Climate Action Initiative
BC AGRICULTURE & FOOD

BC Farm Practices
& Climate Change Adaptation

Shelterbelts

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other project partners
BCAC/ARDCorp

project manager
Emily MacNair

author & photographer
Allen Dobb

graphic design
Rocketday Arts

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Farm Practices & Climate Change Adaptation Series

This series of six reports evaluates selected farm practices for their potential to reduce risk or increase resilience in a changing climate.

The practices selected are well known in contemporary and conservation-based agriculture. While they are not new practices, better understanding of their potential relationship to climate change may expand or alter the roles these practices play in various farming systems.

Climate change will not only shift average temperatures across the province, it will alter precipitation and hydrology patterns and increase the frequency and intensity of extreme weather events. The projected changes and anticipated impacts for agricultural systems are considered in the practice evaluations. More details regarding climate change and impacts for various production systems in five BC regions may be found in the *BC Agriculture Risk & Opportunity Assessment* at: *www.bcagclimateaction.ca/adapt/risk-opportunity*

Farming systems are dynamic, complex, and specific to the local environments in which they operate. This makes the analysis of farm practices on a provincial level particularly challenging. The approach taken for this series, is to explore the application of practices regionally and across a range of cropping systems and farm-scales. While the ratings are subjective and may not reflect suitability for a particular farm, the ratings and associated discussion help to identify both the potential, and the limitations, of selected practices on a broader scale. In some cases, the numerical ratings are expressed as a range, to reflect variation in conditions across regions and cropping systems.

The practice evaluations are informed by background research and input from agriculture producers around the province about their current use of practices. Each document includes: a practice introduction, key findings, an evaluation of suitability to help to address climate change risks, and technical practice background related to adaptation. The documents conclude with practice application examples from various regions of the province. More detailed information about the overall project may be found at: *www.bcagclimateaction.ca/adapt/farm-practices*

Like farming systems, practice applications are location specific and change over time. Continued adaptation and holistic integrated practice implementation will be required as climate conditions change. The effectiveness of most practices for mitigating climate and weather related risks will vary over a range of conditions. Ultimately, if practice adoption can reduce vulnerability and risk overall, it has some effectiveness in supporting adaptation.

This document is not intended to serve as a stand-alone technical guide. Rather, it is hoped that this evaluation supports dialogue—among producers, agricultural organizations and key government agencies—about how these and other practices may apply in a changing climate, and how to address information or resource gaps to support further adoption and adaptation.

Contents

Introduction

Shelterbelts offer British Columbia's farmers and ranchers a way to directly moderate some of the impacts of climate change in their fields, orchards and pastures. Shelterbelts are created by planting adapted species of trees or shrubs, or in some cases, allowing natural plant communities to establish by protecting selected areas from grazing or cropping. Shelterbelts can also be created during land clearing and forestry operations by retaining treed areas.[1] These can be referred to as timberbelts if timber production is an objective for the producer. When actively managed, treed shelterbelts are integral parts of agroforestry and silvopasture systems, and can provide additional harvestable products.[2]

Shelterbelt applications and uses

- → Crop protection
- → Livestock shelter
- → Energy conservation
- → Wildlife habitat and bio-diversity retention
- → Fence-line erosion control
- → Water storage evaporation reduction
- → Soil moisture retention

How Do Shelterbelts Work?

Shelterbelts, or windbreaks, modify the micro-climate mainly by changing wind speed and turbulence. They are most effective when planted or created in rows at right angles to the prevailing wind. They also modify air and ground temperatures, humidity and CO_2 concentration, mostly in the leeward zone.[3] They can affect how snow accumulates and melts, contribute to soil and water conservation, prevent erosion, and provide habitat for wildlife and beneficial insects.

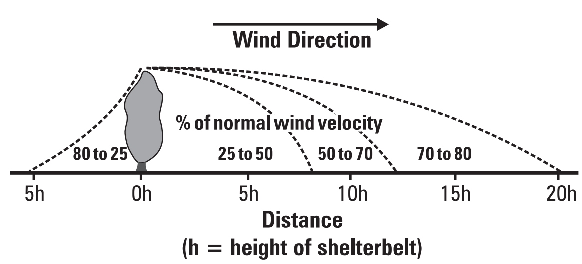


FIGURE 1 Approximate reduction of wind velocity by a single row shelterbelt

Source: Casement and Timmermans, 2007.[4]

Shelterbelts are a barrier to wind flow, deflecting it over the top and compressing it above. This causes an increase in wind velocity above shelterbelts, a decrease in wind velocity on the leeward side, and energy release and turbulence further out in the field (Figure 1). The density and species selected for windbreaks can change these characteristics.[5] The type of species—whether tree, shrub, deciduous or coniferous—can dramatically impact how air flows through or over the shelterbelt, depending on the porosity that is created.

Shelterbelts can have positive effects on crop production by moderating plant water use, reducing physical damage, changing air and soil temperature, as well as impacting CO_2 levels and relative humidity. In some situations, a single row of trees can provide adequate shelter for crop production. The main disadvantages of the single row are the limitations that are imposed on the structural design of the shelterbelt, and the potential for interruption in the shelterbelt effectiveness with the loss of individual trees.

Current Adoption in BC

Just fewer than 20% of all farms in BC reported having natural or planted windbreaks or shelterbelts in the Statistics Canada, 2011 Census of Agriculture. However, the purpose of shelterbelts—whether for farmstead, crop or livestock protection—is not indicated in the census data, suggesting potential for further shelterbelt implementation across a broad range of applications (Figure 2).

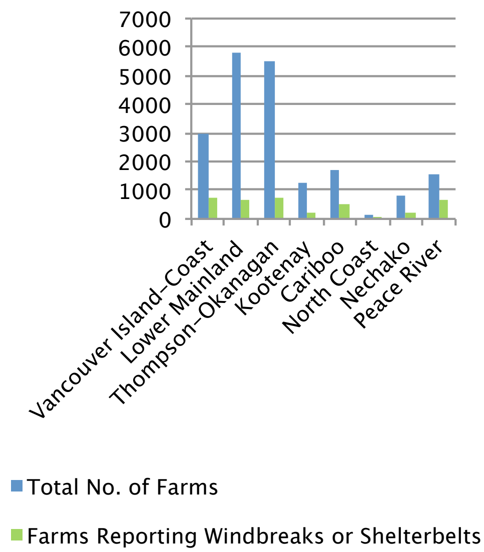


FIGURE 2 Total number of farms, and number of farms reporting windbreaks or shelterbelts, natural or planted, by region

Source: Statistics Canada, 2011 Census of Agriculture, Farm and Farm Operator Data, catalogue no. 95-640-XWE.

Key Findings

- With greater frequency of extreme weather events projected for the entire province, changes in wind frequency and intensity are likely to affect production in all regions. Properly designed shelterbelts have potential to reduce associated risks or vulnerabilities (particularly on farms where they are not already in use).
- The effectiveness and overall suitability of shelterbelts depends on the region, individual farm location and farming system.
- Shelterbelts have been shown to produce benefits for almost all crops, whether or not they are wind tolerant.
- There is a range of other conditions related to climate change that shelterbelts can help to moderate (e.g., extended dry periods, and extreme precipitation events).
- Retained shelterbelts in pastures could provide additional late season forage, and help to moderate losses in forage quality and quantity during drought periods.
- Continued management over the life of the shelterbelt is necessary to maintain shelterbelt effectiveness.
- There is likely potential for increased management of shelterbelts on farms where they are already in use.
- There is relatively low adoption of shelterbelts in Canada, which may be attributed to a number of factors including:
  - → A need for more demonstration and assessment of shelterbelt benefits on a regional and farming system basis; and
  - → A need for further development of shelterbelt design and management within various farming systems.
- Shelterbelts have potential to be highly adaptable when they are managed as part of agroforestry systems.
- The use of shelterbelts and planned retention areas is compatible with existing institutional and legal structures.
- Site specific planning and cost-benefit analysis are necessary to fully assess the suitability of shelterbelt establishment on farms and ranches.

Areas for Further Adaptation Research & Support

- Identification of regions, production systems and sites where there is potential for effective shelterbelt implementation.

- Research and demonstration that support development of shelterbelt establishment and management practices for different farming systems.

- Assessment of the costs and benefits of shelterbelt applications in different farming systems.

- Continuation of research on integrated land use management and agroforestry systems.

- Inclusion of wind measurements and wind related-parameters in climate information. Where possible, include wind parameter measurements in baseline and "new normal" weather descriptions, and on individual weather station reports.

- Identify the relative importance of wind in weather station estimates of evapotranspiration, and link to existing farm production models and calculators.

Evaluation: Adaptation & Shelterbelts

Multi-Criteria Evaluation

Agricultural research is typically undertaken to establish the efficacy of a product or practice under specific conditions. Similarly, cost-benefit analysis is valuable for assessing whether an investment is economically efficient (whether it pays to invest in a particular practice or asset). An evaluation of adaptation options for climate change needs to consider more than just effectiveness and economic efficiency to be useful for both farmers and those interested in supporting climate change adaptation. Multi-criteria evaluation provides a framework for this evaluation — enabling a set of decision-making criteria to be examined simultaneously.

Multi-criteria evaluation (MCE) can be highly structured, or, as it is applied here, more subjective and exploratory. To have value, the evaluation has to have the decision makers it aims to serve in mind. Often when MCE is employed, considerable time is spent gathering input on decision-making criteria and the needs of users. Given the limited scope of this project, it was not possible to gather user-specific input, and instead the criteria were developed by looking at other studies in the field of adaptation to climate change.[6] However, producers did provide input on the relative importance of the selected decision making criteria in a ranking exercise (27 of 29 participants). Perhaps not surprisingly, economic efficiency and effectiveness were the top ranked criteria followed by adoptability, adaptability, flexibility and independent benefits. Institutional compatibility was ranked last by the majority of farmers.

Often MCE is used to select the most desirable option from various alternatives. Ratings for each criterion are determined, and then added together to provide a total score for each alternative. The relative importance, or weight, given to a single criterion can affect the overall suitability rating for a practice. However, for this evaluation, it is the scores for individual criteria that provide insight into how a practice might be suitable for adapting to climate change, and what might need to change to make it even more suitable. The purpose of the evaluation is not to aggregate ratings and compare practices, but rather to improve understanding of how the individual practices relate to adaptation to climate change.

The evaluation takes a broad view (coarse-scale) across areas and farming systems in the regions (and production systems) where the practice might be applied or considered. The ratings were determined under the assumption that there is some basis for the application of a practice within certain farm types. For example, management-intensive grazing does not have application on a farm without livestock, and therefore it would be ineffective as an adaptive practice for that farm when compared to other alternatives.[7] If carried out at a fine-scale (individual farm level), the suitability rating of any practice could be quite different because the specific circumstances of the farm would be considered for each criterion. Likewise, ratings could vary depending on the purpose (e.g., policy formulation vs. farmer adoption), and the perspective of the individual(s) carrying out the evaluation. Even though, a broad view is taken in the evaluation, the criteria in this series are considered from an on-farm perspective.

The evaluation below assesses a farm practice through the following set of decision-making criteria: *Effectiveness*, *Economic Efficiency*, *Flexibility*, *Adaptability*, *Institutional Compatibility*, *Adoptability* and *Independent Benefits*. Each of the criteria are defined and a numerical rating (in some cases a range) has been assigned across a scale from 1–5 to reflect its potential value in adapting to climate change. The discussion that accompanies the rating captures some of the issues contemplated in determining the rating, as well as some of the variation and complexity of practice application across the province and farm systems.

Effectiveness

Whether the adaptation option reduces the risk or vulnerability, and/or enhances opportunity to respond to the effects of climate change.

RATING: 4
moderately effective

Properly designed shelterbelts are likely to be moderately effective in reducing the risk or vulnerability to climate change on farms where they are not already in use. In addition, there is the potential for increased use or management of shelterbelts on farms where they are already in place.

Surface winds that affect agricultural production are a highly localized weather phenomenon dependent on topography, air temperature and pressure differences. The effectiveness of shelterbelts will vary by region and farm location within each region. With predicted increases in average temperatures and greater frequency of extreme weather events for the entire province, changes in wind frequency and intensity are likely to become an increasingly important factor affecting production in all regions.

Shelterbelts have been shown to produce benefits for almost all crops, whether or not they are wind tolerant. Improvements in crop production have been associated with shelterbelts where moisture is a yield limiting factor. Though total precipitation is predicted to increase across BC, summer precipitation and precipitation falling as snow are expected to decrease. With corresponding increases in temperature, growing season moisture deficits are expected to increase. Shelterbelts should help moderate these effects.

Yield differences between sheltered and unsheltered crops can be used to estimate the amount of water conservation for each type of crop. Yield differences reflect increased water application efficiency, increased infiltration and storage from snow or rainfall, reduced evaporation from the soil surface and the ability of plants to use the stored moisture more efficiently.[8] Planned and managed retention areas in pastures could provide additional late season forage, and help moderate losses in forage quality and quantity during drought periods.

Economic Efficiency

The economic benefits relative to the economic costs that are assumed in implementing the adaptation option.

RATING: 3–4
neutral to moderately efficient

The economic efficiency of shelterbelts for on-farm adaptation is highly variable depending on what is being sheltered (crop type, livestock, etc.), the shelterbelt design, and the discount rate used in the analysis. Additional farm benefits that may not be fully captured by estimating crop yields (e.g., reduced soil erosion, evaporation from water storage, and energy efficiency) should be considered along with any harvestable products from the shelterbelt. Similarly, both establishment and on-going maintenance should be included in the determination of cost estimates. Future benefits may be affected by climate change and accompanying uncertainty. An on-site risk assessment should be done to weight future management considerations, and establish appropriate risk factors for the analysis. Some of the factors in determining shelterbelt costs are outlined in more detail in Table 4 (page 12).

Shelterbelts also have social and environmental (public, downstream or external) benefits, and some governments have provided subsidies to help farmers establish shelterbelts.[9] On the Great Plains, studies have shown shelterbelts to be efficient investments without subsidy. Winter wheat yields averaged 15% higher under sheltered conditions in Nebraska, resulting in a 15 year payback period and a positive net present value for a shelter belt investment.[10] Another study that considered future climate scenarios, found that yield benefits increased as more stressful climate change scenarios were introduced.[11] In this study, unsubsidized shelterbelts were profitable with discount rates over 8%, but producers would have a long period of negative returns without government cost-sharing. In southwest Saskatchewan, tall wheatgrass barriers spaced at 15 metre intervals only marginally improved net returns over conventional open-field production, but reduced risks associated with continuous cropping by increasing yields and net returns in dry years.[12] The public benefits (such as reduced soil erosion, and carbon sequestration) of trees distributed from the Agriculture and Agri-Food Canada Shelterbelt Centre in the Canadian Prairie Provinces for the period 1981–2001, were estimated at $140 million (2001 CND$).[13]

Flexibility

The ability of an option to function under a wide range of climate change conditions. An option that reduces income loss under specific conditions, and has no effect under other conditions, would be considered inflexible.

RATING: 5
very flexible

Shelterbelts effectively change micro-climates and decouple the climates of sheltered areas from those that are unsheltered. Thus it is expected shelterbelts would be effective and function under a wide range of climate change conditions.[14] A crop modelling study in in eastern Nebraska found that sheltered maize production continued to perform better than unsheltered crops under a wide range of projected conditions. The scenarios considered included temperature increases of up to 5°, precipitation levels 70-130% of normal, and wind speed changes of plus or minus 30%.

Adaptability

Whether a practice can be built upon to suit future conditions and allows further adaptation.

RATING: 4–5
moderately adaptable to very adaptable

Shelterbelts have the potential to be very adaptable when they are managed as part of agroforestry, systems. In this type of system, production risks are distributed over a number of harvestable products, and management emphasis can also be shifted among products. Small-scale vegetative shelterbelts would be a very adaptable practice, as these can be installed and managed on a shorter-term basis. Treed shelterbelts planted for a specific crop may be less adaptable for a range of conditions. However, if they are well designed, they may be managed or modified to suit future production systems and conditions.

Institutional compatibility

Compatibility of the adaptation option with existing institutional and legal structures.

RATING: 5
very compatible

The use of shelterbelts and planned retention areas is compatible with existing government and legal structures. Until recently, shelterbelt establishment was supported by the federal Prairie Shelterbelt Program in the Peace River region, so there is a long history of this type of institutional support. The *BC Environmental Farm Plan Program* has supported and provided funding for the establishment of shelterbelts and buffers in all regions. Shelterbelt design recommendations may need to be modified to comply with various road rights-of-way or infrastructure specifications.

Adoptability

The ease with which farms can implement the practice under existing management practices, values and resource conditions.

RATING: 2
moderately low adoptability

Although there is long history of shelterbelt promotion in Canada for conservation purposes, there is still a relatively low level of adoption. There are likely several contributing factors including:[15]

- Poor shelterbelt design—including taking too much land out of production—and the resulting marginal benefits;
- The up-front capital and management investment required (with delayed benefits while shelterbelts are being established);
- Yield decreases in the competitive zone immediately near shelterbelts;
- Inadequate quantification of the benefits on a regional and farming system basis;
- A history of land clearing in BC (for both logging and agriculture) may have led to negative perceptions about the value of retaining or planting trees in cropland and pasture;
- Increases in equipment size, especially for grain farming operations, mean that shelterbelts interfere with operational efficiency, increasing fuel and labour costs;
- Limited active management of existing shelterbelts, and lack of fully integrated production (agroforestry), and demonstration;
- The substantial level of knowledge and planning capacity required for adoption; and
- Potential for shelterbelts to become sources of harmful pests, weeds or wildlife impacts.

Independent Benefits

The potential for a practice to produce benefits independent of climate change. For example, a practice that reduces income loss regardless of climate change effects, would be rated high.

RATING: 4–5
moderate to high independent benefits

The ability of shelterbelts to produce benefits independent of climate change is moderate to high. The economic efficiency of shelterbelts is variable, but benefits including reduced soil erosion loss, soil moisture retention, and increased crop quality and yield have been demonstrated under normal conditions.

TABLE 1 Shelterbelts evaluation summary

Evaluation Criteria	Rating	Meaning
Effectiveness	4	Moderately effective
Economic Efficiency	3–4	Neutral to moderately efficient
Flexibility	5	Very flexible
Adaptability	4–5	Moderately adaptable to very adaptable
Institutional Compatibility	5	Very compatible
Adoptability	2	Moderately low adoptability
Independent Benefits	4–5	Moderate to high independent benefits

Shelterbelts Background Information

Shelterbelt Benefits for Crop Production

When shelterbelts are suggested to land owners, the negative effects observed immediately adjacent to windbreaks and shelterbelts are generally thought of first. The overall effect of improved crop yields further into the field are not always appreciated.[16] Nearly all crops have been shown to benefit from protection by shelterbelts. The crop response may be caused by wind protection, resultant changes in the micro-climate or both. Though all crops may respond to shelter with yield increases, some crops are more tolerant to wind and wind-blown soil than others:

- **Tolerant crops**—cereals and forages
- **Moderate tolerance crops**—corn and sorghum
- **Low tolerance crops**—orchard and vineyard crops
- **Very low tolerance crops**—vegetable and specialty crops, and new alfalfa seedlings

TABLE 2 Relative responsiveness of various crops to shelter

Crop	Number of field years	Weighted mean yield increase (%)
Spring wheat	190	8
Winter wheat	131	23
Barley	30	25
Oats	48	6
Rye	39	19
Millet	18	44
Corn	209	12
Alfalfa	3	99
Hay (mixed grass and legumes)	14	20

Source: Kort, 1988[17].

Tolerant & Moderate Tolerance Crops

Since the early 20th century, research has demonstrated that field shelterbelts have positive benefits for crops growing within their shelter.[17] Table 2 provides a summary of research since 1932 from around the world, on the yield response of some wind tolerant crops in temperate climates. Unfortunately, the shelterbelts designs in these studies were not always adequately described. It is possible that with appropriately designed shelterbelts, greater yield increases might be demonstrated. Nonetheless, the response is quite strong across a variety of crops. Alfalfa showed a particularly positive response to shelter in this summary, but there were comparatively few field years of data for this crop.

Where substantial annual moisture falls as snow, and moisture is a yield limiting factor, snow trapping and retention by shelterbelts has been shown to increase crop yields (Table 3). In addition, snow provides an insulating layer to prevent winterkill of sensitive crops like winter wheat and forage legumes. Treed shelterbelts designed for snow control may need thinning or pruning to create shallow and wide snowdrifts. Deep snow drifts can delay spring fieldwork in annual cropping systems (Figure 3).

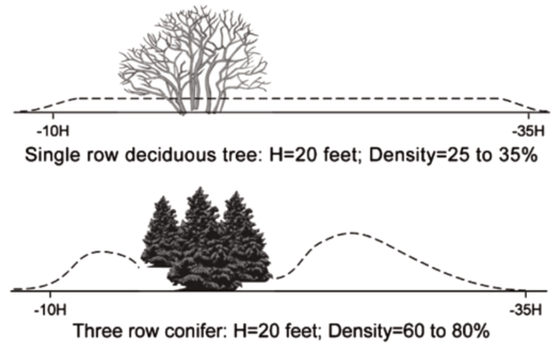


FIGURE 3 Effect of shelterbelt density on snow accumulation

Source: Brandle et al. 2004.[14]

Low Tolerance & Very Low Tolerance Crops

Numerous benefits are associated with the creation of tall windbreaks to protect orchard and vineyard crops:[19]

- Improvements in pollination and fruit set, resulting in higher yields;
- Less mechanical damage from whipping of leaves, branches, buds and flowers, and bruising of fruit;
- Less root breakage and tree deformation;
- Less transpiration, and greater irrigation efficiency;
- Efficient use of pesticides due to better water distribution and reduced evaporation; and
- Reduced spray drift to non-target species.

TABLE 3 The effect of persistent snow on crop yields[18]

Winter precipitation	Number of field-years	Weighted mean yield increase (%)
Snow	377	20.8
No snow	313	12.5

Vegetable crops are highly vulnerable to wind and wind abrasion. Improved crop quality and yield increases are the major benefit of shelterbelt protection systems. Most benefits occur within a zone that is 10 x the shelter height on the leeward side, or within 0–3 x the shelter height of the wind break on the windward side.[20] Windbreaks do not have to be tall to be effective, if they are placed in a sequence to create protected zones. Vegetation strips of lupine, oats and fall rye, were shown to be highly effective in melon production in the southeast U.S.

Shelterbelt Benefits for Livestock Production

Forage production in fields and pastures can be improved with the use of shelterbelts, but shelterbelts can also benefit livestock directly. Shelterbelts moderate temperatures and this directly affects animal performance:

- In winter, shelterbelts reduce wind-chill and the amount of nutritional energy animals need for body maintenance, thus reducing feed costs.
- In summer shelterbelts and buffers provide shade for animals, which reduces stress and improves animal performance.
- The temperature of confined livestock facilities can be affected in much the same way with the use of planned shelterbelts, reducing energy costs for building heating and cooling.
- As well as providing shelter, managed retention areas in developed pasture—especially aspen types—can be used to moderate seasonal declines in forage quality.

Shelterbelts Costs

The cost of shelterbelt establishment depends on the objectives, type, application and plant species (or structures) involved. Costs can generally be divided into three categories: 1) planning and site preparation; 2) planting and/or establishment; and 3) on-going maintenance. However, the primary cost consideration, especially for field shelterbelts, is the amount of land taken out of production. In integrated and planned agroforestry situations, shelterbelts can provide revenue from wood, wood fibre or other products. The retention of existing trees, or other native vegetation, will reduce establishment costs in some situations.

Farm specific planning and a cost-benefit analysis are necessary to fully assess the suitability of shelterbelt establishment. Some of the areas of potential cost are outlined for two shelterbelt applications in Table 4. The first scenario outlines on-farm costs that might be associated with establishing a planted shelterbelt. The second scenario identifies potential costs for planned retention areas in a pasture development situation.

Some Considerations for Shelterbelt Planning

Shelterbelts need to be properly designed and integrated into the farming system to be effective, and there are a number of considerations for planning.

- Vegetative shelterbelts can be competitive and use up available resources needed for crop plant growth. Treed shelterbelts may need to be crown or root pruned to maintain effectiveness, or minimize competitive effects.
- Plant species need to be adapted to soil and site conditions and carefully selected to obtain the desired protection, while minimizing the use of resources like irrigation water. Some species may produce alleopathic effects on crops.[21]

TABLE 4 Potential cost considerations for two shelterbelt applications

Costs	Planted field tree-shrub shelterbelt	Planned retention areas in improved pasture development
Planning and site preparation	▪ Planning, time and/or specialist services ▪ Land taken out of production for shelterbelt ▪ Opportunity cost based on crops grown, expected prices, delay in benefits ▪ Site preparation including: cultivation, weed control, mulching, cover crop	▪ Planning time and/or specialist services ▪ Land taken out of improved forage production for shelterbelt ▪ Opportunity cost based on expected forage yield differences in open vs. timbered areas ▪ Reduced equipment and site development costs
Planting and establishment	▪ Planting costs, i.e., shrub and tree costs by species, seedling size, planting method—mechanical vs. hand planting, number of rows* ▪ Understory seed costs, i.e., grass seed mix ▪ Irrigation and weed control ▪ Fencing or cages for protection from wildlife and livestock	▪ Fencing costs for grazing management
Maintenance	▪ Top-pruning, root pruning ▪ Irrigation (some situations) ▪ Fence maintenance (some situations)	▪ Fence maintenance

* *Total plant cost will vary with species and planting density. The following example is provided to give a rough measure for estimating plant material costs. Species with a recommended planting density of 3 metres, at $2.50/seedling would cost $837.50/km/row.*

- Yield responses can be highly variable, and are sensitive to shelterbelt design, location and the kind and variety of crop grown. Conditions vary widely across the province.
- Primary objectives should be considered in the design for example, a more porous design for good snow distribution may conflict with a design for maximum wind protection of sensitive crops.
- Shelterbelts may attract wildlife that can damage crops.
- Shelterbelts may increase fencing requirements in some situations.
- Shelterbelts may make certain equipment operations more difficult, and restrict the scale of equipment that can be used in some cropping situations.

Characteristics to consider in planning effective shelterbelts

- Height and density
- Orientation
- Length and width
- Continuity/uniformity, cross-sectional shape or structure
- Tree or shrub species
- Maintenance
- Harvestable products
- Grazing management if applicable

Shelterbelt Examples

Field Vegetable Shelterbelt *(Thompson-Okanagan region)*

Originally established in 1997, the value of this poplar and pine windbreak shelterbelt for improving the quality and production of field peppers has been recognized on this farm in the Thompson-Okanagan region. Peppers are vulnerable to wind in the spring immediately after planting, and spring winds are common at this site:

> *We love windbreaks… because we can block ourselves from wind we can get two weeks extra on a crop. Think about what that means economically…*

Management of the windbreak has changed over time to suit the conditions, minimize water use and meet the needs of the sheltered crops. Some disease issues indicated there was not enough air movement later in the season:

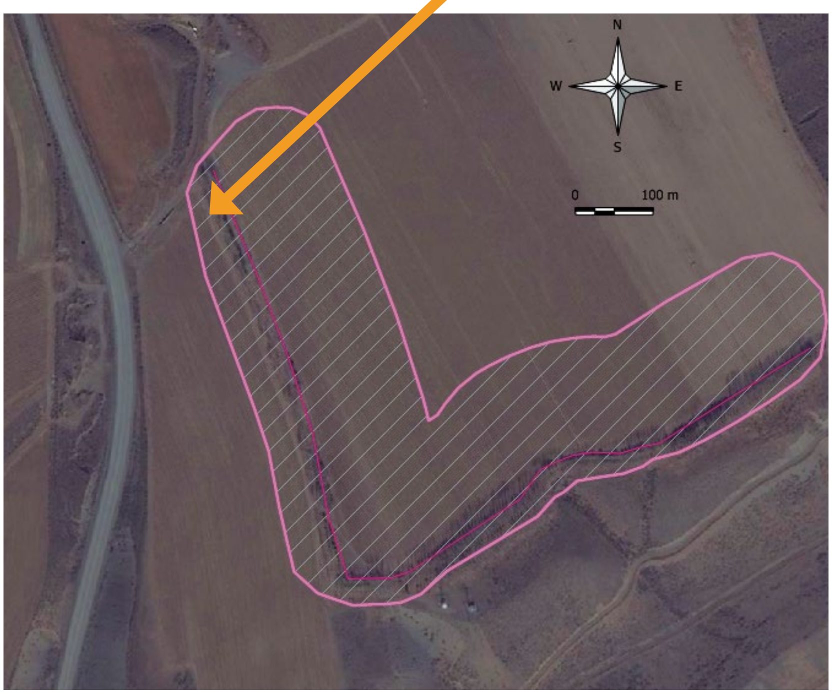
> *Where there was no air movement we had more Phytophthora and Pythium problems on the peppers. So we don't have the wind, but without the wind we have those problems. Later in the year we didn't have the air movement in there. So [we] went along, and took all the branches off the bottom 12 feet [and] we let a certain amount of air come in.*

The shelterbelt also uses some of the irrigation licence and the water is turned off in the mid to late summer, allowing the trees go dormant to minimize water use. With benefits clearly identified, this producer is establishing more windbreaks, looking at species that require less water, and experimenting with mechanical shading systems.

Highlights

- Extended growing season for wind intolerant crop
- Increased production
- Shelterbelt management for crop disease control and water conservation

Shelterbelt at the north end, with peppers in the foreground.



The planted shelterbelt from above, and an estimate of the quiet area created by protection from winds from the west and south (area estimate = 10 x height on the leeward side, and 3 x height on the windward side; windbreak is the dark pink line and the quiet area is in light pink). The shelterbelt is approximately 15 metres high, and is about 1.2 km in length.

Integrated Pasture & Shelterbelts *(Cariboo region)*

The value of shelterbelts in rangeland and pasture contexts is not always appreciated, especially in areas with substantial annual precipitation, like the east-central Cariboo region. This forage-based organic livestock producer knows that annual growing season moisture is a limiting factor, and that natural shelterbelts and forested buffers retained in earlier land clearing operations are highly beneficial.

> *You get more snow [referring to snow capture] and you have more snow on the shady side [of the shelterbelt] and I have pictures where you can see the shelterbelt and the really green grass for a distance and it tapers out and [then] it's brown… because this all here [forage production] is dependent on the moisture we get.*

Windrows, which contained dead woody debris and have regrown, would have ordinarily been re-piled and burned in conventional land clearing practice. Management of these retained shelterbelts is fully integrated with management intensive grazing, pasture rejuvenation and forage harvest rotation (alternate haying, grazing and rejuvenation). Grazing in the shelterbelts themselves is timed to be beneficial for wildlife, and some work has been done to create openings and laneways to improve the efficiency of machinery operations. Some aspen harvest is integrated in this system. Other benefits in this holistically managed operation are also recognized.

> *I learned about the research they are doing with the mycorrhizae and that grass depends on mycorrhizae from trees and the tree mycorrhiza depends on mycorrhiza from grass, and the ideal distance is maximum 150 metres from shelterbelt to shelterbelt and that's what I have here. I wish I had some money to plant some shelterbelts again. Even this [referring to open area] is a more wind protected site, but this here [referring to another site] is on top of the hill, and also here it's really windy so that it's really important have [shelterbelts].*

Highlights

- Natural and retained shelterbelts
- Shelterbelt management
- Moisture conservation
- Increased forage production
- Improved fertility
- Integrated agroforestry with aspen harvest
- Wildlife benefits

The arrangement of shelterbelts forested buffers, and timberbelts on a forage-based organic livestock operation in the east-central Cariboo.

Cattle grazing in the pasture in the very southeast corner of the aerial photo, with a forested buffer in the background.

Mixed-Farm Shelterbelts *(Peace River region)*

In traditional land clearing practice in the Peace River region, trees were knocked down, piled in windrows, and then burned, re-piled and burned again. The land between windrows was cultivated, and often these windrows were left to be dealt with later. This allowed crop production to begin without additional expense. In some areas, these brush piles were left intentionally and have revegetated to form natural shelterbelts. These shelterbelts have been retained on this mixed grain, oilseed and beef cattle farm just north of the Peace River.

> *We don't want to take out any of our bush strips either. We leave them on purpose. Instead of farming a quarter section in one field, it's chopped into 3 or 4 pieces.*
>
> *Well for hay, pasture and cattle… cattle need shelter. So you tend to leave bush pieces, partially for erosion control, partially for cattle shelter, partially to hold snow for grazing [and] for hayland.*

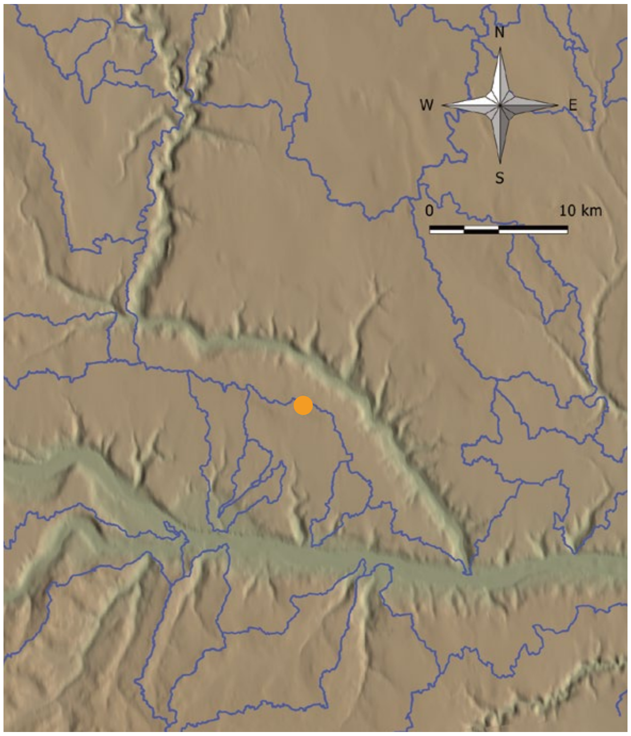
Orientation to the prevailing wind is a major factor for shelterbelt effectiveness. The prevailing winds in this area are from the northwest, with harder storms coming from the southwest. The variations in shelterbelt direction produce different micro-climate effects.

> *It's a pain. If you are trying to use the land north of the bush you lose the first 30-40 feet the hay doesn't dry out.*
>
> *On a dry year it holds moisture.*

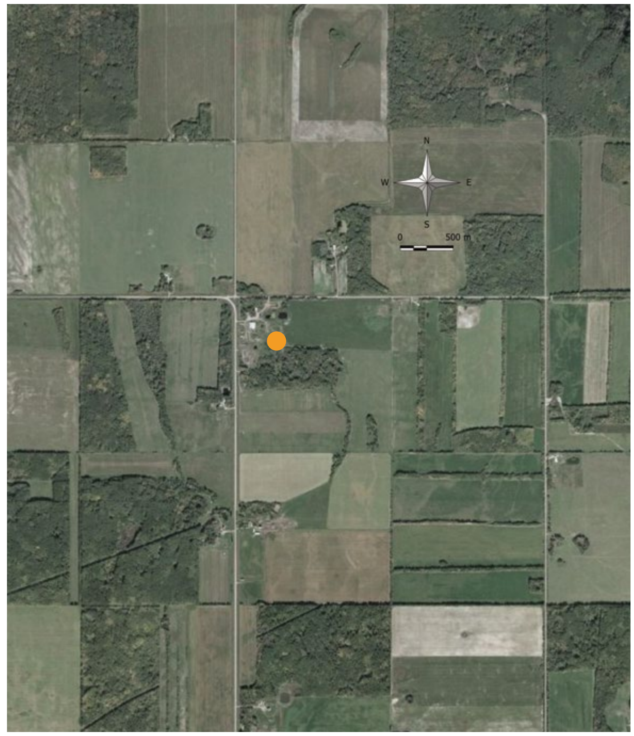
The value for erosion control can also vary, depending on the direction of the slope and the natural drainage patterns. Narrow fields oriented in the direction of the slope may tend to work against contour farming practices, because it is less efficient for large-scale equipment to work and turn over short distances. In turn, the gridded land survey and property boundaries have influenced the land clearing practice, as property lines were usually followed. In this location, which slopes to the south-southwest, these natural shelterbelts are beneficial, but with mixed effects for erosion control, depending on their orientation in relation to the slope.

Highlights

- → Natural retained shelterbelts
- → Moisture conservation
- → Erosion control
- → Livestock protection
- → Mixed farm enterprise allows integration



Hill-shaded map (above) shows the relief and sub watersheds around this mixed farm. The farm is located at the top of the watershed (orange point) with lands sloping to the southwest and toward the Peace River.



The orientation of shelterbelts around this farm (orange point marks the same location from the map above).

Endnotes

1 Physical structures like slat fences can also be used to create positive mico-climatic effects to shelter and shade crops. Shelterbelts may also be called windbreaks, timberbelts or buffers, depending on how they function and how their purpose is viewed within the production system.

2 Lisa Zabek and Dave Trotter, *Agroforestry Factsheet - Windbreaks/shelterbelts, timberbelts, buffers* (BC Ministry of Agriculture, 2010), *http://www.agf.gov.bc.ca/resmgmt/publist/0-100Series/100100-3_Shelterbelts.pdf*

3 K. G. McNaughton, "Effects of windbreaks on turbulent transport and microclimate," *Agriculture, Ecosystems & Environment* 22 (1988): 17–39.

4 Brendan Casement and John Timmermans, *Field Shelterbelts for Soil Conservation Agri-facts* (Alberta Agriculture and Food, 2007), *http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex2073/$file/277_20-3.pdf?OpenElement*

5 G. M. Heisler and D. R. Dewalle, "Effects of windbreak structure on wind flow," *Agriculture, ecosystems & environment* 22 (1988): 41–69.

6 A.H. Dolan et al., *Adaptation to Climate Change in Agriculture: Evaluation of Options* (University of Guelph, Department of Geography, 2001), *http://www.uoguelph.ca/gecg/images/userimages/Dolan%20et%20al.%20(2001).pdf*

7 Enterprise diversification, may in fact be suitable adaptive strategy to minimize the effects of climate change, however it is not among the practices evaluated in this series.

8 Gylan L. Dickey, "Crop water use and water conservation benefits from windbreaks," *Agriculture, Ecosystems & Environment* 22–23, no. 0 (August 1988): 381–392.

9 In Canada, shelterbelt establishment has been supported by the federal PFRA Prairie Shelterbelt Program, the Canada – Provincial Environmental Farm Plan and Greencover programs, and provincial programs in Quebec and Ontario.

10 J. R. Brandle, B. B. Johnson, and D. D. Dearmont, "Windbreak economics: The case of winter wheat production in eastern Nebraska," *Journal of soil and water conservation* 39, no. 5 (1984): 339–343.

11 M. L. Marsh, "The value of shelterbelts to agricultural production in the northern Great Plains: An economic assessment in a changing climate" (1999), *http://digitalcommons.unl.edu/dissertations/AAI9947124/*

12 B. G. McConkey, R. P. Zentner, and W. Nicholaichuk, "Perennial grass windbreaks for continuous wheat production on the Canadian prairies," *Journal of Soil and Water Conservation* 45, no. 4 (July 1, 1990): 482–485.

13 Surendra Kulshreshtha and John Kort, "External economic benefits and social goods from prairie shelterbelts," *Agroforestry Systems* 75, no. 1 (2009): 39–47.

14 J. R. Brandle, L. Hodges, and X. H. Zhou, "Windbreaks in North American agricultural systems," *Agroforestry systems* 61, no. 1 (2004): 65–78. *http://digitalcommons.unl.edu/agronomyfacpub/389/*

15 J.W. Sturrock, "Shelter: Its management and promotion," *Agriculture, Ecosystems & Environment* 22–23, (August 1988): 1–13.

16 University of Missouri--Columbia Center for Agroforestry, *Training Manual for Applied Agroforestry Practices* (University of Missouri Center for Agroforestry, 2006), *http://www.centerforagroforestry.org/pubs/training/*

17 J. Kort, "Benefits of windbreaks to field and forage crops," *Agriculture, Ecosystems & Environment* 23 (1988): 165–190.

18 Ibid.

19 Richard L. Norton, "Windbreaks: Benefits to orchard and vineyard crops," *Agriculture, Ecosystems & Environment* 22–23, (August 1988): 205–213.

20 Charles S. Baldwin, "The influence of field windbreaks on vegetable and specialty crops," *Agriculture, Ecosystems & Environment* 22–23, (August 1988): 191–203.

21 Allelopathy, refers to the biochemical inhibition of growth, survival or reproduction of one species by another.