buffer.

- Pruning must be done in accordance with current acceptable arboriculture practice, as determined by the International Society of Arboriculture, during the season that is best suited to the trees in question. Pruning should be carried out under the direction of or by a qualified professional.
- **Trees should never be topped or lift pruned.** Both will damage the structure of the tree and will significantly reduce the effectiveness of the buffer.
- Pruning should be limited to cuts that are necessary to remove dead, diseased, damaged, and defective branches in order to direct growth and correct structural weaknesses while preserving the natural character and structure of the tree.
- No pruning should be carried out for the first 5 years after planting.

Maintenance guidelines have been developed in consultation with BC Landscape Standard, 7th edition (BC Landscape and Nursery Association).

9 COST ESTIMATE

Date of cost estimate: October 2020

Item	Quantity	Stock Size/ Length	Unit Price	Cost	Source/ Supplier
SITE PREPARATION					
Utility marking				$84.00	
Tree removal				$1,780.00	
Subtotal				$1,864.00	
INSTALLATION					
Clematis ligusticifolia	38	1 gal	$14.00	$532.00	
Lawson's cypress (columnar)	53	2 gal	$16.50	$874.50	
Excelsa cedar	34	5 gal	$22.50	$765.00	
Poplar erecta	60	2-3 ft potted	$19.95	$1,197.00	
Deer fence		190 ft		$3,500.00	
Deer cages - large	34		$20.00	$680.00	
Deer cages - small	113		$16.00	$1,808.00	
Labour				$5,000.00	
Subtotal				$14,356.50	
TOTAL				$16,220.50	

9.1 Plan Metrics

- **Total buffer length** (addition of all tree/shrub rows) = 427 m (1,400 ft)
- **Cost/unit length** = $38/m ($12/ft)

Plan #2 Poultry Broiler Operation

Addresses dust, odour, and visual screening issues.

SAMPLE VEGETATIVE BUFFER PLAN – POULTRY BROILER OPERATION

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LIST OF FIGURES

1 INTRODUCTION

This plan is for installation of a vegetative buffer at a poultry broiler operation to mitigate dust and odour emanating from the poultry barn and drifting toward a residential area. The buffer will provide a visual screen between the farm and neighbours, and winter energy savings by sheltering the barn from winter winds. This project is being funded under Canadian Agricultural Partnership as a vegetative buffer demonstration site.

2 SITE SUMMARY

SITE SUMMARY			
Landowner:		Lessee:	
Business Name:		Address:	
Assessor:		Site Visit Date:	February 2020
Category of Operation:	Poultry	Type of Operation:	Broiler
Metrics of Operation:	20,000		

3 VEGETATIVE BUFFER OBJECTIVES

OBJECTIVE	High	Medium	Low
Dust mitigation	X		
Odour mitigation	X		
Pesticide drift mitigation			
Visual screening/aesthetics		X	
Energy efficiency: summer cooling			
Energy efficiency: winter shelter			X
Noise reduction			
Light reduction			
Biodiversity and riparian enhancement			
Other:			

Figure E2-1: Base map.

3.1 Primary Objective(s)

Dust and Odour Mitigation

Dust and odours emanate from the poultry barn and drift toward a residential area. This is exacerbated by the fact that the barn fans are on the east side of the barn facing the neighbours. The impact is most noticeable during the summer when the prevailing winds blow toward the northeast (direction of neighbours) and when fans are in highest use to keep the barn cool.

3.2 Secondary Objective(s)

Visual Screen

A visual screen between the barn and neighbours would improve neighbour relations. Eight neighbouring residences have views of the poultry barn from their backyards.

Energy Efficiency (winter shelter)

The farm is located on the Sumas Prairie. In the winter, it is subject to strong winds that blow toward the southwest. A buffer would provide shelter from the wind, and potentially reduce energy costs for heating.

4 SITE ASSESSMENT

Factors	Description
Utilities/services	There are no overhead or buried utilities or services in the buffer zone.
Vehicle and machinery access	The producer requires 6 m (20 ft) of clear space along the length of the barn to access the fans on the east side from the rear (south end) with a tractor. The driveway and silo at the northeast corner of the barn must be kept clear for vehicle access. A 1 m (3 ft) gap should be left adjacent the barn to allow access by foot to the east side of the barn from the north end.
Slope	The property is level.
Buffer conflict with existing trees	Seven small deciduous trees need to be removed to make way for the buffer.
Regional tree pest and disease concerns	There are no signs of pest or disease issues in trees on the property or nearby.
Inventory of existing tree species on property	Trees on the property include western red cedar, hedging cedar, and several unidentified small deciduous trees.
Drainage	A depression that is shared with the neighbouring property floods seasonally (east of the barn). The ground will need to be raised prior to buffer installation.
Irrigation	There is no irrigation system in place. A hose bib is located on the north end of the barn.
Adjacent land uses	**North:** South Sumas Road runs along the north side of the poultry operation, beyond which is a church and residential properties. **East:** Residential properties. The neighbour to the east has a horse paddock. A subdivision is located 100 m (350 ft) to the east of the barn. Immediately east of the barn (on the producer's property) is a pasture used for horse grazing. The producer would like to preserve this use. **South and West:** The producer owns hay fields, which surround the barn on the south and west sides.
Neighbour relations	Neighbour relations are amicable. The poultry operation has not received complaints about their operation.
Livestock	Horses reside on the neighbour's property immediately east of the buffer. Once the buffer is established, they will be allowed to graze in the pasture adjacent to the poultry barn within the buffer zone. Buffer trees must be livestock friendly. **Do not plant buffer tree species that may be toxic to livestock (refer to the Vegetative Buffer Beneficial Management Practices Guidebook).**

5 MICRO CLIMATE EVALUATION

Micro climate Factors	Description
Predominate wind direction: warm season	NE
Predominate wind direction: cold season	SW
Average annual precipitation	1667 mm (66 in)
Average first and last frost dates	November 9 / April 6

Wind Direction:

Local weather data confirm that during the warm season, wind blows dust and odour in the direction of neighbouring residential properties to the northeast. The tree buffer should be positioned to the east of the barn fans to intercept dust and odour particles that travel towards the neighbours.

Precipitation:

The average annual precipitation is relatively high. July and August have the lowest amounts of rainfall (averaging 54 and 61 mm, respectively). This is a satisfactory amount to sustain a mature tree buffer; however, during the initial establishment years, irrigation will be required to ensure healthy growth and root establishment. Typically, irrigation should commence in late June and continue until mid to late October. Earlier or later irrigation may be required if drier than normal weather occurs.

Frost and Snow:

The first frost can occur in early November; however, snow does not typically fall until late November or early December. Planting is best undertaken from late October to mid-December. Planting can occur further into the winter provided the ground is not frozen. Late winter/early spring planting is acceptable (February to March); however, fall planting is preferred because it allows more time for roots to begin establishment before hot weather arrives.

Shade:

There are no crops present on either the poultry operation or adjacent properties that would be adversely affected by shade from the tree buffer.

6 BUFFER DESIGN

6.1 Buffer Design Characteristics to Accomplish Objectives

All vegetative buffer rows serve the primary purpose of mitigating dust and odour while providing the added benefits of the secondary objectives: visual screening and shelter from winter winds. As described in the Vegetative Buffer Beneficial Management Practices Guidebook, the optimal buffer design for odour and dust mitigation includes the following characteristics:

- **Placement:** A buffer positioned downwind of the emission source (during warm season months) enables the filter and chimney effects to intercept particles.
- **Setback:** Buffer effectiveness increases with increased distance from the source.
- **Configuration:** The most effective buffers have multiple rows. Buffer vegetation should provide contiguous cover, with no gaps between tree crowns or between tree crowns and the ground.
- **Height:** The buffer should reach a minimum height that corresponds to a 45 degree angle from the second storey fan hood to the tree top. In this case, that would be ~18 m (60 ft).
- **Length:** The length of the buffer should be sufficient to intercept emissions at each end of the barn.
- **Tree species:** Evergreens provide the added benefit of year-round particle interception and visual screening. They also have greater surface area for particle interception.

6.2 Buffer Design Plan

Figure E2-2: Buffer design map and planting plan.

Row	Considerations	Rationale	Design Plan
A	▪ Odour and dust are blown from barn emission fans on the east side of the barn toward residential properties to the northeast. ▪ Residential properties have an unobstructed view of the poultry barn. ▪ The barn is subjected to strong winter winds that blow toward the southwest, which may increase barn heating costs during cold periods. ▪ The pasture immediately east of the barn must be kept clear for horse grazing. ▪ Clearance requirement for fan access: 8 m (26 ft). ▪ Maximum available buffer space: 1.5 m (5 ft) × unlimited height.	▪ A conifer species would provide particle interception, year-round visual screening and a winter wind break. ▪ Tree species must be narrow (to maximize horse grazing area) and must be non-toxic to horses.	▪ Plant a single row of Smaragd cedar offset 0.6 m (2 ft) from the property line, running north south and extending at least 14 m (45 ft) beyond the ends of the barn.
B	▪ A narrow conifer species is necessary to use for row A. The only available narrow conifer species grow to a maximum height of 20 ft (6 m), which does not provide sufficient height to fully intercept particle emissions from the upper storey fans. ▪ Although the horse pasture east of the barn must remain clear, a tree row with a raised crown would still allow space for the horses. ▪ Clearance requirement for fan access: 8 m (26 ft). ▪ Maximum available buffer space: width of tree trunk (no crown) × unlimited height.	▪ A second buffer row of taller trees would provide additional particle interception beyond the height of the conifers in row A. ▪ A deciduous species would have a raised crown, which would maximize pasture space. ▪ A deciduous species would provide a pleasing visual screen when in full leaf, which would coincide with the time of year that neighbours are most likely to use their backyards. ▪ Tree species must be tall and must be non-toxic to horses.	▪ Plant a single row of Patmore ash offset 11 ft (3.3 m) from row A.
C	▪ Wind can pass unobstructed from south to north through the horse pasture adjacent to the barn (on poultry property). This could contribute to dust and odour travel toward the neighbours. ▪ Clearance requirement for barn access from the south end: 12 m (40 ft); from north end: 1 m (3 ft). ▪ Maximum available buffer space: no restrictions provided trees are planted only at each end of the barn.	▪ A wider and taller conifer species would provide additional particle interception and winter wind shelter in the gaps at each end of the barn. ▪ Tree species must be non-toxic to horses.	▪ Plant a single row of excelsa cedar (running east west) at the north and south ends of the barn. The southern row will have to be split into two staggered rows to allow tractor access to the east side of the barn.

7 SITE PHOTOS

Photo locations are marked on the base map (Figure E2-1).

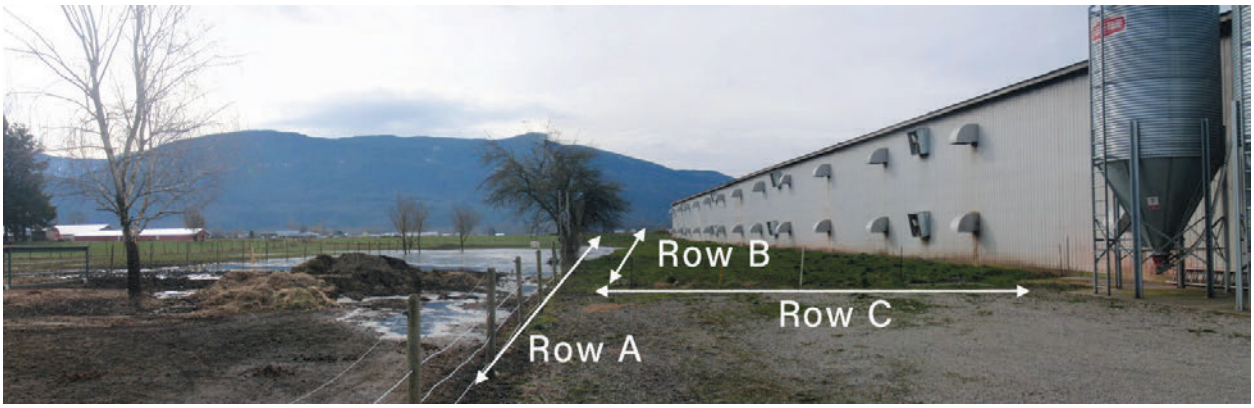


Photo 1: Looking south toward all buffer row locations.

Photo 2: Looking north. Note spring flooding in neighbour's horse pasture, stretching into the buffer zone.

Figure E2-3: Site photos

8 IMPLEMENTATION PLAN

TASK	Row A	Row B	Row C
Site Preparation			
Fill low flooded area, raising the ground to be even with the surrounding land on the poultry property	X	X	
Remove all existing deciduous trees (approx. 7 small deciduous trees)	X		
Mark maximum planting zone widths and position, including clearance area required for tractor passage between rows C2 and C3, and personnel passage between row C1 and the barn	X	X	X
Installation			
Use an excavator to dig a trench for planting row A (maximum width and depth identical to that of the root balls)	X		
Plant Smaragd cedar	X		
Plant Patmore ash		X	
Plant excelsa cedar			X
Stake all deciduous trees		X	

8.1 Installation Requirements

- Planting should be done in the late fall.
- Trees should be watered in as they are planted. Irrigation may be required if a dry spell occurs after planting prior to the start of the rainy season.
- Install drip line irrigation and a timer connected to the available hose bib (see map). The producer is responsible for controlling the timer and irrigation system.

8.2 Biosecurity Protocol

Standard poultry farm biosecurity protocols are in place. All workers should be familiar with the biosecurity protocol in Appendix 6 in the Vegetative Buffer Beneficial Management Practices Guidebook. Consult the producer before accessing the site to ensure their biosecurity requirements are being met.

8.3 Planting Prescription

See buffer design map (Figure E2-2).

8.4 Maintenance Plan

Maintenance Schedule

Task	J	F	M	A	M	J	J	A	S	O	N	D	Frequency
Inspection	/	/	/	/	/	/	/	/	/	/	/	/	Monthly
Water				/	/	/	/	/	/	/			Weather dependent – during all dry periods
Fertilize													Not usually required
Mulch			o	o									Annually
Prune		o									o		As required

/ = required; o = if necessary

Inspection and General Guidelines:

Inspect vegetative buffers monthly

VISUAL CHECK	Check for signs of stress, mortality, pests, or disease. Seek advice and treatment promptly if required.
TREE LEAN	Straighten any leaning trees after heavy wind storms. Firmly tamp the soil around the tree base to ensure there are no air pockets.
STAKES and TIES	Maintain tree stakes and ties for one full growing season (remove in spring 2021). Starting in April 2020, every four months check that the ties are not causing depression in the bark or girdling the tree. Loosen, repair, or replace as necessary.
MOWING DAMAGE	Avoid damaging the trees and shrubs during mowing and weed trimming. Do not mow or line trim (weed wack) within 30 cm (1 ft) of the tree base. If weeds are becoming problematic, mulch can be applied.
CONTAMINATION	Avoid spillage, drift, or runoff of fuel, fertilizer, toxic materials, road salt, and pesticides in the vicinity of the buffer. Herbicides (e.g., Roundup) should not be applied within 1 m (3 ft) of the outside drip line (canopy edge) of the buffer trees.

Irrigation:

Trees are susceptible to drought stress for the first 3-5 growing seasons after planting while their roots are establishing. Irrigate (drip system) during the growing seasons of 2020-2022 at a minimum, possibly to 2024 for cedar trees.

- The goal of watering is to penetrate the depth of the upper root zone (30 cm).
- **From mid-April to the end of October, water twice a week in either the early morning or evening.** If it rains significantly (> 10 mm in 24 hours), a watering can be skipped. During periods of hot weather, increase watering to 3 days/week.
- If your site has a high water table/flooding in the spring, do not start regular irrigation until you see that the water table has receded (test by digging a hole).
- Take care not to damage the irrigation system during mowing or weed trimming.

Irrigation System Maintenance

SPRING	- Undo the end cap to flush the line of any dirt trapped inside. - Reconnect the timer and replace the batteries. New batteries should last a full watering season. - Thoroughly check for leaks and blocked nozzles. Replace or clean clogged nozzles. Test timer operation. Check that water is flowing through all nozzles.
DURING USE	Once a week, walk along the drip irrigation system when it's on and ensure that water is flowing at each nozzle. If a nozzle is not working, replace it. If an entire section of the circuit is not dripping, look for a kink in the mainline tubing. Look for leaks. It's simple to replace a section of tubing by using two barbed couplers and new tubing.
FALL	- Before freezing temperatures occur, remove the end cap and allow water to drain out. Blowing out the system is recommended. - Store the timer indoors. Remove the batteries if they are corroded.

Fertilizer:

Fertilizer should not be necessary except where a professional has determined there is a nutrient deficiency based on either a soil test or visual assessment. If foliage is becoming thin or discoloured, there may be a nutrient imbalance. Consult an expert prior to applying any fertilizer. Soil acidity plays a critical role in a tree's ability to absorb available nutrients. For reference, the optimal pH range for trees and shrubs is 6.0-7.0. At the recommendation of a professional, pH can be adjusted to this optimal range.

Mulch:

Mulch was not installed at the time of planting and is not required since a drip irrigation system is in place. If you are concerned about weed growth or have a particularly dry site, installing mulch may be beneficial.

Use non-composted bark mulch as follows:

- Use mulch composed of chips and fines from hemlock and douglas fir. The mulch should not contain invasive plants, cedar bark, salts, or other contaminants.
- Maximum depth of the mulch should be 10 cm (4 in) when settled.
- Keep mulch a minimum of 10 cm (4 in) away from the tree base. Never mound mulch around the tree stem.
- Avoid clogging irrigation nozzles with mulch.

Mulches such as compost, leaf litter, or bark mulch can improve soil fertility. Avoid using impermeable plastic film.

Pruning:

Pruning should be done only to improve tree structure or health within the buffer.

- Pruning must be done in accordance with current acceptable arboriculture practice, as determined by the International Society of Arboriculture, during the season that is best suited to the trees in question. Pruning should be carried out under the direction of, or by, a qualified professional.
- **Trees should never be topped or lift pruned.** Both will damage the structure of the tree and will significantly reduce the effectiveness of the buffer.
- Pruning should be limited to cuts that are necessary to remove dead, diseased, damaged, and defective branches in order to direct growth and correct structural weaknesses while preserving the natural character and structure of the tree.
- No pruning should be done for the first 5 years after planting.

Maintenance guidelines have been developed in consultation with *the BC Landscape Standard*, 7th edition (BC Landscape and Nursery Association).

9 COST ESTIMATE

Date of cost estimate: August 2020

Item	Quantity	Stock Size/ Length	Unit Price	Cost	Source/ Supplier
SITE PREPARATION					
Soil				$1,120.00	
Machine				$0.00	
Subtotal				$1,120.00	
INSTALLATION					
Thuja plicata 'excelsa'	12	6 ft	$30.00	$360.00	
Thuja occidentalis 'Smaragd'	243	#5 pot	$15.00	$3,645.00	
Fraxinus pennyslyvanica 'Patmore'	26	3 m	$30.00	$780.00	
Tree delivery				$150.00	
Excavator and operator				$1,300.00	
Tree stakes				$260.00	
Irrigation				$500.00	
Labour				$2,440.00	
Subtotal				$9,435.00	
TOTAL				$10,555.00	

9.1 Plan Metrics

- **Total buffer length** (addition of all tree/shrub rows) = 282 m (925 ft)
- **Cost/unit length** = $37/m ($11/ft)

9 SITE ASSESSMENT FIELD FORMS

SITE SUMMARY	
Land Owner:	
Lessee Name:	
Business Name:	
Address	
Contact Number:	
Category Of Operation: (e.g., poultry, hog, cattle, crop)	
Metrics Of Operation: (e.g., number of livestock)	
Type Of Operation: (e.g., broiler, layer, specialty, breeder, dairy, feedlot, pasture, orchard, vineyard, berries, produce)	
Site Visit Date:	
Assessor Name:	

OPPORTUNITY EVALUATION			
BUFFER OBJECTIVES	PRIMARY (✓)	SECONDARY (✓)	COMMENTS
Dust Mitigation			
Odour Mitgation			
Pesticide Drift Mitigation			
Visual Screening/Aesthetics			
Energy Efficiency: Summer Cooling			
Energy Efficiency: Winter Shelter			
Noise Reduction			
Light Reduction			
Biodiversity And Riparian Enhancement			
Other			

SITE ASSESSMENT	Check off all items considered and include description where applicable. If possible sketch item on site overview map.		
FACTORS	Yes (✓)	N/A (✓)	DESCRIPTION
SOURCE OF ISSUE(S)			
Dust: Source(s)			
Odour: Source(s)			
Pesticide Drift: Source(s)			
Visual Screening/Aesthetics: Views or Activities To Screen			
Energy Savings – Summer Cooling: Location of Benefit			
Energy Savings – Winter Shelter: Location of Benefit			
Noise: Source(s)			
Light: Source(s)			
Other:			
OPERATIONAL REQUIREMENTS			
Access requirements			
Ventilation requirements			
Waste disposal locations/ requirements			
Sight line requirements			
Snow deposition requirements			
Biosecurity requirements			
Regulatory/bylaw requirements: (e.g., related to proximity to infrastructure, roads, easements, municipal maintenance access)			
Certification-related requirements: (e.g., organic farms)			
Future expansion/renovation plans:			
Other:			
Other:			

SITE ASSESSMENT	Check off all items considered and include description where applicable. If possible sketch item on site overview map.		
FACTORS	Yes (✓)	N/A (✓)	DESCRIPTION
SITE CHARACTERISTICS			
Utilities/services (e.g., power, gas, water, cables[8])			
Buried assets: (e.g., septic, wells, irrigation, drainage tile)			
Irrigation: location of hose bibs/ hookups, production concerns with water use			
Watercourses: (e.g., streams, ponds, wetlands, ditches, foreshore)			
Soil type: clay, silty, sandy			
Soil conditions: (e.g., compact, low nutrients, rocky, no top soil)			
Drainage: (e.g., seasonal flooding, poor water retention, critical drainage areas)			
Slope: describe topography (indicate slope direction(s) on site base map)			
Microtopography: (e.g., berms, depressions, frost pockets)			
Wildlife conflicts: note any potential challenges (e.g., deer browse, undesirable bird attractants)			
Other:			
Other:			

8 Service providers or utility marking services should be called to mark buried services/assets if you do not know their locations.

SITE ASSESSMENT	Check off all items considered and include description where applicable. If possible sketch item on site overview map.		
FACTORS	Yes (✓)	N/A (✓)	DESCRIPTION
EXISTING VEGETATION			
Inventory and condition of existing trees on property (list all species; determine reasons for any that are in poor condition)			
Regional pest and disease concerns (note any buffer species that may be vectors for issues that affect crop vegetation; e.g., juniper host of pear trellis rust)			
Livestock toxicity concerns (note any buffer species that should be avoided due to toxicity to on-site livestock)			
Existing trees in buffer zone (note any trees that conflict with the proposed buffer; determine whether they will be incorporated into the buffer or removed)			
Other:			
Other:			
LAND USE AND NEIGHBOURS			
Adjacent land use: describe all other land uses (by producer and by neighbours) in each cardinal direction of the buffer. Note any potential negative impacts of the buffer (e.g., shading a crop[9])			
Neighbour relations: comment on any positive or negative concerns			
Local bylaw or regulatory concerns			
Other:			
Other:			

9 See Appendix 3 for a shade distance calculator.

MICROCLIMATE EVALUATION	Refer to Appendix 2 for information on obtaining local weather information.	
FACTORS	**DESCRIPTION**	**COMMENT IN RELATION TO BUFFER DESIGN**
Prevailing wind direction: warm season		
Prevailing wind direction: cool season		
Annual average precipitation		
Average date of first frost		
Average date of last frost		
Extreme weather susceptibilities: (e.g., snow loading, heavy winds)		
Other:		
Other:		

BUFFER DESIGN	
FACTORS	**DESCRIPTION**
Dimensions: land available to support a mature buffer. Determine maximum length, width, and height	
Setback distances: (e.g., from fences, utilities, buildings)	
NO-GO Zones: all zones where trees/shrubs cannot be planted (e.g., due to operational or site constraints)[10]	

INSTALLATION REQUIREMENTS	
FACTORS	**DESCRIPTION**
Site preparation: (e.g., debris removal, soil movement, tree clearing)	
Access routes for landscape contractors	
Other	

10 See Appendix 3 a shade distance calculator and Appendix 4 for BC Hydro guidelines for planting near power lines.

10 APPENDICES

Appendix 1 – Glossary

Canopy density: Density of branches and leaves or needles in a tree canopy. Also referred to as canopy porosity. A high density canopy has low porosity.

Canopy porosity: Porosity of branches and leaves or needles in a tree canopy. Also referred to as canopy density. A high porosity canopy has low canopy density.

Coniferous tree: Tree that bears cones and has needle-like or scale-like leaves.

Evergreen tree: Tree or shrub that bears their needles or leaves year-round.

Deciduous tree: Tree or shrub that sheds its leaves or needles annually.

Downwind: In the direction in which the wind is blowing. If something is downwind, the wind is blowing towards it.

Impacted area: A location that will benefit from a vegetative buffer. In the case of an emission source, the impacted area may be neighbours' homes.

Source: The location of the issue that is being addressed by a vegetative buffer. Example sources of dust and odour include barn emission fans, feedlots, grazing pastures or manure storage areas.

Upwind: In the direction from which the wind blows. If something is upwind, the wind is blowing away from it.

Appendix 2 – Weather data sources

There are many sources for meteorological data in British Columbia. Several websites are listed below; they provide wind direction and wind speed information, which can be used in the Vegetative Buffer Plan. Wind speed and direction (often expressed as WSD on web sources) are the most pertinent weather details for buffer planning.

When planning and designing vegetative buffers, it can be beneficial to access data from the closest weather station to the site because it may provide the most accurate information on wind conditions near your location. In many cases, though, there may not be a weather station close by. Local knowledge of wind direction may be more accurate due to the influence of local topography.

Meteorological Data Sources

B.C. Ministry of Transportation and Infrastructure: hourly wind speed and direction data can be downloaded by the public. https://prdoas3.pub-apps.th.gov.bc.ca/saw-paws/weatherstation

Current Weather and Wind Station Data.
https://www.arcgis.com/home/item.html?id=cb1886ff0a9d4156ba4d2fadd7e8a139

Farmwest: large network of privately owned weather stations; not all include wind direction data.
Check the webpage, and contact them to see if there is a weather station near your site.
farmwest.com

Wind Alert: provides information which can be downloaded by the public http://www.windalert.com/

Greater Victoria school-based weather station network: hourly wind speed and direction data can be downloaded by the public. http://www.victoriaweather.ca/data.php?field=winddir&id=8&year=2015&month=0

Wind Rose Generators

B.C. Ministry of Environment weather stations allow you to create a wind rose instead of downloading raw data:
http://envistaweb.env.gov.bc.ca/

Lakes Environmental provides free software for generating wind rose plots: WRPLOT View
http://www.weblakes.com/products/wrplot/

How to read a wind rose diagram
https://sustainabilityworkshop.autodesk.com/buildings/wind-rose-diagrams

Appendix 3 – Shade distance calculator

When planning a buffer it is important to determine whether the buffer has the potential to negatively impact adjacent crops by creating shade. The information provided here explains how to determine the height at which the buffer is going to start shading a crop. The result will help inform the choice of buffer tree species. To do the calculation you need to know the distance between the edge of the crop and the buffer. It is also helpful to know the earliest date in the spring and latest date in the fall that the crop in question would be negatively impacted by shade.

The equation to calculate shade distance is as follows:

h = L/SLF or L = SLF (h)

h = height of the tree buffer

L = length of shadow (i.e., distance between the tree buffer and crop edge)

SLF = shadow length factor

To determine the SLF, go to http://www.nrc-cnrc.gc.ca/eng/services/sunrise/advanced.html, then select Sun angles and enter the date and city.

Note about date: Shadow length is longest on December 21 (winter solstice) and shortest on June 21 (summer solstice). Choose an early spring date and late summer date to represent the earliest and latest times of the year that shade (from tree shadow) would negatively impact the crop.

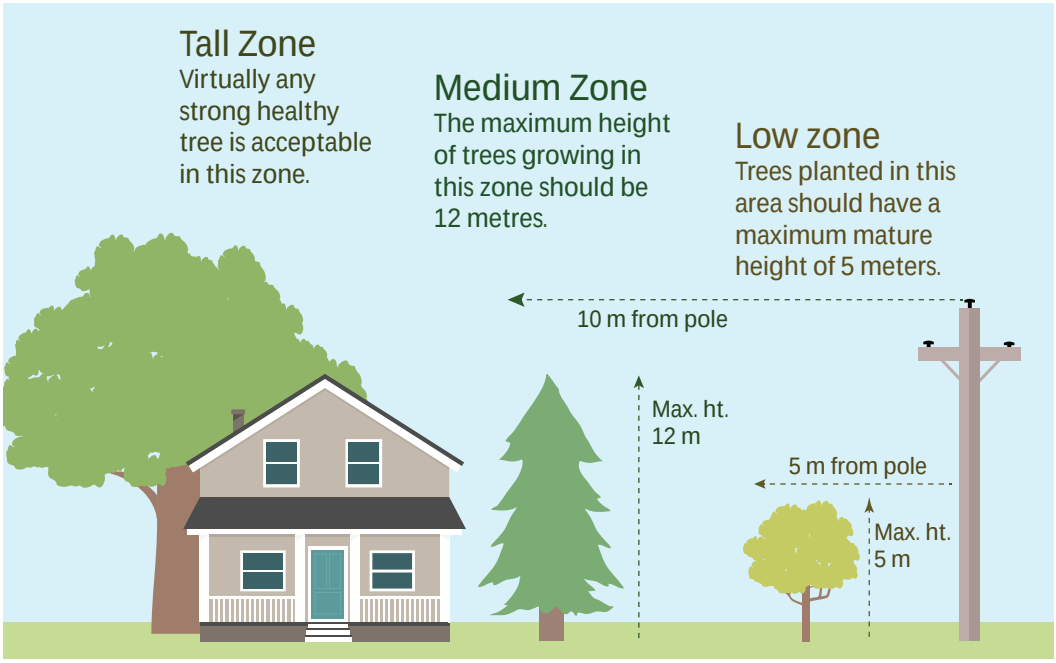
Example:

Tree buffer is 18 ft from the adjacent vineyard; L = 18 Location = Kelowna

Date	Time	SLF	RESULT
			Max. Tree Height (ft)
April 21	10:00 a.m.	1.01	18
	noon	0.79	23
	2:00 p.m.	1.03	17
September 21	10:00 a.m.	1.40	13
	noon	1.15	16
	2:00 p.m.	1.49	12

Conclusion: Within the growing season, shade will impact the edge of the vineyard when trees have grown taller than ~12-13 ft. This will occur in late September. There is more leeway in buffer height in early spring.

Appendix 4 – BC Hydro guidelines for planting near power lines



For further details, visit: BC Hydro's Planting Near Power Lines

Appendix 5 – Other vegetative buffer BMPs

Iowa Green Farmstead Partner Program

Delmerva Poultry Industry – Vegetative Environmental Buffers

Appendix 6 – Biosecurity considerations for landscape professionals

Biosecurity protocol varies farm to farm. The following protocol was used during the installation and monitoring of vegetative buffers at the demonstration site.

Before leaving the office

1. Preparation and planning: Create a Farm Equipment Kit which can be left on site for the duration of the installation process. At no time should dirty equipment be loaded into the truck. The following items should be included in the kit:

Farm Equipment Kit

- ❏ Coveralls: have a pair that is designated to the site. Dispose of soiled coveralls or clean them between site transfers.
- ❏ Boots: choose boots that can be easily disinfected; ensure they are cleaned between site transfers.
- ❏ Protective equipment: e.g., have disposable gloves, disposable booties, and polyethylene bags to store used coveralls, boot covers, and contaminated material.
- ❏ Disinfectant: use a disinfectant such as Virkon (Amass et al. 2001). Include an equipment pail, boot pail, boot brush (plastic or non-porous), hand disinfectant wipes, and cleaner in the kit.
- ❏ Mix Virkon to a 1% mixture in a hand pump. Make sure it is mixed fresh for each farm visit, and do not leave it in sunlight (Virkon degrades over time, so it should be mixed fresh frequently. It may last for a couple of days, but discard it if it is loses its colour. Sunlight accelerates degradation).

2. Call to schedule a site visit: Ask producers about the biosecurity protocol they are using and the plant pests or animal diseases that are affecting their operation.

Farm entry procedures

- ❏ Notify the producer of your arrival.
- ❏ Remain beside the vehicle and put on clean coveralls from the Farm Equipment Kit, and designated footwear. If the vehicle has to be left outside the controlled access zone, put on the coveralls and boots at the gate. If the vehicle can go onto the site, pull the boots or booties on while stepping out of the vehicle.
- ❏ For all vehicles entering a site: use a broom to sweep organic debris from the vehicle tires and undercarriage. Then spray down the vehicle tires with fresh water to remove any remaining organic material and spray them with Virkon until they are well soaked.
- ❏ Upon entering the site, park the vehicle away from heavy traffic areas and in a clean, dry area with no obvious manure accumulation. On poultry operations, park the vehicle at least 20 m (65 ft) from fan exhaust.
- ❏ Visitors to the site who do not have designated boots in the Farm Equipment Kit must wear booties. This includes visitors who conduct deliveries and management site visits.

During field installations

- ❏ If pre-approved by the producer, leave all equipment on the site for the duration of the installation process. This includes excavators and field tools.

Field exit procedures

- ❏ Clean equipment by knocking or scraping off soil lumps and sweeping loose soil off to the side of the vehicle.
- ❏ Wash all equipment used on the farm, then disinfect with Virkon or another disinfectant.
- ❏ Finish by washing all equipment and vehicles that leave the farm with a power washer to remove organic debris. Then disinfect with Virkon, targeting tires, the undercarriage, and any other parts that may have had contact with soil.
- ❏ Disinfectants need to be in contact with the pathogen for 15-20 minutes to be effective.
- ❏ If equipment has been satisfactorily cleaned, it can be returned to the "clean" area of the vehicle. If not, place it in designated plastic carriers in the "dirty" area of the vehicle.

Farm exit procedures

- ❏ Clean and disinfect the exposed portion of arms and hands, including fingernails, in the equipment pail.
- ❏ Clean and disinfect footwear using a boot pail. Remove any visible organic debris first, then return the boots to the plastic carrier in the "dirty" area of the vehicle and disinfect using the equipment pail solution.
- ❏ Remove soiled coveralls and booties, taking care to avoid contaminating street clothing. Seal them in a heavy duty polyethylene bag or plastic carrier in the "dirty" area of the vehicle.
- ❏ Clean and disinfect the exterior of the equipment tool box and Farm Equipment Kit with detergent/disinfectant and water.
- ❏ At no time should dirty equipment be loaded into the truck bed or interior, unless it is sealed in a plastic bag.