BEST MANAGEMENT PRACTICES
Agroforestry Series Volume 2

Establishing Tree Cover

Canada

Ontario

OFA Ontario Federation of Agriculture

Ontario Stewardship
Sustaining Resources Together

Eastern Ontario Model Forest

What is a Best Management Practice or "BMP"?

▶ a proven, practical and affordable approach to conserving soil, water and other natural resources in rural areas

Who decides what qualifies as a BMP?

▶ a team that represents many facets of agriculture and rural land ownership in Ontario, including farmers, researchers, natural resource managers, regulatory agency staff, extension staff and agribusiness professionals

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METRIC–IMPERIAL CONVERSION FACTORS

Convert		To		Metric
%	►	kg/1000 L	multiply by	10
%	►	kg/tonne	multiply by	10
mg/L	►	%	divide by	10,000

Convert		To		Imperial
%	►	lbs per 1000 gallons	multiply by	100
%	►	lbs per ton	multiply by	20
ppm	►	%	divide by	10,000

Note: 1 m^3 = 1000 L

UNITS OF MEASURE

While Canada "went metric" over 30 years ago, many commonly used measurements such as land area are still expressed using imperial units. Acres of land are a good example: landowners seldom, if ever, refer to the size of their property in hectares. For your convenience, most of the measurements used in this manual are provided in both metric and imperial units. However, where common usage, common sense, space limitations or regulatory concerns dictate, one or the other may appear exclusively.

CONVERSION FROM...	FACTOR	EXAMPLE
METRES TO FEET	1 metre = 3.281 feet	A 20.6-m tall tree is 67.6 ft (20.6 x 3.281)
FEET TO METRES	1 foot = .3048	A 100-ft buffer is 30.48 m (100 x .3048)
ACRES TO HECTARES	1 acre = .405 ha	A 35-acre field is 14.16 ha
HECTARES TO ACRES	1 ha = 2.47 ac	A 1.4-ha plot is 3.5 ac

CONVERSIONS – METRIC AND IMPERIAL

Common Conversions

1 gallon	=	4.546 litres	1 acre	=	0.405 hectare
1 gallon	=	1.201 US gallons	1 acre	=	43,560 $feet^2$
1 gallon	=	0.161 ft^3	1 lb/ac	=	1.12 kilogram/hectare
1 US gallon	=	3.785 litres	1 ton/ac	=	2.25 tonnes/hectare
1 US gallon	=	0.833 Imp gallon	1 gal/ac	=	11.2 litre/hectare
1 ton	=	0.907 tonne	1000 gal/ac	=	11200 litre/hectare
1 pound	=	0.454 kilogram	1000 gal/ac	=	11.2 $metre^3$/hectare
1 tonne	=	2205 pounds	1 metre	=	3.28 feet
1 $foot^3$	=	6.229 gallons	1 metre	=	39.4 inches

Application Rate Conversions

Metric to Imperial (Approximate)		Imperial to Metric (Approximate)		
Litres per hectare x 0.09	= gallons per acre	Gallons per acre x 11.23	=	litres per hectare (L/ha)
Litres per hectare x 0.36	= quarts per acre	Quarts per acre x 2.8	=	litres per hectare (L/ha)
Litres per hectare x 0.71	= pints per acre	Pints per acre x 1.4	=	litres per hectare (L/ha)
Millilitres per hectare x 0.015	= fluid ounces per acre	Fluid ounces per acre x 70	=	millilitres per hectare (mL/ha)
Grams per hectare x 0.015	= ounces per acre	Tons per acre x 2.24	=	tonnes per hectare (t/ha)
Kilograms per hectare x 0.89	= pounds per acre	Pounds per acre x 1.12	=	kilograms per hectare (kg/ha)
Tonnes per hectare x 0.45	= tons per acre	Ounces per acre x 70	=	grams per hectare (g/ha)
Kilograms per 1000 L x 10	= lbs per 1000 gallons	Pounds per ton x .5	=	kilograms per tonne (kg/t)

FOREWORD

This book is the second in a two-volume series on *agroforestry*.

Volume 1, *Woodlot Management*, addresses the management of existing woodlots, including

- farm woodlots
- established plantations
- riparian woodlots
- treed fencerows
- wooded wetlands.

Volume 2, *Establishing Tree Cover*, addresses the planning and establishment of agroforestry plantings.

Words that appear in the glossary on page 127 are italicized at first mention.

Thank you, and we hope you find this book helpful.

CONTENTS

INTRODUCTION

AGROFORESTRY

Trees can be important contributors to farm operations, creating both economic and environmental benefits.

They generate food and wood products, such as maple syrup and sawlogs. These products offer income opportunities that add financial diversity and flexibility to a farm enterprise. They also provide many less direct but no less important benefits. Take a look at the photographs on the next few pages for some examples.

Well-planned forestry operations can provide farmers with a sustainable supply of wood products and fuelwood.

The practice of integrating trees with agricultural crops and/or livestock is known as *agroforestry*. If you're new to agroforestry, it may seem daunting to determine what suits your property, develop a long-term management plan, and do the work to meet your goals. The challenge lies in knowing the best ways of establishing and maintaining tree cover to maximize benefits for your farm operation. This book will get you started by:

In agroforestry, trees, shrubs and small woodlots are part of a farming system that promotes sustainability.

- ▶ explaining agroforestry and the principles of establishing tree cover on farmland
- ▶ describing best management practices (BMPs) for planning, planting, establishing and managing tree cover – including their pros and cons, and impacts on soil, water, air and habitat quality
- ▶ highlighting new tree cover opportunities.

Tree planting can be an enjoyable family and neighbourhood activity that provides many benefits for years to come.

Well-designed and well-managed field windbreaks reduce wind erosion and sandblasting, and increase crop yields.

Both livestock and pasture benefit from shade trees.

Tailored to your particular farm's landscape and operation, agroforestry can help you achieve production goals while conserving the resources on which that production depends.

Windbreaks and Shelterbelts
These are single or multiple rows of trees grown around farm field perimeters and farm buildings to protect cropland, buildings, pastures, and livestock.

Treed Buffer Strips
Growing and maintaining trees along watercourses, ponds and wetlands helps to reduce nutrient runoff and soil erosion, and protect water quality.

Plantations
Converting lands to forest cover can provide valuable forest products within 30 years.

A major goal of agroforestry lies in integrating the land use practices of agriculture, forestry, and animal husbandry within a farm or landscape.

Intercropping
Intercropping with Black Walnut provides an opportunity to establish a long-term investment while continuing to produce annual field crops.

Silvipasture
Silvipasture provides a short-term return on investment from livestock while tree cover is being established.

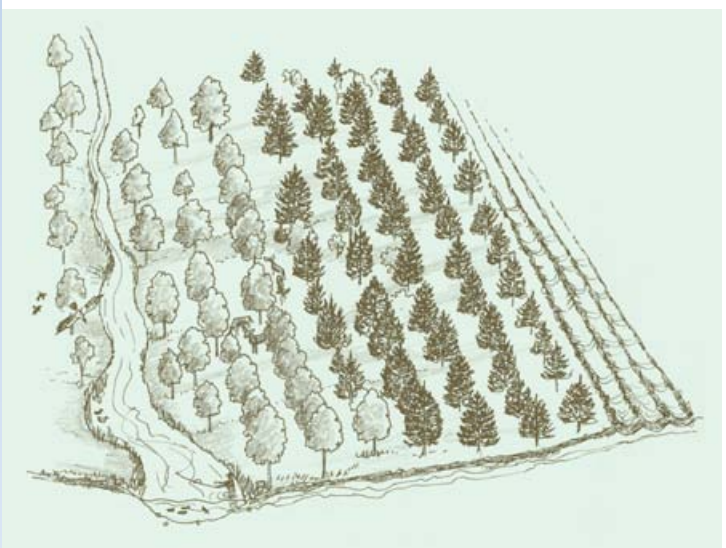
Woodlots
Farm woodlots have always been an integral part of farmsteads.

Agroforestry practices offer many varied opportunities for Ontario's farmers and rural landowners.

Many of the values in windbreaks and other tree plantings on the farm are not measured in dollars. They're tied to your favourite memories – hunting along the corridor for rabbits, grouse and turkey, seeing young fawns in the recently planted old pasture, or heating the home with thinnings from the back woodlot.

Tree cover provides much-needed habitat for nesting birds and other wildlife species.

Woodlots can be a good source of timber for on-farm use or income.



Tree cover benefits the environment in many significant ways:

- reducing soil erosion helps maintain surface water quality
- increasing carbon *sequestration* through tree vegetation reduces greenhouse gases
- providing wildlife habitat promotes biodiversity.

Treed buffers reduce the environmental impact of farm operations and improve habitat for fish and other aquatic species.

Specialized non-wood forest products such as wild ginger can be grown for niche markets.

Intercropping in young forest plantations with field or horticultural crops during early establishment may provide annual income.

Silvipasture plantings can be designed to provide feed for livestock while the tree crops mature.

After careful consideration and planning, this landowner planted Black Walnut on a 2-hectare (5-ac) section of an old pasture. He's glad he did. These trees have thrived on the site and will one day provide a significant return on his original investment. The *plantation* has also become an attractive addition to the farm environment.

Forests have been used by farmers since the early days of settlement.

Christmas tree and ornamental conifer plantations can provide winter income.

Two key benefits of agroforestry to farmers are the convenience and cost savings enjoyed by having their own woodland and tree crops for on-farm use. The value of these crops and all other agricultural commodities produced on a farm and consumed by individuals living on that farm is referred to as *income in-kind.*

Hunting or simply viewing wildlife is popular with many rural landowners.

Woodlots are a source of many foods including fiddleheads, mushrooms, berries and wild leeks.

Owls, hawks, snakes and foxes will use tree cover to hunt for mice and other rodents.

Many farm fences and posts are made from materials harvested and processed from a farmer's own woodlot.

Farmers continue to use forest crops grown on the farm. Statistics consistently show that forest products provide the largest income in-kind benefit of all the commodities produced on the farm.

For the period 1999–2003, the average value of forest products amounted to 77% of the total value of all products produced and used on the farm. In 2003, the income in-kind value for forest products was just over $29 million.

CHALLENGES

In the past, several challenges have limited the large-scale adoption of agroforestry practices in Ontario. These have all served to slow the establishment of tree cover on the landscape.

Broad challenges to adopting agroforestry practices include:

- ▶ shortage of time
- ▶ costs and labour required
- ▶ lack of awareness of available technical and financial assistance
- ▶ long-term returns versus short-term cash flow needs
- ▶ level of financial incentives for tree planting
- ▶ lack of awareness of prices for various forestry products
- ▶ concern that trees may interfere with other farm operations
- ▶ concern that trees may attract problem wildlife.

Positive economic returns from woodlands can go a long way to addressing these concerns, as you'll see in the following example.

ECONOMIC COMPARISON – WOODLOT AND CROPLAND, 1977–2003*

How do economic returns from a well-managed woodland compare to those from agricultural crops? The answer is, very well indeed, according to several case studies by the Ministry of Natural Resources. Here's a glimpse at the results of their analyses.

	$/acre
▶ agriculture NPV:	$ 2,927.00
▶ woodlot NPV**:	$ 6,292.00 based on:
▷ timber sales:	$ 3,225.00
▷ fuelwood sales:	$ 599.00
▷ maple syrup sales:	$ 2,468.00

*expressed in 2003 dollars, a 5% compound interest rate and on a per-acre basis

**NPV is Net Present Value, used to fairly compare the value of annual sales from agricultural sales to periodic sales from agroforestry.

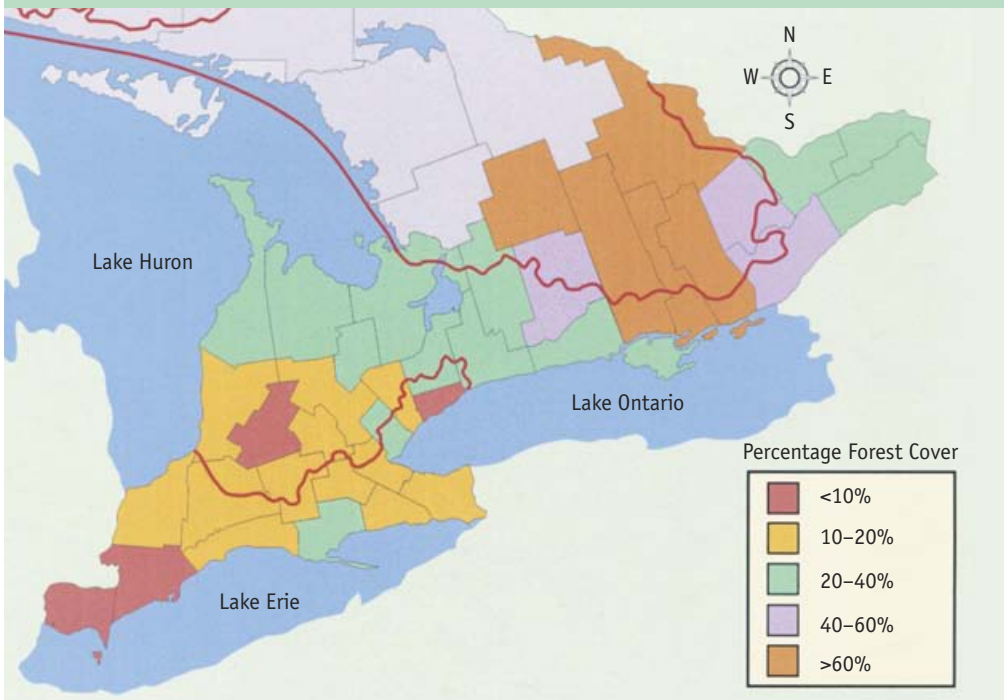
For more information about this and related case studies, please see **www.huronstewardship.on.ca** and click on **Local Projects**.

AGROFORESTRY'S POTENTIAL IN ONTARIO

The BMPs in this book have been developed for the areas south and east of the Canadian Shield in Ontario. That said, the agroforestry principles and practices described in these pages may have application in other regions of Ontario and Canada.

Ontario has approximately 900,000 hectares (2.23 million acres) of *marginal farmland*. Some of it is managed for pasture. However, most of the marginal farmland in Ontario would be suitable for tree crop production of one kind or another. When combined with the over 4.7 million hectares (11.6 million ac) of existing woodlands and plantations, there is a great opportunity for farmers and rural landowners to undertake agroforestry practices.

FOREST COVER IN SOUTHERN ONTARIO



With just over 1-million square kilometres, Ontario offers a diversity of landform and climate that affects not only the distribution of native plant and animal species, but also the type and intensity of agriculture practised within it. This landscape and climatic variability from north to south and east to west also influences the opportunities for agroforestry.

Sandy and other highly erodible soils can benefit from tree cover.

Growing trees may be the best use for highly erodible lands, like those in the left illustration. Trees can also be the best choice for less productive (marginal) soils, such as those found in bedrock-controlled areas and in stony, hilly (morainal) landscapes, as shown on the right.

SITE REGIONS IN SOUTHERN ONTARIO

This book focuses on Site Regions 6e and 7e. A Site Region is an area with relatively uniform climate, soil, plants, animals and other organisms interacting to produce a recurring pattern of forest cover types. For example, Sugar Maple–Beech is a more common cover type of Site Region 6E. In Site Region 7E, Red Oak–Hickory–Ash is a more common cover type.

Planting trees in the 1930s helped reduce wind erosion in many areas of Ontario. Many of these forests are now owned by municipalities.

The income in-kind value of fuelwood cut and burned on Ontario farms is greater than any other crop harvested and consumed at home. Harvesting firewood can also be a good way to use farm labour during slower times of the year.

UNDERSTANDING TREES

This section introduces some of the basic principles of tree growth and development, growth requirements, and patterns of tree cover development.

A working knowledge of these principles will help you form better decisions about what to plant and how to manage the planting for survival and growth.

HOW TREES GROW

Like agricultural crops, trees convert light energy into chemical energy through *photosynthesis.* This chemical energy, in the form of sugars, is used by trees for growth and other biological processes.

In trees and field crops alike, all plant growth is influenced by a variety of interrelated factors.

INITIATION

Most trees grow from seeds or nuts, although there are other methods of initiation such as vegetative reproduction and coppice (from stumps).

Most tree cover plantings use nursery stock – as seedlings (up to three years old) or as bare root/whip stock (two to five years old). Tree seeds are sown in nursery beds. Root development is manipulated to make stock easier to handle in field planting conditions. Stock is lifted, packaged and stored until planting time.

The Spruce seedlings in this nursery bed have reached the desired size and are ready for lifting.

PLANTING

Wedge planting is a common method of planting by hand. Make a straight vertical cut in the soil. Then insert the shovel at a downward angle toward your first cut, making a wedge. Lift out the wedge. Insert the seedling against the vertical cut, and carefully re-place the wedge, stepping on the wedge firmly to close up air spaces.

Nursery stock can be planted using several hand or machine methods. To prevent seedlings from drying out, it's most important to reduce tree exposure to sun and wind.

It's equally important to ensure that all roots are properly placed in the ground and no air spaces are left in the soil so the roots do not dry out. See also page 55 for more planting options.

These first-year Oak seedlings grown from acorns were planted in early spring through holes cut in the plastic mulch. Mulch provides good weed control, giving this direct-seeding technique potential as an effective planting method.

ESTABLISHMENT

In tree cover plantings, trees need to become established after planting before rapid growth can occur. Trees focus on root growth and development at this time. Some trees do not grow much in height if there are impediments such as competition from heavy vegetation.

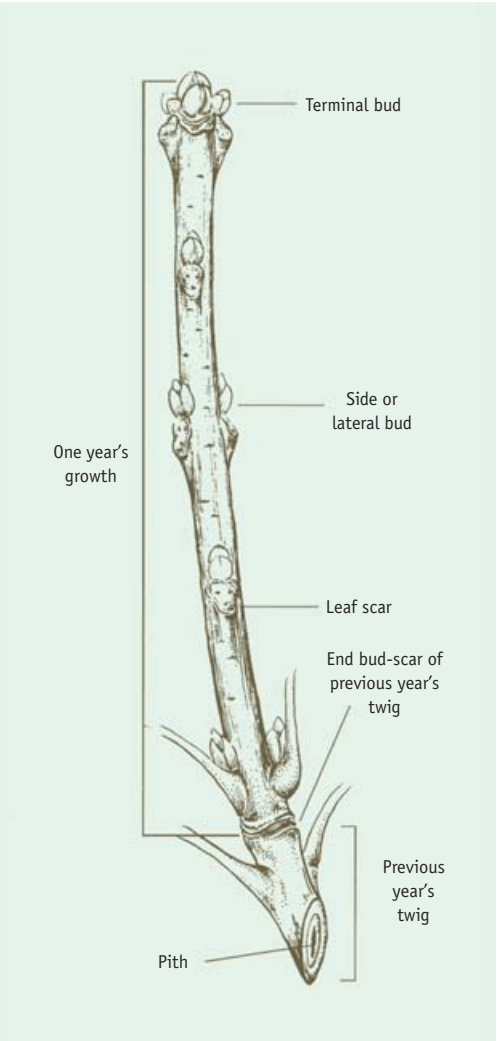
GROWTH

After a tree is established, and if it has sufficient resources (light, water, nutrients), it will often go through a period of very active and rapid growth. This is a survival mechanism designed to ensure a tree can dominate its surroundings in the quickest possible time. Usually during this stage, a tree will put on most of its height growth. If resources are limited, the tree may survive until they become available.

A period of rapid height growth takes place once tree cover plantings become established.

Each year, a tree will grow both above and below the ground. Above-ground growth includes height, diameter, leaves, and seeds; below-ground growth includes root length and diameter.

All growth happens in specialized tissues called *meristems*, which have the ability to divide and make new cells. Meristem tissues are concentrated at branch and root tips as well as in a thin layer of cells called the *cambium*, which is found just beneath the bark.



Height and Branch Growth

Height and branch growth generally begins as soon as a tree comes out of dormancy in the spring. Warmer temperatures and longer days trigger bud opening, and cell division and growth in the branch just below the buds.

Some buds will grow to form new lateral branches; others will develop into leaves. Still others will eventually become flowers.

A leaf is like a factory, using energy from the sun to process raw materials (H_2O, CO_2) into sugar and oxygen (a byproduct).

Apical Dominance

Many trees such as this White Spruce tend to have a dominant leader that releases hormones to suppress the growth of lateral branches near it. This is known as apical dominance.

Conifers tend to exhibit more apical dominance than hardwoods, giving conifers their characteristic pyramidal shape. Some hardwoods such as Maple and Oak will have stronger apical dominance when they are young than when they are mature.

Diameter Growth

After a period of rapid height growth, trees accelerate their diameter growth. Here's how it works. As noted earlier, the cambium is a thin layer of living cells between the wood of a tree and its bark. Each year these cells divide and increase the diameter of the trunk and branches by adding a new layer of wood to the tree. Tree diameter growth is highly variable, depending on competition from other trees and vegetation, site, tree age, and the tree's characteristics.

HOW TREE COVER PLANTINGS DEVELOP

Tree cover plantings go through several growth stages, each with unique growth patterns and challenges.

Tree cover plantings – whether for former croplands, windbreaks, or intercropping – usually start at the nursery. Here, seeds are sown in beds until time for root pruning and either transplanting or lifting for storage. Most seedling nurseries grow their stock in seedbeds protected by windbreaks and mulch or screen covers.

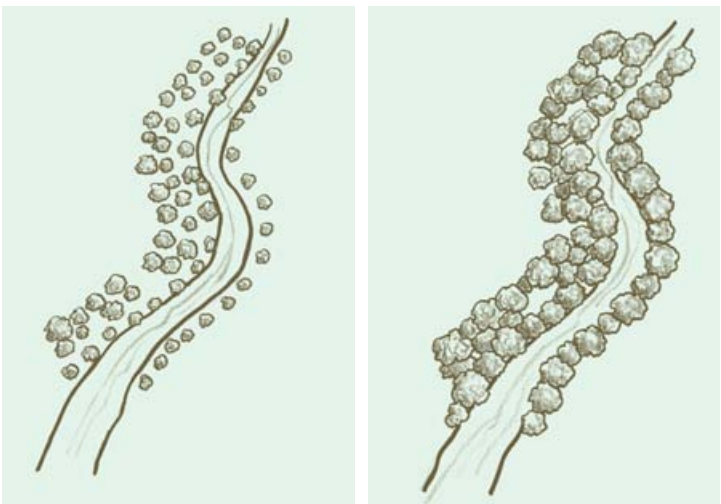
Tree cover plantings are often set in fields where soil quality is poor, weeds dominate the vegetative cover, and tree performance is low. Tree cover plantings are, in essence, a new land use. However, these fields are often substantially more exposed than the seedbeds from which the tree seedlings were removed (1–3 years at time of planting).

Newly planted stock is at the mercy of the weather and other factors. Seedling survival rates increase with management practices such as site preparation, emergency irrigation, and weed control. Tree growth is concentrated on re-establishing a proper shoot-to-root ratio for survival (1–2 years after planting).

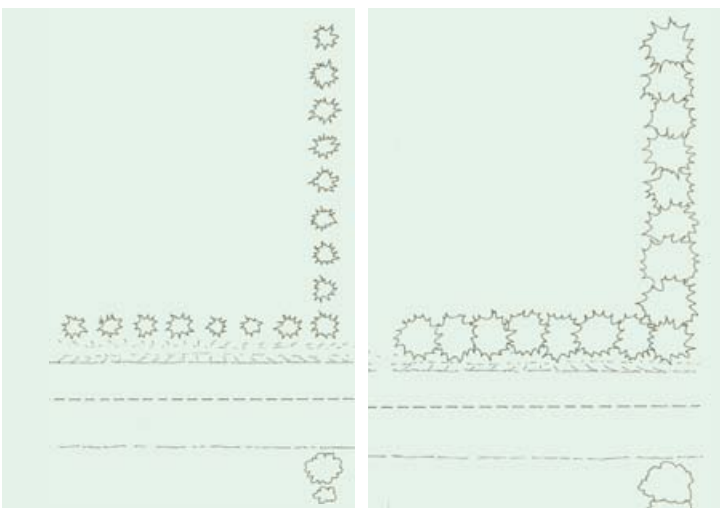
After the first year or two, trees extend and diversify root systems to exploit available soil and resources. Height growth can be negligible unless competing vegetation is controlled (1–6 years after planting).

When planted trees have passed 1–1.5 metres (3–4.5 ft) in height growth, they're considered free to grow. Height and crown growth accelerate during this stage. Diameter growth follows and increases unchecked until the lateral branches of neighbouring trees in the same plantation overlap. This stage – where weeds are suppressed and the conditions are forest-like – is known as crown closure (4–15 years after planting).

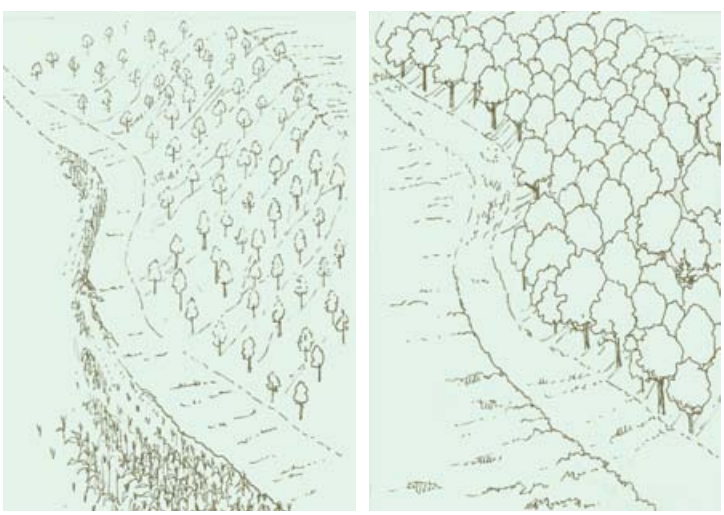
Treed buffer strip at planting (L) and crown closure (R).

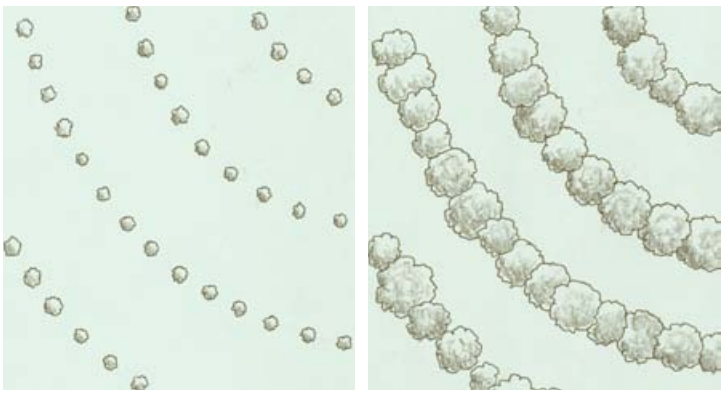


Treed windbreak at planting (L) and crown closure (R).

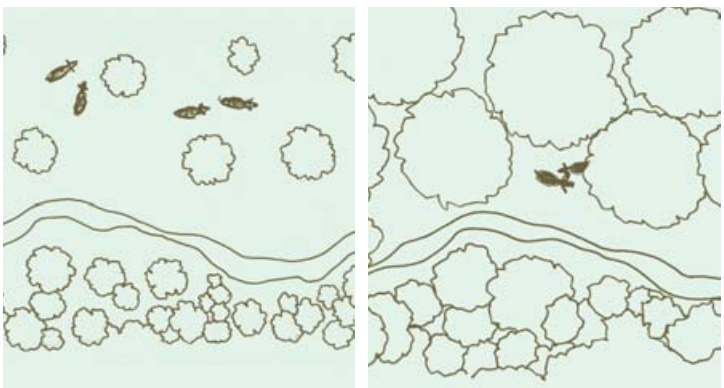


Hardwoods at planting (L) and crown closure (R).





Intercropping at planting (L) and crown closure (R).



Silvipasture at planting (L) and crown closure (R).

PLANTED TREE SPECIES REQUIREMENTS

Each tree species has characteristics that influence its requirements to survive and flourish. The study of trees' capacity to reproduce, establish, and develop is referred to as *silvics*. Silvics also includes ecological characteristics such as the tolerance for less-than-ideal conditions and adaptability to survive in disturbed conditions.

Generally, tree species' requirements include:

- **cover** – some species can withstand the extreme conditions of open fields while others benefit from some degree of protection
- **space** – young trees compete for resources with other vegetation and, once established, with other trees both above and below ground for available rooting volume
- **light** – light-loving species perform well in open-field conditions
- **moisture** – sufficient available moisture is critical during establishment
- **nutrients** – a seedling's ability to access available nutrients is important for species performance.

Red Pine is often a preferred species for reclaiming retired farm fields (*afforestation*) due to its quick growth rate and ability to survive the exposed and droughty conditions of coarse-textured soils.

A working knowledge of silvics is important when planning to establish tree cover. Understanding tree species' site preferences and tolerances will save you a lot of trouble, by helping you match species to your site conditions. A working knowledge of species' ability to survive in non-forested conditions will also help you plan management practices to ensure survival and tree vigour.

White Ash and Black Walnut are well-suited to the rich, loamy sites found along most floodplains. However, weed control is essential in riparian areas to ensure that these species reach their growth potential.

This landowner decided to invest in weed control after considering the growth requirements of the planted species.

FORESTED VS. NON-FORESTED CONDITIONS

Forested Site Conditions

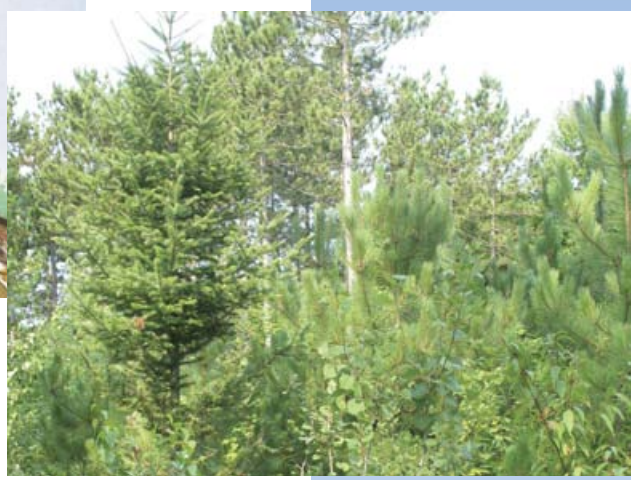
Trees have adapted to a wide variety of site conditions (climate, soil, etc.) and disturbance.

In **undisturbed forest ecosystems**, growth conditions are moderated by the existing trees:

- mature trees provide cover and partial shade
- nutrient cycling is most often in a state of equilibrium, so that few plant nutrients are deficient
- sufficient moisture is usually available for plant growth – mature trees help to keep soil water tables high and forest litter acts as natural mulch
- space is perhaps the biggest limitation for tree growth and survival in undisturbed ecosystems.

In disturbed ecosystems (e.g., after a severe forest fire) or along forest edges, you'll see greater exposure, less shade and less inter-tree competition. Trees that thrive in these conditions are known as *pioneer species*.

Many young trees thrive in the environment provided by natural forest ecosystems.



Considered pioneer species, Poplar and White Birch have growth characteristics that help them to thrive in the extreme conditions that follow a destructive forest fire.

Non-Forested Site Conditions

Non-forested site conditions are less suitable than forested site conditions.

Exposure is greater and shade is rare at time of planting. Nutrient availability is closely related to soil management history and degradation. Soil moisture can be limiting due to soil conditions, water table activity, competition with existing vegetation, and exposure.

Available space during establishment (up to five years) is also a consideration. Competition for space above and below ground comes from weeds and other competing vegetation, rather than other trees.

Many young trees struggle to survive in the less suitable growth environment found in most tree cover planting sites.

COVER REQUIREMENTS

Some tree species require more cover than others. Species such as White Spruce and Sugar Maple are more suited to plantings in less exposed or protected areas. Others such as Jack Pine and Red Oak survive, and often thrive, in extremely exposed conditions.

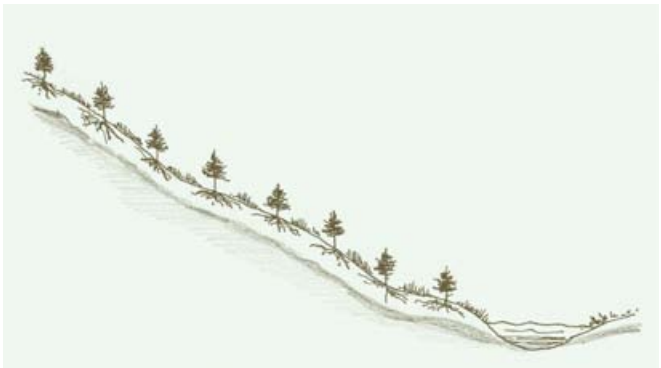
Windbreaks are often exposed to extreme micro-climates. By design, *windfirm* species are most often selected for the windward row in multiple-row windbreak and shelterbelt plantings.

Why the difference?

It has much to do with the local climate and its impact on growth requirements, and species adaptations to extreme conditions.

Local site conditions of an area include the range and averages of temperature, wind speed and direction, humidity, evaporation, *evapotranspiration*, and precipitation.

CLIMATE CHARACTERISTIC	IN PROTECTED CONDITIONS	IMPACT ON GROWTH AND SURVIVAL	IN EXPOSED CONDITIONS	IMPACT ON GROWTH AND SURVIVAL
TEMPERATURE	• fewer extremes	• less stress	• more extremes	• more stress (heat, frost)
WIND	• speed modified	• less drying out (*desiccation*)	• speeds are higher	• more desiccation
HUMIDITY	• higher	• less desiccation	• lower	• more desiccation
EVAPOTRANSPIRATION	• lower rates	• more moisture for growth – less drought	• higher rates	• more drought
PRECIPITATION EVENTS	• less intensity • less runoff	• less damage • more available moisture	• greater intensity • more runoff	• more damage (ice, flooding) • less available moisture



Young plantings are buffered from extreme temperatures, winds and moisture conditions in forested or other protected conditions (e.g., downwind from existing forest, floodplain with deep ravine slopes). By contrast, open areas expose young seedlings to extreme ranges in climatic conditions – leading to plant stress, desiccation and damage.

Conifers are more tolerant of exposure and are planted in the outer rows of mixed (conifer–hardwood–shrub) plantings.

Species' Adaptability to Exposure

A tree species' ability to withstand the extremes of exposed sites has much to do with its anatomy and physiology.

For example, "hard" Pines such as Jack, Red and Scots Pine have tough bark, dense wood, and thick cuticles (waxy coatings) on their needles. This makes them less prone to desiccation and more windfirm. These species have evolved in more exposed sites. By contrast, young White Pine has a softer bark, softer wood and thinner cuticles. It thrives in protected areas.

Jack Pine (above) is more tolerant of exposed conditions than White Pine (right).

SPACE AND LIGHT REQUIREMENTS

During establishment (up to five years following planting), planted seedlings compete with weeds and other forms of existing vegetation such as shrubs for space and light.

Space

Young trees need space for root expansion and height growth.

In the first few years following planting, tree roots grow laterally and downwards to capture available moisture for survival.

This period of growth is followed by a proliferation of finer roots that will exploit the available soil volume for moisture and nutrients. In many cases, this is impeded by the fibrous roots associated with grass species found in former pastures, hayfields and abandoned cropland.

Young trees need to exploit available rooting volume in the soil in order to survive and progress to accelerated height growth. Weeds compete below ground for effective rooting volume. Grass- and weed-infested sites are prone to poor survival and tree growth problems.

Light

Each tree species requires varying amounts of light to survive, grow, and reproduce. Some species will thrive under the shade of existing trees. Called *shade-tolerant*, these trees have adapted to regenerating in the understory of an existing forest.

Light-loving (shade-intolerant) species have developed in open conditions, and as a general rule perform well in open-field conditions. As noted earlier, these trees are often known as pioneer species.

Some tree species fall in the middle and are called *mid-tolerant*. Many of these species are adapted to growing in gaps created in the forest when one or a few large trees die or fall over.

There is little shade in most open-grown conditions. Some shade may be afforded to young plantings from competing vegetation, but this has to be managed carefully to avoid excessive above- and below-ground competition.

Some plantings are naturally shaded. Plantings on north- and east-facing slopes on steep hills and ravines may be shaded for much of the growing season. Some replacement windbreak and roadside plantings may be shaded as well.

Consider local shade conditions and plant shade-tolerant species for tree cover where necessary.

Competitive vegetation may be managed to provide cover and some shade for sensitive seedlings. Natural shading along the edge of fields is also beneficial.

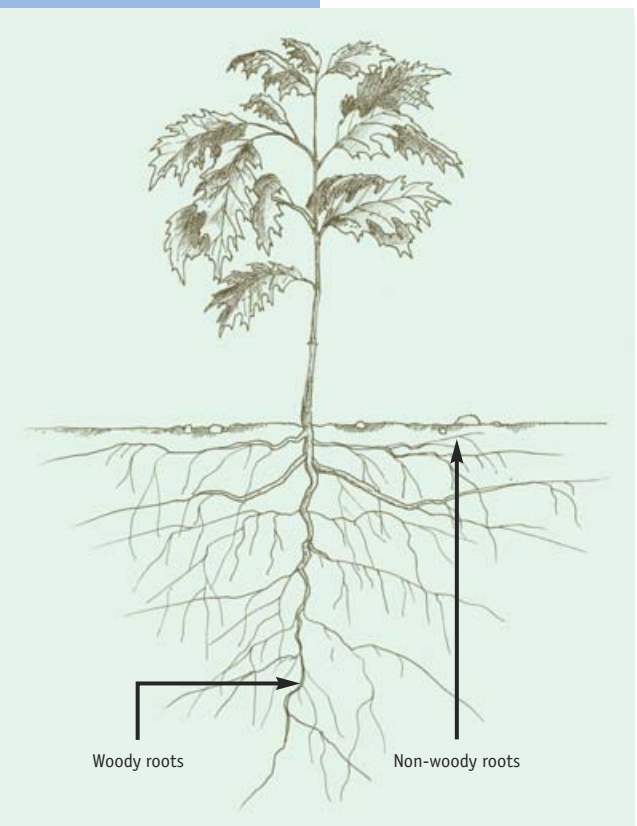
	SHADE-TOLERANT SPECIES	MID-TOLERANT SPECIES	INTOLERANT SPECIES
CONIFERS	Hemlock, Balsam Fir	White Spruce, White Pine, Norway Spruce, White Cedar	Red Pine, Jack Pine, Tamarack, Eastern Red Cedar, European Larch
HARDWOODS*	Beech, Ironwood, Sugar Maple, American Chestnut, Black Maple, (Black Gum), (Big Shellbark Hickory), (Ohio Buckeye)	White Ash, Red Oak, White Oak, Basswood, White Elm, Silver Maple, Red Maple, Black Oak, Shagbark Hickory, Bitternut Hickory, (Cucumber Tree), (Ohio Buckeye), (Chinquapin Oak)	Aspen, Poplar, Cottonwood, Black Cherry, White Birch, Black Locust, Common Hop Tree, Dwarf Hackberry, Honey Locust, (Kentucky Coffee Tree), Northern Pin Oak

*parentheses denote Carolinian species (in Canada, growth is limited to the southern Great Lakes area)

Some tree species display different levels of shade tolerance throughout their lifespan. The slow-growing Eastern White Cedar requires full sunlight when young, but is perfectly capable of surviving in full shade when it's older.

This landowner selected Spruce trees – a mid–tolerant species – to match the site conditions in this partially shaded roadside planting.

MOISTURE REQUIREMENTS



All plants require moisture for their day-to-day biological functioning, and trees are no exception to this rule. A tree draws in water through its roots. The water is transported up through the stem and branches, and out to the leaves.

Some of the moisture in the leaf is used for photosynthesis, although the vast majority is lost through the process of evapotranspiration. In most cases, a tree's root system may extend well beyond its crown – sometimes as far as four to seven times the *drip line*.

Roots provide two basic functions for the tree. They absorb and transport water and nutrients from the soil and provide support for the above-ground portion of the tree. Roots will grow wherever the environmental conditions are favourable, which in most cases is in the upper few feet – although the major portion of a tree's root system is in the top few inches of soil.

There are two basic root types. Woody roots are large, lateral roots formed near the base of the root and stem, and provide support and anchorage to the tree.

Non-woody (feeder) roots are found mostly in the upper few inches of the soil and are used for absorption. Some species like Ash have extensions called root hairs to increase the absorptive capacity of the tree. Most tree roots have *mycorrhizae* (fungi) associated with them, which increases their capacity for absorption.

The availability of water throughout the growing season differs from site to site. Available moisture is linked to physical site characteristics such as position on the landscape, *soil texture* and stoniness, soil depth to bedrock, and depth to water table.

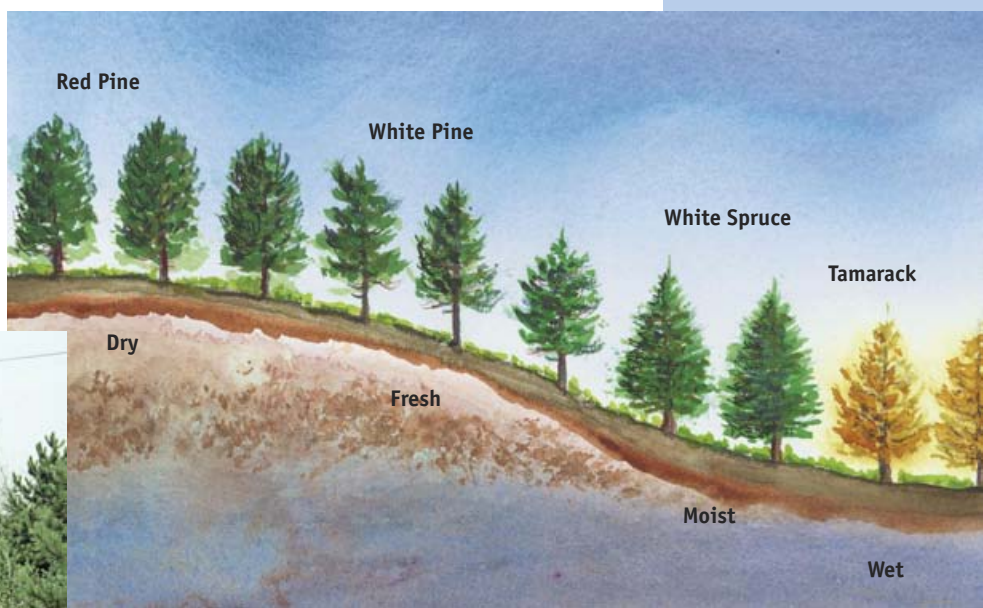
Soil and sites can be ranked using these features into one or more of four moisture *regimes*. Some species are adapted to only one, while others are adapted to all. The next chart provides a summary of the most common species by moisture regime.

MOISTURE REQUIREMENTS OF SELECTED TREE SPECIES

MOISTURE REGIME	DESCRIPTION	SUITABLE SPECIES*
1. DRY	• soil drains rapidly • water table often below root zone	**Jack Pine**, **Red Pine**, White Cedar Red Oak, White Birch, Black Cherry
2. FRESH	• soil is well-drained • moisture capacity ideal for tree growth	**White Pine**, **White Spruce**, **Norway Spruce**, **European Larch**, White Cedar, Red Pine, **Sugar Maple**, **Red Oak**, Red Maple, **White Ash**, White Birch, **Black Cherry**, **Basswood**, Black Walnut
3. MOIST	• standing water seasonally present • soils imperfectly drained	White Pine, White Spruce, Norway Spruce, European Larch, **White Cedar**, **Green Ash**, **Bitternut Hickory**, **Black Walnut**, **Bur Oak**, Trembling Aspen, **Red Maple**, Silver Maple, White Ash, White Birch, Black Cherry
4. WET	• standing water usually present • poorly drained organic soils	**Tamarack**, White Cedar, **Silver Maple**, **Green Ash**, **Black Willow**, **Black Ash**, Red Maple

*Bolded species in the chart indicate species that prefer that moisture regime.

In uniform sandy textures, soil moisture regime changes from dry to wet when you move downslope from the top to the bottom of the knoll. Species suitability to site conditions closely follows soil moisture regime.



Red Pine will not thrive in moist or wet soil moisture regimes.

NUTRIENT REQUIREMENTS

Trees also need nutrients to grow. Most trees can grow within a relatively wide range of soil nutrient levels. Soil nutrient availability is related to a number of factors.

soil texture – the relative coarseness or fineness of a soil material

- ▶ clay soils tend to be more fertile
- ▶ loamy soils are intermediate in fertility
- ▶ sandy soils tend to be less fertile

soil pH

- ▶ most trees prefer a pH in the 5.5–7.5 range
- ▶ when the pH of a soil is above (more alkaline) or below (more acidic) this range, some nutrients may become unavailable to the plant.

This Red Pine plantation on a calcareous site is showing mortality and decline. For more information about site assessment and matching species to site, please read on!

Lime Content in Soil

Some soils have naturally high levels of lime (calcium or magnesium carbonate). These soils are known as calcareous soils. Calcareous soils are alkaline and can have parent materials with relatively high pH ranges (i.e., above 8.0).

Calcareous soils are normally found in agricultural southern Ontario – south of the Canadian Shield – in areas with soils developed from bedrock rich in calcareous minerals.

The presence of *carbonates* at depth and in the soil parent material (usually greater than 50 cm or 20 in. from soil surface) indicates a nutrient-rich site.

However, if the upper soil layers have been removed by soil erosion or excavation, carbonates close to the soil surface cannot readily supply nutrients to growing trees (high pH). This site condition will eventually kill Red Pine and may impact the growth of White Pine, White Spruce and Norway Spruce.

Most soil parent materials (subsoils) on the Canadian Shield are acidic and not calcareous – indicating a lower level of soil fertility than non-eroded calcareous soils.

SUMMARY OF NUTRIENT LOSSES FROM THE NUTRIENT CYCLE

SOIL TYPE	POTENTIALLY LIMITING NUTRIENT
HIGH pH (alkaline)	boron, copper, calcium, iron, manganese, phosphorus, zinc
LOW pH (acid)	boron, calcium, molybdenum, phosphorous, potassium

PLANNING FOR TREE COVER

Agroforestry practices require some forethought. Some initial planning can help you turn your intentions into reality. Planning helps you:

- organize and document your ideas
- set and achieve your goals
- avoid costly mistakes
- ensure that resources are well-managed
- maximize potential returns
- monitor your progress
- prepare for the tax implications of owning a woodlot.

Management planning starts with creating a vision for your property – an idea of what you would like to do over the next few decades. The effort to develop a tree cover plan should match the level of detail needed. For example, planning a 20-hectare planting on a diverse site requires considerably more effort and operational detail than a 5-hectare planting on a very uniform site.

The need to develop a management plan for your entire property is usually related to your goals. If your goals are to manage a large, diverse property for stewardship and for profit, then a detailed, comprehensive, farm and natural area stewardship plan may be in order. Make sure that the tree planting component of your plan is compatible with your overall goals for your property and with specific objectives you have for any of your land that adjoins the area to be planted.

The management plan can be as detailed as you want it to be, and although there is no standard structure for such plans, there are a number of common sections.

Important sections of a good management plan will contain the:

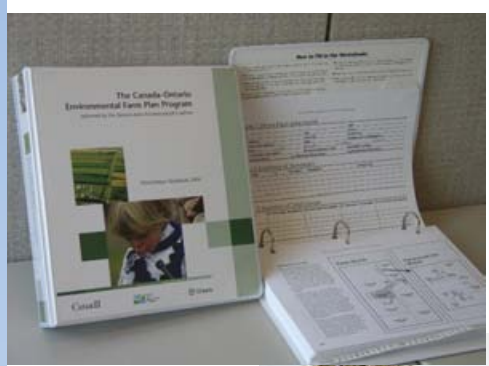
- scope – what the plan is all about, who wrote it, where the property is located
- term – how long the plan is valid for
  - many plans have a five-, 10- or 20-year lifespan
- objectives – what you want to achieve over the short and long term
- inventory – what you have (land, forest) to work with
- management actions – what activities you plan to undertake to achieve your objectives
- record of activities – list of what you have accomplished.

A management plan is a document that maps out a way of achieving your objectives.

Planning – it's a family activity.

You may want to include the following additional information in the plan:

- a section on the management history – what has been done in the past will have a major impact on what can be done in the future
- maps of the property – these make the job of implementing the plan easier
  - aerial photographs can also be very beneficial
  - stand boundary maps help during forest operations
- incorporation of a wildlife management plan (see EFP worksheet #23).



The Environmental Farm Plan identifies forest resource planning as a BMP.

Idle land can be an opportunity.

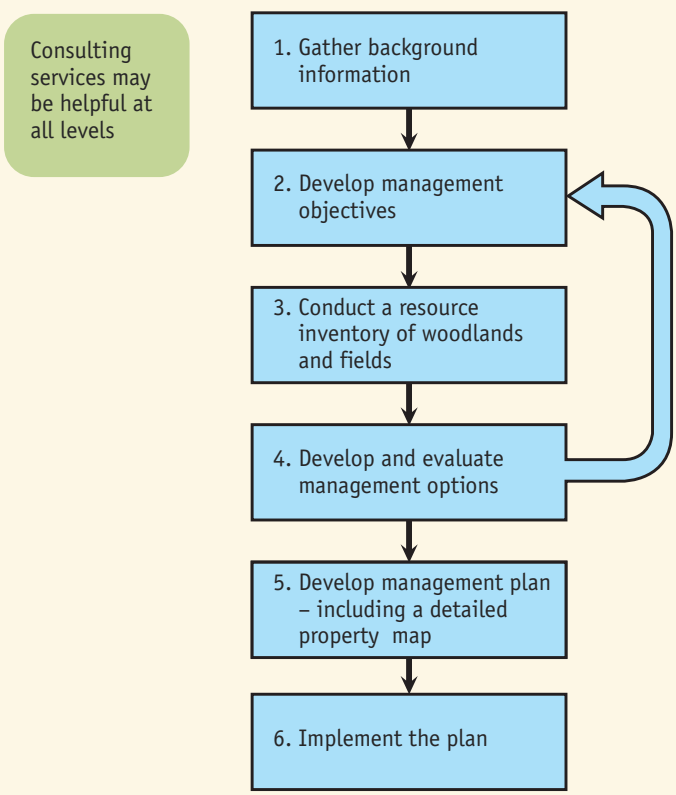
Planning has long-term implications. Discuss goals with your family before developing your plan.

6-STEP PLANNING

Management planning can be looked at as a series of steps. Each step brings you closer to benefiting from the potential of your property.

The following flow chart lists some of the more common steps in the planning process. For the balance of this section, we'll explore the general principles underlying the six steps. The rest of the book will explore BMPs for specific agroforestry applications. Draw from these to develop your plan.

AGROFORESTRY PLANNING STEPS



Your inventory will tell you if your management objectives are reasonable. In some cases, you may need to adjust your objectives or your planned activities.

Part of planning is taking the time to develop a vision of what you want your property to do and look like in the future.

STEP 1 – GATHER BACKGROUND INFORMATION

Checklist

Have the following items on hand before getting started:

- ✔ contact names for consultants, forestry services, private nurseries
- ✔ county soil map and report
- ✔ surveyor or municipal forest plan – to determine common forest cover types for the area
- ✔ sources for or actual topographic maps or aerial photographs for your property
- ✔ tools for measuring slope in the field – clinometers (surveying instruments), stake and string
- ✔ graph paper and ruler
- ✔ field measuring tape, i.e., >20 metres (66 ft)
- ✔ distance measurements between fields and natural areas, lot lines, and surface water bodies
- ✔ field slope measurements
- ✔ depth to saturated soil or evidence of water table (rust-coloured blotches and grey colours)
- ✔ land use history – crops grown, pesticides used, soil tests results and nutrients applied
- ✔ soil sampling equipment – shovel or soil auger.

Aerial photographs are excellent planning tools. They show most features needed to create accurate maps. These may be obtained from the Ontario Ministry of Natural Resources through their website at: http://themnrstore.mnr.gov.on.ca.

The photos to the right show the same site, the one on the far right having been taken 23 years after the one on the left.

The Ontario Woodlot Association brings woodlot owners together to learn about sustainable forest management. Their website is well worth a visit: http://www.ont-woodlot-assoc.org/.

STEP 2 – DEVELOP MANAGEMENT OBJECTIVES

Developing realistic and appropriate management objectives for your property is an important step in the planning process. Your objectives should encompass what you want to achieve over both the short and long term.

Short-term objectives should be quite specific for the present and near future. For example, "Over the next five years, I plan to:

- establish a Red Pine plantation
- plant 500 trees each spring adjacent to my wetland
- control competing weeds."

Long-term objectives should be broadly worded to cover the next 20 years of your operation. For example, "Over the next 20 years, I plan to:

- promote hardwood regeneration in a Red Pine plantation
- connect two woodlots through yearly planting
- harvest nuts from my nut tree planting."

To get started, ask yourself:

- what do I want my woodland to be like in 10 or 20 years?
- what do I need to do now to start working toward this vision?
- what am I capable of, in terms of time, equipment, financial resources?
- what type of help will I need along the way?

LINKING OBJECTIVES TO LANDSCAPE PLANNING

Now that you've developed objectives for your property, look at the bigger picture. Does your plan fit or clash with land use, natural areas and other agroforestry plantings in your neighbourhood?

Your property is part of the bigger landscape. Target your planned efforts in areas that will have the maximum benefit to both you and to the surrounding environment. Planting trees or leaving an area to regenerate naturally can connect woodlots, increase forest size, and provide a buffer for water bodies.

Altering wetland features can have a disastrous impact downstream. Here we see the results of forest clearing around a natural stream two kilometres away.

STEP 3 – CONDUCT A RESOURCE INVENTORY OF WOODLANDS AND FIELDS

Conduct a resource inventory of your property to:

- provide a snapshot of your natural resources
- determine suitable management options
- organize information on inventory features such as the land's potential to support agroforestry activities
  - include information on soils, current farm practices, and linkages to existing natural features.

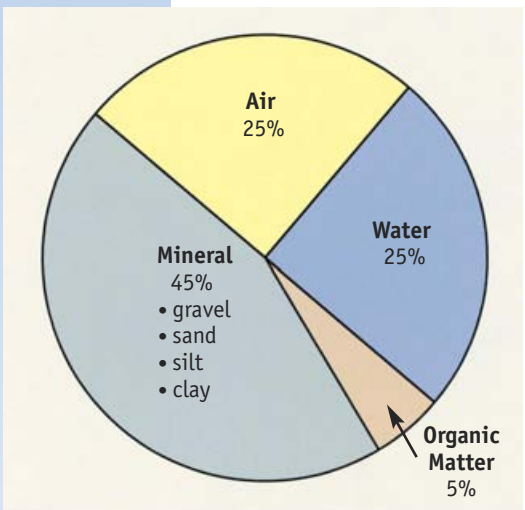
If your goal is to incorporate trees into the existing farming operation or convert some open land to treed land, then you should inventory your non-forestry areas.

A **non-forested land inventory** will help answer these questions:

- how much area is available for trees?
- what are the soil types?
- are there any site-related problems that could affect my plans?
- where should I establish trails, shelterbelts and windbreaks?
- how will my planned activities impact my current farming practices?
- can I use my existing farm machinery?

Use a map to sketch potential agroforestry activities. Where would you like to plant the windbreak or wetland buffer? Where will any new roads or trails be located? What areas are you planning to leave untouched?

SITE ASSESSMENT CONSIDERATIONS



Soils are made up of four primary components: air, water, organic matter and mineral particles. The ideal soil will have a composition similar to what's shown in the pie chart. The amount of air and water within a soil will fluctuate throughout the year.

A carefully planned tree cover project includes a site assessment. A site assessment should be done before matching species and management practices to site conditions.

Soil and site characteristics influence and in some cases dictate the survival and growth of a young plantation. A poor match of species to site is not always evident in the early years following planting.

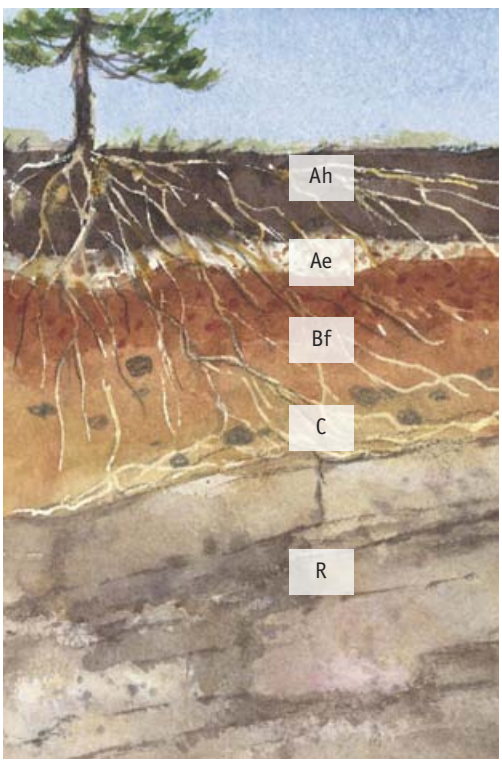
Soil characteristics can vary greatly, sometimes in a relatively small area. If your planting site is large or if it varies in topography, then you may be dealing with a number of site types. Planting trees can be expensive and time consuming, so be sure to take the site into account before you purchase your seedlings.

There are four main factors dictating which species have the best chance of survival on any given site. These are:

- depth to *seasonal water table*
- *soil texture* class
- presence of carbonates
- depth to bedrock or other root-restricting layers.

Match species to site. The effects of inappropriate matching of species to site on growth may not be evident in the early years after planting. If tree seedlings that are selected for planting don't suit local site conditions, trees may not survive and will not thrive.

Conversely, trees planted on sites where they thrive will grow into commercially valuable trees. Consult with a forestry professional if you have questions.



Ah horizon: Also called the topsoil. Contains most of the organic matter: roots, humus, litter, worms, fungi. Darkest in colour and most fertile.

Ae horizon: Is a light-coloured layer where iron and some organic matter have moved out of the horizon.

Bf horizon: Iron compounds and organic matter have moved into this horizon – giving it a rich reddish-brown colour.

C horizon: Weathered parent material that is less changed than the first two layers. Will contain mineral materials (sand, silt, clay and coarse fragments), and alone, will not support plant growth.

R horizon: Unweathered bedrock.

Choosing a species that suits your site and will meet your objectives is the key to successful planting and the future forest it creates.

DEPTH TO SEASONAL WATER TABLE OR MOTTLES

Depth to the seasonal water table is important because it indicates the amount of water available for tree growth, and whether the site is too wet for some tree species.

The groundwater table moves up and down throughout the year – usually hitting its highest level (closest to the surface) in the spring or fall. Seasonal flooding can kill trees like White and Red Pine that are intolerant of high groundwater levels.

Soil layers with gley (grey colours) indicate a permanently high water table. The higher the gley colours and mottles are in the soil profile, the poorer the drainage of the site.

Mottles (rust blotches) and gley (grey colours) in the same profile indicate generally wet soil conditions, with a fluctuating soil water table. Grey colours alone usually mean a permanently high water table.

Tree roots need to breathe. Species such as White Cedar adapt to wetter sites by developing shallow rooting systems.

SOIL TEXTURE CLASS

Every soil is made of individual grains or particles that may be amassed into larger soil aggregates. Larger aggregates are most noticeable when the soils are fine-textured, e.g., clay or high clay content. The size of these particles dramatically influences:

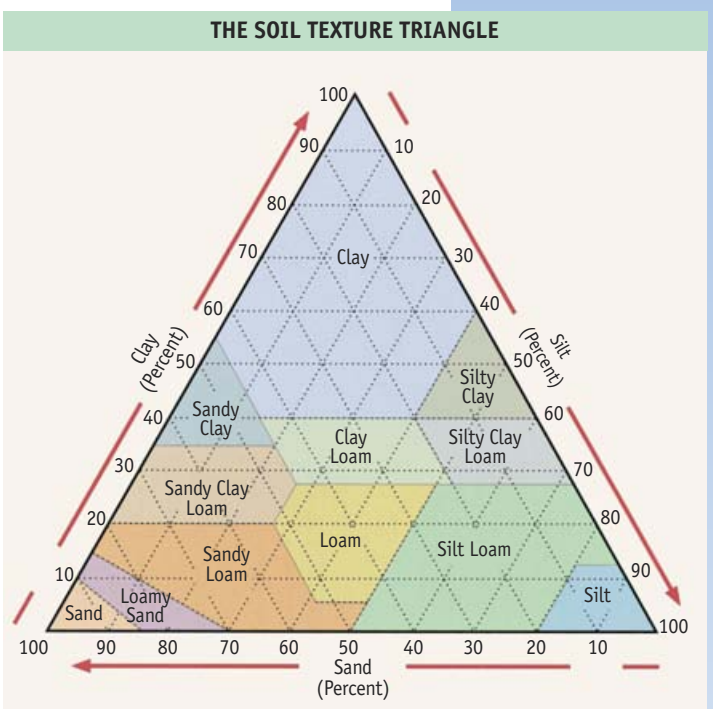
- **water-holding capacity**
  - soils with larger particles tend to hold less water than soils with smaller-sized particles
  - this is very important for both tree survival and tree growth processes, but too much water can create undesirable conditions for growth, such as poor aeration

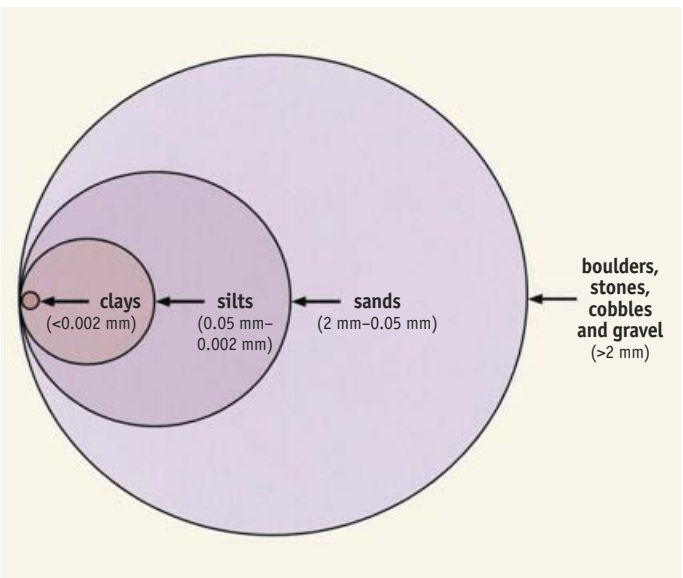
▶ **aeration**
- ▷ tree roots need air for respiration, growing best where there's a balance of air space and water between the particles

▶ **surface area**
- ▷ surface area is important because it helps maintain water films and affects nutrient availability
- ▷ finer soils have a higher surface area than coarser soils
- ▷ a 1-gram sample of coarse sand would have a total surface area of roughly a Canadian toonie – the same 1-gram sample of clay would have a total surface area that would cover a tennis court

▶ **nutrient retention**
- ▷ coarser soils tend to have less available nutrients than finer soils.

Soil texture is the proportional distribution of particle sizes (sand, silt, clay) within a soil. The soil texture triangle is a method of determining the soil texture class. If your soil is 20% clay, 30% silt and 50% sand, it would classify as a loam soil. Loams are a mix of sands, silts, and clays – often sharing the best characteristics of each.





Soil particles range in size from large boulders to microscopic clay particles.

Species suitability tables on page 49 link soil texture and depth to mottles (seasonal water table). Use the site factors from your location to determine which species are best suited to the site you intend on planting.

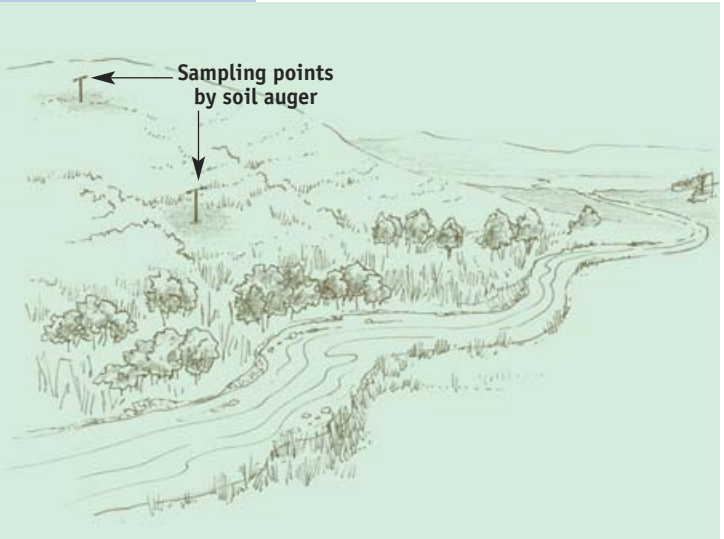
PRESENCE OF FREE CARBONATES

Free carbonates are soluble calcium carbonates that occur naturally within some soils. In severely eroded soils, the free carbonates may be found at or near the soil surface. Most species are able to tolerate carbonates and may not be severely impacted by their presence in the rooting zone.

However, Red Pine cannot tolerate high concentrations within 50 cm (20 in.) of the soil surface. Carbonates can kill a mature Red Pine once it reaches seed-bearing age (25–40 years). Red Pine will also suffer on shallow soils over limestone bedrock: decline may be noticed after 40–50 years.

Most areas with carbonates have been severely eroded. Test for free carbonates – you may want to seek assistance from a forestry professional – by dripping a 10% hydrochloric acid solution onto the soil. Note that:

- ► if the soil reacts to the acid, carbonates are present and Red Pine should not be planted
- ► if there is any doubt whether carbonates are present in the soil, do not plant Red Pine
- ► the presence of carbonates may also impact White Pine and Norway Spruce.



Check soil and site conditions on upper and lower slope positions.

Species such as Red and White Pine are not tolerant of high lime soils.

DEPTH TO BEDROCK OR OTHER ROOT-RESTRICTING LAYERS

Your potential for planting success is impacted by soil depth, which influences soil water retention and rooting depth.

Picture the soil as a sponge: the deeper (thicker) the sponge, the more water it can hold or retain. Trees planted in shallow sites are subject to the effects of dry weather before trees that were planted on deeper soils. Soil depths that are:

- less than 15 cm (6 in.) over bedrock may be too dry to plant most tree species
  - ▷ avoid planting on sites where you can't get your shovel in the full depth
- 15–30 cm (6–12 in.) can be planted with a number of drought-tolerant species such as Jack Pine, White Pine, White Spruce and Bur Oak
  - ▷ application of mulch around seedlings may enhance survival
  - ▷ some mortality should be expected
- shallow soils greater than 30 cm (12 in.) are generally tolerable for most species
  - ▷ drought-related mortality may still occur depending on environmental conditions
  - ▷ rocky soil – 50% rock means 50% less root space and nutrients.

Other root-restricting layers such as compacted soils can also limit tree growth by limiting root development and subsequent water and nutrient uptake. Compacted soil layers can occur both naturally in soil and as a result of some farming practices. Severely compacted layers can be somewhat alleviated with sub-soiling tillage equipment. Deep-rooting forages such as alfalfa can also help to break up compacted layers or hardpans.

Some soils are so shallow that leaving them for natural field *succession* may be the most suitable management decision.

STEP 4 – DEVELOP AND EVALUATE MANAGEMENT OPTIONS

Armed with the background and resource inventory you've collected, you can now develop and assess management options. A forestry consultant would be helpful during this process. Reflect on your values, goals and objectives when assessing options.

✔ **Assess and select a silvicultural or management system suitable for the type of tree cover you want to establish.** Plantations will have different needs than windbreaks or buffers.

✔ **Identify business goals.** Are you looking for short-term income or a long-term investment? Do you burn fuelwood or use wood products in-kind? Are you planning to do this work yourself?

✔ **Protect the environment.** This is the time to assess the impact of management on wildlife habitat goals, recreational needs, and the protection of fragile and natural areas on your land (e.g., steep slopes, streams, wetlands).

AGROFORESTRY ON LEASED LAND

Like all agricultural activities, agroforestry opportunities may be realized on leased land. Some agroforestry activities, however, may not be feasible on leased land where lease agreements can be short-term (generally one to three years). Planting trees is a long-term commitment requiring many years of input and expenses before any return on investment is generated.

Longer-term leases might, in some cases, allow for the planting of Christmas trees, nut trees or other crops on leased land. Some Christmas tree species such as Balsam Fir may take 10 years to reach maturity. At the end of the lease, the land could be put back into other agricultural production.

Lease agreements for agroforestry activities should:

► be reviewed by a lawyer
► have a specific term that is appropriate to the agroforestry activity
► clearly lay out costs, responsibilities, and liabilities of all the parties involved
► list the ramifications of selling the property or cancelling the lease.

INVESTMENT CONSIDERATIONS

Depending on the agroforestry operation, it may take several decades before a landowner can begin to see a return on an investment in trees. A new plantation of Red Pine, for example, will require a considerable investment upfront to establish and maintain. A landowner may not see any significant return on this investment until the plantation is over 50 years old.

Christmas trees can be harvested after approximately 10 years.

It's vitally important to evaluate the potential return on your investment for all agroforestry practices. Is it worth it? If so, when will you recover your costs? When will you earn a profit?

Unfortunately, these questions cannot be easily answered. Your agroforestry operation is subject to:

- ▶ variability in forest growth and development, and natural disasters
- ▶ variability in market conditions and future commodity prices
- ▶ interest rates, inflation and other economic forces.

As you begin to plan your agroforestry operation, you should consult:

- ▶ an accountant or tax specialist with experience in counselling farm and woodlot owners
- ▶ a forester as you develop your management plan.

Don't Forget a Business Plan

As part of your management plan, create a business plan. A business plan summarizes the operational and financial objectives for your planned activities. Your aim will be to demonstrate how your woodlot can become a viable, income-generating business venture with expectation of future profit.

PUBLIC PROGRAMS FOR LANDOWNERS

Trees are a long-term investment and you should be aware of any opportunities to help you achieve your long-term goals.

Over the years there have been a number of woodlot incentive programs that have subsidized management operations. Although some of these programs may no longer be in existence by the time you read this, it seems very likely that new ones will evolve in the future.

Managed Forest Tax Incentive Program (MFTIP)

- ▶ encourages eligible non-farm landowners to create and follow a management plan
- ▶ taxes eligible areas at 25% of the municipal tax rate for residential property
- ▶ contact the Ontario Forestry Association (1-800-387-0790) or the Ontario Woodlot Association (1-888-791-1103)

Conservation Land Tax Incentive Program

- ▶ protects significant wetlands and other areas of interest
- ▶ contact your local office of the Ontario Ministry of Natural Resources

Environmental Farm Plan (EFP)

- ▶ helps farmers adopt more environmentally sustainable practices
- ▶ refer to worksheets #22 and #23 and their accompanying info sheets to assess your forestry practices.
- ▶ contact the Ontario Soil and Crop Improvement Association (1-800-265-9751)

Trees Ontario Foundation

- ▶ provides a variety of incentive-based planting programs (1-800-265-9751)

Land Trusts

- are registered, charitable, non-profit organizations dedicated to preserving and protecting natural, historic and cultural areas
- designed to secure and protect sites through land purchase or donation, conservation easements, or cooperative programs with landowners

CONTINGENCY PLANNING

Like all agricultural practices, agroforestry operations are subject to unexpected events that may require a change in management philosophy. The management planning process can and should be considered a dynamic process where adjustments to the management plan may be required periodically.

As the planner, you can't be expected to account for everything. Here's what you can do:

- acknowledge that unexpected events may impact your existing management plan
- be aware that areas that are subject to invasive plants, like Buckthorn, may require a different management strategy
- identify firebreaks and access roads in your management plan for use during an emergency.

Not all disasters can be prevented. However, safety and prevention should be paramount. Remember to:

- promote forest health in your choices
- carefully assess safety risks
- remember that native insects are a natural part of the life cycle of a forest – evaluate any risks and options while considering a pest control operation
- seek professional help and advice.

Both plantings are 10 years old. The difference is that the Christmas tree plantation on the far left is ready for harvest and the Spruce plantation on the right will be managed for future timber harvests. Return on investment is not just measured in dollars, but time as well. Consider the time required for a proposed tree cover planting to provide return on investment.

PLANNING CONTINGENCIES	
EVENT	**IMPACT**
DROUGHT	• drought can have both short- and long-term impacts on forest health • moisture is the most limiting biological requirement
INSECT ATTACK	• forests are often adapted to periodic insect damage or defoliation • insects such as the Pine sawfly can seriously impact quality and value of young Pine and Spruce
DISEASE	• invasive diseases such as White Pine blister rust can devastate plantings, causing economic loss and a decrease in reforestation
FIRE	• seldom a problem in southern Ontario forests • conifer stands are more susceptible than hardwoods
ICE, SNOW, WIND	• physical damage to growing trees

STEP 5 – DEVELOP MANAGEMENT PLAN

The management plan can be a formal document or an informal file, depending on the needs and intent of the landowner. The plan usually consists of a written section and maps. The written portion should include a:

- ▶ description of goals and objectives
- ▶ description of areas where tree cover is to be established
- ▶ description of long- and short-term goals
- ▶ management plans and prescriptions (actions to achieve goals and objectives)
- ▶ records for expenses, income and other information.

STEP 6 – IMPLEMENT PLAN

When implementing your plan:

- ▶ follow the management prescription – include environmental protection considerations
- ▶ record what you have done (even the briefest of notes will be helpful)
- ▶ take advantage of local sources of knowledge.

White Pine weevil can impact the quality and value of White Pine crop trees.

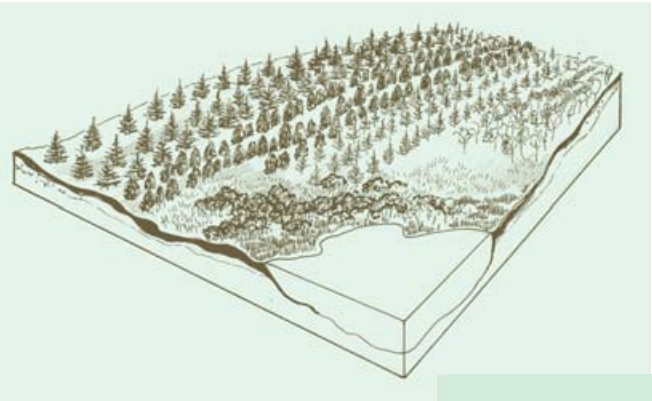
BMPs FOR AFFORESTATION

You can do many things with new trees in old farm field sites. This section will help you sort through the options to find what might work on your site, help you choose what to plant, and explain BMPs for plantings of conifers, as well as hardwoods and specialty trees.

Afforestation is the conversion of bare or cultivated land into forest. This term is often used interchangeably with *reforestation* which, technically speaking, is the restoration of a forest that has been removed by fire or harvest.

Agroforestry alternatives for open farm field sites include options for:

- **creating new forest stands and adding to existing ones**
- **creating treed barriers**
- **growing crops between rows of trees**
- **pasturing livestock**
- **adding shelter to woodland areas**
- **establishing nut groves**
- **growing Christmas trees**
- **growing nursery stock.**



Intensively managed, high-value plantations may be appropriate on more productive sites.

Plantations are quite suitable for marginal lands in agricultural southern Ontario.

AFFORESTATION OPTIONS

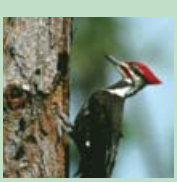
Bobolink nest in fencerows, hayfields and pastures.

As you learn more about the opportunities for replanting open farm fields, remember that your decisions should reflect:

- your objectives – often there will be more than one way to achieve your objectives
- the site you intend to plant – every site is different and any given site will usually support a range of species
- your resources – planting can require a considerable investment of time and money.

There are many types of plantations, from single species planted in a grid pattern to multiple species planted randomly. Each type has its advantages. See the following chart for help in choosing the type that will best help you achieve your objectives.

Open fields can be an aesthetically appealing part of the landscape.

AFFORESTATION OPTIONS		
SPECIES		**DESCRIPTION**
PURE CONIFER (1 species)		• timber production, Christmas trees • easiest to manage • may be more susceptible to disease and insect outbreaks • high potential for economic harvest of timber products
PURE CONIFER (2 or more species)		• timber production, Christmas trees • more diversity – mixed stands may be better at withstanding varying environmental conditions • lower yields of timber per unit area of individual species • one species can provide cover and shelter to another • easier to match species to local site conditions • may be lower commercial yield of wood products • potential for undesirable competition between species
MIXED CONIFER AND HARDWOOD		• mixing of species with similar site and shade requirements • conifers are easier to establish • similar benefits to two or more conifer species • lower potential for economic harvest of timber products • more difficult to schedule thinning to benefit all species • some species suppress others due to different growth rates
PURE HARDWOOD (single or multiple species)		• timber production, nut production • hardwoods require more intensive management for successful establishment • highest value of timber per unit area of desired species
MAPLE ORCHARD		• future maple syrup production • easy access and tubing installation • spacing can be controlled, promoting crown development • can integrate with conifers and shrubs for protection • established windbreaks or shelterbelts can protect the orchard
WILDLIFE PLANTING		• mast trees, roost trees • White Pine in a shelterbelt • mixed canopy layers should benefit more species
NURSE CROP PLANTING		• under-planting one species below another • can supply a diversity of products – a crop of one species followed by a future tree crop

CHOOSING WHAT TO PLANT

Choosing the right species is a matter of selecting those that:

- ► are adapted to your open field conditions
- ► will grow to meet your objectives and provide you with the benefits you seek
- ► are available from a nursery in the quantity and at the price you want.

Not every species will be suited to the often extreme conditions for your open field planting site. Open field sites frequently have:

- ► full sunlight
- ► degraded soils
- ► high winds
- ► competition from other vegetation
- ► temperature and moisture extremes.

After you evaluate your site and determine your management objectives, you will probably find that there are a number of suitable species for your open field site. From these options, choose the species that is best and available.

When looking for nursery stock, keep these key concerns in mind. Are they:

- ► available when needed?
- ► available in the quantity needed?
- ► from a seed source adapted to the regional climate?
- ► the right stock type and quality?
- ► competitively priced?

NATIVES VS EXOTICS

Problem non-native species are not limited to introduced insects, disease and understory plants. Many exotic tree and shrub species continue to be planted and grown across southern Ontario. Some can cause significant ecological problems such as:

- ► increased disease and pest presence, e.g., Scots Pine and European Pine Shoot Beetle
- ► displacement of native species and disruption of natural ecosystems, e.g., Norway Maple, European Alder, European White Birch, Tartarian Honeysuckle, Multiflora Rose
- ► *hybridization* with natives, e.g., White Mulberry, European Highbush Cranberry.

A very few *exotic species* have proven to be benign and even beneficial. Two examples are Norway Spruce and European Larch, which are often used in plantation trees and/or windbreaks. They may meet your specific objectives without disrupting neighbouring natural communities. Remember to ask for seed sources that are proven to be adapted to the climate in your area.

Conifer species are often better suited to afforestation conditions than hardwoods and shrubs.

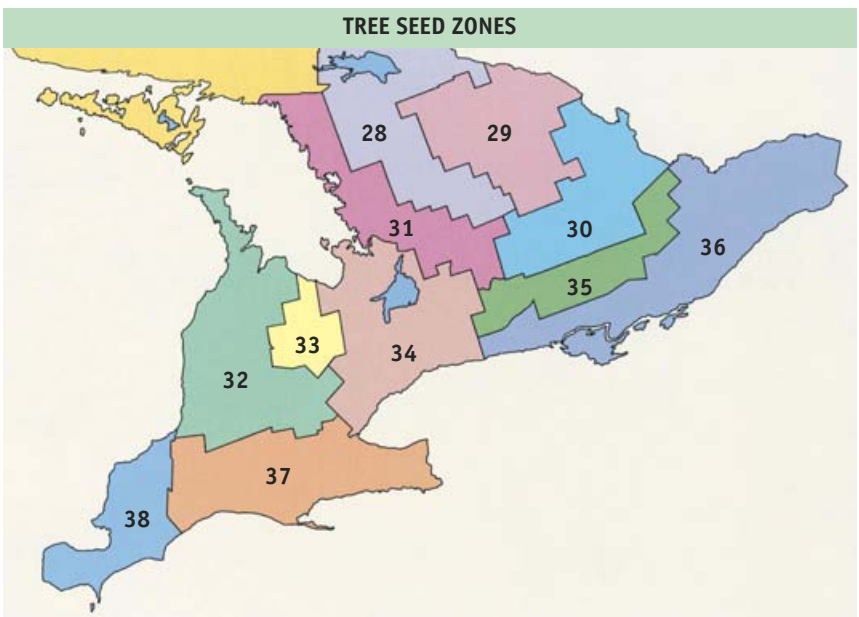
Norway Maple can displace native trees.

Norway Spruce is a beneficial exotic species.

CHOOSING GOOD PLANTING STOCK

SEED SOURCE

Trees have evolved over thousands of years to be genetically adapted to their local climate. Your seedlings need to be grown from locally adapted seed. No amount of tending, fertilization, or irrigation will help an ill-adapted tree grow as well as a tree that is adapted to the climate.



The Ontario Ministry of Natural Resources has developed tree seed zones to help people choose stock grown from suitable native seed sources. Seed collected from anywhere within a zone can be planted safely within the same zone.

A nursery supplier can usually locate seedlings grown from an appropriate seed zone for your land. Being able to choose the best source for your site requires that seed source particulars are known. This is not the case every time. Always ask your supplier about seed source, whether you're buying one tree or ten thousand.

If you cannot find seedlings grown from your seed zone, consider delaying planting or seek out additional information from a forestry professional on the implications of planting out-of-zone stock. Remember, the most expensive planting is a failed planting.

STOCK TYPE

There are two main types of nursery stock available: bare root and container.

Bare Root Stock

- ► seedlings usually two to three years old
- ► often most appropriate for southern Ontario open field sites
- ► careful handling is essential to prevent root damage

Container Stock

- ► seedlings grown in a small container, which is planted along with the tree to form a compost plug to hold roots
- ► seedlings usually one to two years old
- ► often not suitable for open field sites
- ► seedlings may not grow well under grass or weed competition
- ► less perishable as the roots are protected by soil and the container

Larger container stock is available at some nurseries and may have application in smaller, higher-value plantings.

Direct seeding is a third option with some species such as Red Oak and Black Walnut, provided competing vegetation is well-controlled.

STOCK QUALITY

When you pick up your seedlings, examine the roots and buds for:

- ► healthy green foliage on conifers
- ► firm, live buds on unflushed hardwoods and larches
- ► undamaged stem tissue
- ► balanced seedlings – a good amount of roots to support a moderate-sized shoot with a sturdy stem (good caliper)
- ► moist stock with no mould or sour odours
- ► roots with fine white hairs.

High quality stock is more likely to survive and thrive in the extreme conditions found in open planted fields.

MATCHING TREE SPECIES TO SITE CONDITIONS

Depth to mottled zone indicates the depth of a fluctuating, seasonal soil water table. Tree roots can obtain available soil water above and within the mottled zone during the growing season.

Tree seedlings will perform poorly, or die, if planted off-site. Replanting trees can be expensive and time-consuming, so it's essential to understand your site conditions before you purchase seedlings. Choosing a species adapted to your site and that will meet your objectives is the key to successful planting and the future woodland it creates.

As discussed previously, there are four main factors that dictate which species have the best chance of survival on any given site. These are:

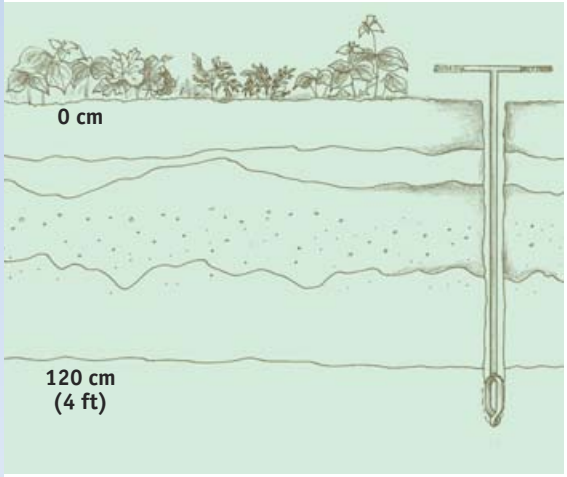
- depth to seasonal water table
- soil texture class
- presence of carbonates
- depth to bedrock or other root-restricting layers.

Tables are available to help you judge hardwood and softwood species suitability. Here's how to use them.

Soil characteristics can vary greatly, sometimes in a relatively small area. If your planting site is large or if it varies in topography, then you may be dealing with a number of site types.

1. Select sites for soil inspection.
2. Test for free carbonates by dripping a 10% hydrochloric acid solution (dilute muriatic acid) onto the soil. If the soil reacts to the acid, carbonates are present and planting Red Pine should be avoided.
3. Dig with shovel or auger.
4. Hand-texture soil material from several depths, e.g., 0–10 cm (up to 4 in.), 30–40 cm (12–16 in.).
5. Measure depth to mottles, carbonates, bedrock or other root-restricting layer.

If a compacted or impenetrable layer of stone or bedrock is found, adjust suitability rating down one suitability ranking for each species.



How to assess soils in order to match species to site:

- **use auger or shovel to check 120 cm (4 ft) depth**
- **determine soil texture throughout 120 cm**
- **use dominant texture group in top 70 cm (2.3 ft) for table on page 49**
- **find depth of mottled zone – if present**
  - **no mottles = >150 cm (5 ft) column**
  - **if an isolated layer of mottles in this area is found, treat as 100–150 cm (3.3–5 ft) depth to mottles**
- **use 10% HCl – to determine layer with free carbonates**
- **note depth to root-restricting layer or bedrock.**

DEPTH TO MOTTLES	>150 cm (>60 in.)	100–150 cm (40–60 in.)	80–99 cm (31–39 in.)	50–79 cm (20–30.5 in.)	20–49 cm (8–19 in.)	0–19 cm (0–7.5 in.)
TEXTURE GROUP						
SHALLOW TO BEDROCK (<50 cm [20 in.])					Pr* Or **Pj** Mr Sw Mh **Ta** Le **Ce**	Sw Ms **Ce** **Ta**
GRAVELS/GRAVELLY SANDS AND LOAMS	Pr* Or Pw* Mr **Sw** Sn Le **Ce**	Pr* Or Pw* Mr **Sw** Aw Sn Mh Le **Ce**	Pr* **Or** Pw Aw **Sw** Mr **Sn** Mh **Le** **Ce**	Pr* **Or** **Pw** Aw **Sw** Mr **Sn** Mh **Le** **Ce**	Pw **Ms** **Sw** **Or** **Sn** Aw **Ce** Mr **Ta**	Sw Ms **Ce** Or **Ta** Ag
SANDY	**Pr** Or **Pw** Aw Sw Mh Sn Mr Le Ce	**Pr** **Or** **Pw** **Mr** **Sw** Mh **Sn** Aw **Le** Ce	**Pr** **Or** **Pw** **Aw** **Sw** **Mr** **Sn** Mh **Le** Ce	**Pr** **Or** **Pw** **Aw** **Sw** **Mr** **Sn** Mh Le Ce	**Pw** **Or** **Sw** Aw **Sn** **Ms** Ce Ag **Ta**	**Sw** Ms **Ce** Ag **Ta** Or
LOAMY	Pr* Aw **Pw*** **Or** Sw Mh **Sn** Wb **Le** Mr Ce	Pr* **Aw** **Pw*** **Or** **Sw** **Mh** **Sn** **Wb** **Le** **Mr** Ce	Pr* **Aw** **Pw** **Or** **Sw** **Mh** **Sn** **Wb** **Le** **Mr** Ce	**Pw** **Aw** **Sw** **Or** **Sn** **Mh** Le **Wb** Ce Mr	**Pw** **Ms** Sw Mr **Sn** Aw **Ce** **Or** **Ta** **Ag** **Wb**	**Sw** **Ms** **Ce** **Ag** **Ta** **Or**
CLAY LOAMS	Pr* **Pw** Or **Sw** Mh **Sn** Wb Le Mr Ce	Pr* Aw **Pw** Or **Sw** Mh **Sn** Wb **Le** **Mr** Ce	Pr **Aw** **Pw** **Or** **Sw** Mh **Sn** **Wb** Le **Mr** Ce	**Pw** **Aw** **Sw** **Or** **Sn** **Mh** Le **Wb** Ce Mr Ce	Pw Aw **Sw** **Or** **Sn** **Ms** Ce Ag Ta Wb	**Sw** **Ms** **Ce** **Ag** Ta Or
CLAYS	Pw **Sw** **Sn** Le Ce	**Pw** **Sw** Or **Sn** **Mh** Le **Wb** Ce Mr	**Pw** Aw **Sw** Or **Sn** **Mh** Le **Wb** Ce Mr	Pw Aw **Sw** Or Sn Mh Ce Wb Mr	Pw Aw **Sw** **Or** Sn Ms Ce Ag Ta	**Sw** **Ag** **Ce** **Ms** Ta Or

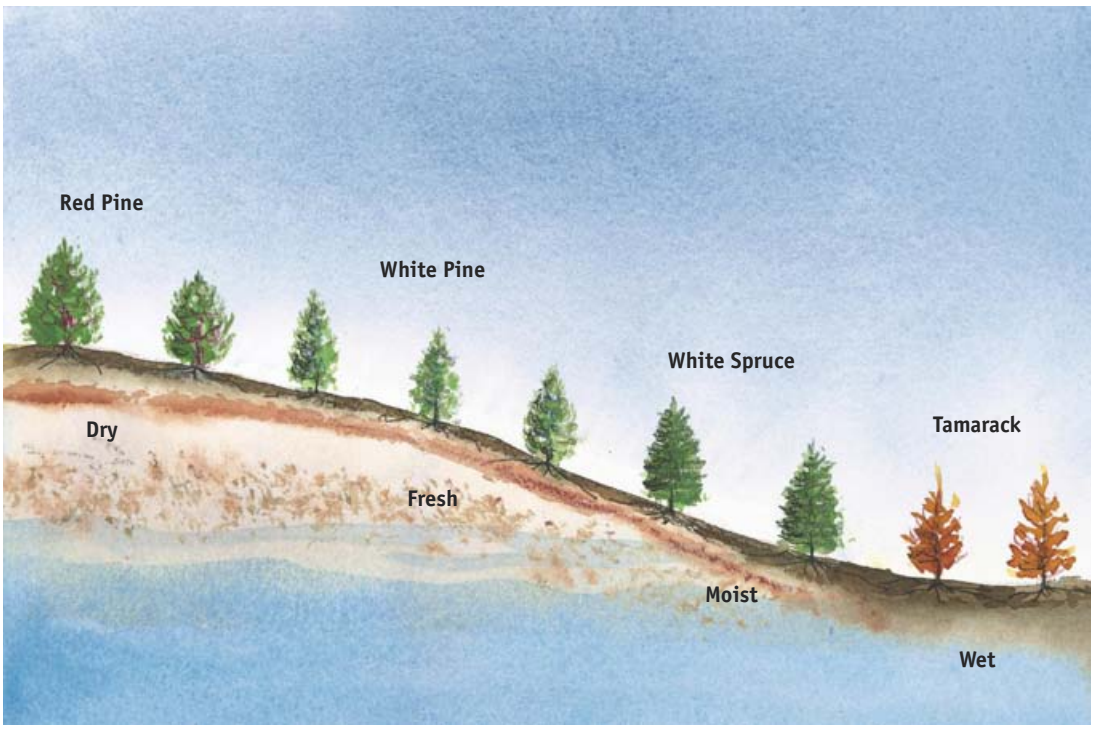
*if carbonates are present within 50 cm (20 in.), do not plant (Red Pine or White Pine)

Species key:

Conifers Pr – Red Pine; Sn – Norway Spruce; Sw – White Spruce; Ta – Tamarack; Ce – White Cedar; Pw – White Pine; Pj – Jack Pine; Le – European Larch

Hardwoods Mh – Sugar Maple; Ag – Green Ash; Mr – Red Maple; Or – Red Oak; Ms – Silver Maple; Wb – Black Walnut; Aw – White Ash

Suitability rating: a rating of suitable species survival and early height growth. If species is not listed, do not plant!
For example: **Pw** – Most suitable **Pw** – Very suitable Pw – Suitable



In uniform sandy textures, the soil moisture regime usually changes from dry to wet when you move downslope from the top to the bottom of the knoll. Species suitability to site conditions closely follows soil moisture regime.

Agroforestry plantations play an important role in the southern Ontario landscape, because they:

- provide opportunities for growing products and protecting the environment
- sequester carbon from the atmosphere
- offer good economic potential
- rehabilitate shallow or highly erodible sites
- accelerate the process of succession to natural forests
- add diversity to the local area
- increase forest interior and edge wildlife habitat
- connect natural areas to fragmented or isolated woodlots
- can provide recreational opportunities
- reduce soil erosion and hold water.

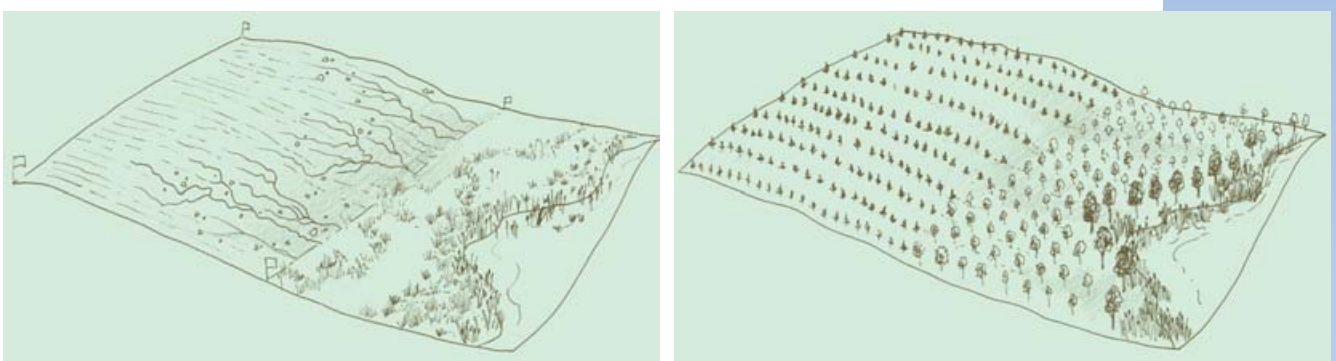
BMPs FOR PLANTATION ESTABLISHMENT

Good tree planting doesn't start with a shovel and a tree. Begin planning at least one year in advance.

✔ **Create a planting plan** for your site and include a:

- ► description of your objectives
- ► map of where the trees will go
- ► planting arrangement and tree spacing
- ► good estimate of how many trees you will need.

Seedlings can be sourced from private nurseries, county nurseries and conservation authorities.



Check site conditions. Match plantation type and species to local site conditions.

DETERMINING HOW MANY TREES TO ORDER

The number of trees you need to order is related to:

- ► the size of the area you want to plant
- ► the number of trees per unit area (planting density)
- ► your objectives for the plantation
- ► your budget.

✔ **Order your seedlings early!** Some species sell out quickly. Many nurseries take advance orders.

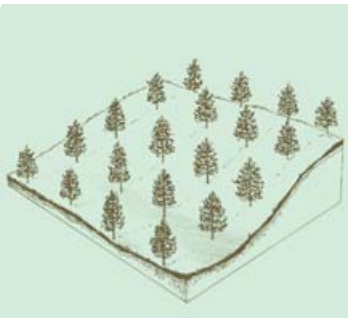
✔ **Locate any additional help** you may need such as:

- ► site preparation – often needs to be done the fall prior to planting
- ► planters – hiring planters or using a planting machine is appropriate for large numbers of trees
- ► post-planting tending – will your site need vegetation or pest (rodents, deer) control?

A plantation starts off at a certain density that decreases over time through management or mortality. Choosing the right initial planting density influences the rate of growth, and ultimately when the plantation will need thinning.

PLANTATION DENSITY – RANGES			
PLANTATION DENSITY	**HIGH**	**MEDIUM**	**LOW**
NUMBER OF TREES	• 2000–2500/ha (800–1000/ac)	• 1000–2000/ha (400–800/ac)	• <1000/ha (400/ac)
SPACING • BETWEEN TREES • BETWEEN ROWS	 • 2–3 m (6.5–10 ft) • 2–3 m (6.5–10 ft)	 • 2.5–3 m (8–10 ft) • 2.5–3.5 m (8–12 ft)	 • >3 m (10 ft) • >5 m (16 ft)
PURPOSE	• sawlogs and poles	• sawlogs and veneer	• veneer, nuts, syrup, specialty forest products
SPECIES SUITABILITY	• most conifers – Red Pine, White and Norway Spruce, White Cedar, European Larch	• conifers and hardwoods, (e.g., Red Oak and Red Pine, or White Pine and Black Walnut)	• Maple orchards • nut-tree and veneer orchards • intercropping and alley cropping operations • ginseng, herbs, mushrooms
MANAGEMENT IMPLICATIONS	• higher labour needed to establish • minimal labour for weed control • moderate labour for thinning and pruning	• moderate labour required to plant • moderate labour required for weed control • moderate need for thinning • high labour requirement for pruning	• moderate labour required to plant • high labour requirement for weed control • low need for thinning • high labour requirement for pruning
COST AND PROFIT POTENTIAL	• higher establishment cost • low maintenance cost • little or no profit with first thinning • moderate long-term profit potential	• moderate establishment cost • moderate maintenance cost • high long-term profit potential	• moderate establishment cost • moderate maintenance cost • high short- and long-term profit potential

High-density White Spruce plantation.



Medium-density White Pine plantation.

Low-density Maple orchard.

Plantations are usually established in rows. The distance between the rows, and between the trees in the rows, determines the planting density. You can calculate the number of seedlings required per acre with the following formula:

Number of trees per acre = 43,560 (ft^2) / (# ft between rows X # ft between trees in the row)

TREE NUMBERS FOR COMMON ROW AND TREE SPACING DISTANCES

SPACING BETWEEN		NUMBER OF TREES	
TREES metres (ft)	ROWS metres (ft)	PER HECTARE	PER ACRE
1.8 (6)	1.8 (6)	2989	1210
1.8 (6)	2.5 (8)	2244	908
2.5 (8)	2.5 (8)	1682	681
3 (10)	3 (10)	1076	436
3.5 (12)	3.5 (12)	746	302

OPTIONS FOR SITE PREPARATION

Before you plant, ensure that your planting site is ready for trees. Although site preparation can be costly, it's usually a necessary expense that helps ensure seedling survival and therefore reduces unnecessary replanting and excessive tending costs. Good site preparation can improve compacted soils, help site drainage problems (flooded in spring, dry in summer), and reduce heavy field vegetation.

The type of site preparation needed is a function of the type of planting, species selected, site conditions, and the level of competition.

Hardwoods are normally planted on more productive sites that support greater levels of competing vegetation, and therefore are more demanding and generally require more intensive site preparation. Conifers can often survive on sites with less intensive site preparation.

Careful planning of site preparation methods and timing is necessary to ensure your planting is successful. Factors like heavy rainfall, slope and topography, soil stoniness and texture can influence your decisions. Consult someone with experience in planting trees.

Once you've prepared your site, it's time to plant the trees.

SITE PREPARATION OPTIONS		
TYPE OF SITE PREPARATION	**METHOD**	**DESCRIPTION**
CHEMICAL	spot spraying	• apply a small amount of herbicide to individual planting sites to kill existing vegetation prior to planting • use a backpack sprayer • is better suited to smaller planting operations
	band spraying	• tow power sprayer behind a tractor or ATV • apply herbicide in bands, which become planting rows
	boom spraying	• apply herbicide to the entire planting area using an agricultural boom sprayer • allows control of vegetation over entire area
MECHANICAL	brush cutting	• may be necessary on some overgrown sites • is often used prior to and in combination with other site preparation methods (mechanical and chemical)
	ploughing or furrowing	• may not be necessary on all sites • used to break up sod layer • often used in combination with discing • plough to depth of 25 cm (10 in.) • follow contours of land • wait at least a week after herbicide application • will often improve drainage
	discing	• produces a smooth surface • aerates soil and promotes rooting
COVER CROPS	sowing white clover or rye grass	• can be an alternative to herbicides • won't out-compete planted trees • helps control competing vegetation • helps stabilize the soil, preventing erosion • helps conserve soil moisture • helps fertilize the soil

Mounding is a site preparation used on poorly drained sites. Seedlings are planted on the mound formed beside the deep, dead furrow to maximize depth to saturated soil conditions.

OPTIONS FOR PLANTING

Season

✔ **Plant trees in:**
- ► early spring as soon as soil can be worked and before tree leaves flush
- ► early fall after leaf drop and before frost – this is less common than spring planting, and depending on the site, frost-heaving can be a problem

Nursery Stock Handling

Good stock handling is important for seedling survival.

✔ **Handle gently** (don't throw or stack trees).

✔ **Keep seedlings cool** (<10 °C [50 °F]), **moist**, and with **good air circulation** in storage and when shipping. Also:
- ► on the site, use tarps, water and shade
- ► while planting, use bags or buckets to hold trees.

Planting

✔ **Place roots in a sufficiently deep hole or slit** – not bent or balled up.

✔ **Position root collar of tree at soil surface.**

✔ **Firm the soil around roots** with no air pockets.

✔ **Plant trees straight**, not at an angle that will cause lateral buds to compete with leader, which is evidence of poor planting.

Roots are especially fragile. Keep cool and moist: even brief exposure to warm, dry winds can kill roots. Dip roots in water, but do not soak or they may drown.

Bare-root seedlings must be carefully handled to avoid damage.

Machine planting is appropriate for relatively level sites and stone-free deeper soils. Local planting agencies or contractors may have them available for your use.

OPTIONS FOR POST-PLANTING MAINTENANCE

The trees you plant will need tending to maximize their chances of survival.

Herbicide Application

- controls competing vegetation, providing more light, moisture and nutrients to the seedling
- the most effective and often cheapest method is band or spot spraying
  - band spraying – requires a power boom sprayer
  - spot spraying – requires a backpack sprayer, small area around trees are sprayed
- should be done annually for three or four years, until trees are free-to-grow from competing vegetation

For information on recommended herbicides and licensing requirements, contact your local office of the Ontario Ministry of Agriculture, Food and Rural Affairs. OMAFRA Publication 75, *Guide to Weed Control*, has been the definitive source of weed control information for more than 50 years.

Tillage

- can be applied to whole or partial site
- may improve soil aeration
- may improve soil drainage
- easily combined with chemical site preparation

Mowing

- a low-cost method to control competing vegetation
- easy to do (with the right equipment), but may be less effective
- may require more than one "treatment" per year – usually early season, mid-summer, and early fall

Mulch

- suppresses competing vegetation, allowing more light, moisture, nutrients to reach the tree
- offers many options – wood chips, straw, compost, newspaper, commercial plastic or organic fabrics/moulds
  - some mulches are more effective than others
- can be installed yourself
- an option for slopes where mechanical tending is difficult
- labour-intensive – some plastic or paper products are difficult to keep anchored
- may require some mowing between the rows to reduce cover for animals

The use of pesticides to control weeds, insects and disease is strictly regulated. Ontario landowners who want to do their own pesticide applications must first obtain an Ontario Growers Pesticide Safety Certificate.

Call 1-800-652-8573 for more information.

Follow the recommendations in OMAFRA Publication 75, *Guide to Weed Control*.

Tree Shelters

- ► protect trees from tending and animal damage
- ► involve staked plastic mesh or tubes that are placed around trees
- ► can be installed by landowner, but are labour-intensive
- ► may be higher cost per acre than other methods
- ► not a substitute for tending of competing vegetation
- ► must have some airflow to prevent a greenhouse effect in the fall when trees should be going dormant

Using a backpack sprayer or wick applicator can be an effective method of controlling the vegetation around each tree. A 1-metre vegetation-free radius around each tree will also help deter rodent "girdling" (injuring the bark) at the base of the tree.

Tree shelters are an expensive but effective method to protect high-value transplant stock (whips and saplings).

Note that not all species grow well in tree shelters. Consult a forestry professional.

Mulching around young seedlings suppresses weeds, reduces moisture losses, and improves seedling survival rates. The high costs of commercial mulch make it better suited to small projects.

BMPs FOR ADDRESSING PLANTATION PROBLEMS

Establishing the plantation is not without risk. There are many things that can go wrong and it's unrealistic for you to expect that every tree will survive. Planted trees are vulnerable to a number of stresses that can impact their survival.

Normally it takes two to five years for the trees to reach a free-to-grow stage. Successful plantations should exhibit at least 65% survival of healthy trees well-distributed over the planting site. Infilling can be done in the early years after the initial planting, when required. Verify the most appropriate species for the site prior to replanting.

COMMON SITE-RELATED PROBLEMS AND SOLUTIONS

SITE-RELATED PROBLEMS		SOLUTION
MOISTURE PROBLEMS – EXCESS OR DROUGHT		• be aware that some moisture problems can't be corrected • irrigate/water trees • match species to site • prepare site (ploughing, furrowing) to break up compacted soils • subsurface drainage
COMPETITION FROM WEEDS AND GRASS		• apply herbicide application • use mulch or tree shelter
INSECTS AND DISEASE		• monitor plantation • consult with a forestry professional • determine type of insect or disease • determine if control is required • infill as necessary
BROWSING – DEER AND LIVESTOCK WILL DAMAGE TREES		• keep livestock out of plantation (while trees are young) • plant less palatable species • plant lure species
RODENT DAMAGE		• control grass and other vegetation to reduce populations • consider use of tree guards to reduce damage

ESTABLISHMENT-RELATED PROBLEMS

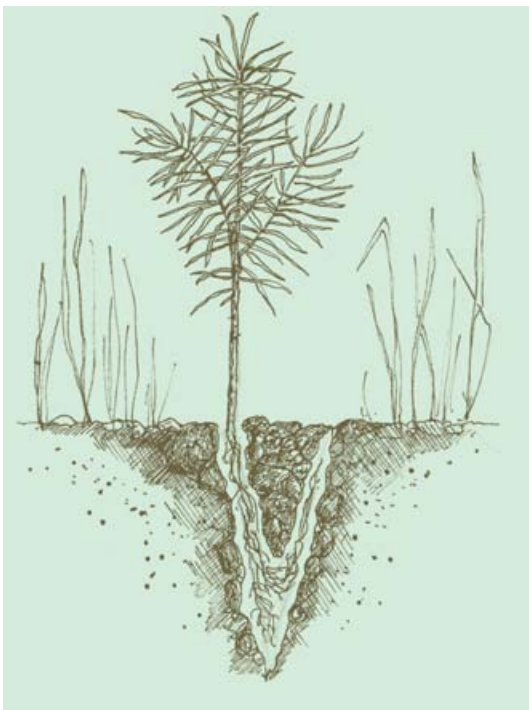
Some problems are caused by poor planting and cultural practices.

Poor planting may result in exposed roots, seedlings that are planted too deep or too shallow, and severely leaning trees.

Poor stock quality can mean dried-out seedlings, seedlings that were stored at too high a temperature, and nursery problems during packing or poor handling practices between storage and planting.

Poor species selection means you've planted the wrong trees for your site.

Poor planting will result in unnecessary mortality. The seedling above has exposed roots.



This seedling had its roots set properly.

✔ **Choose the right tree for the site and prepare and tend the site appropriately.** Your goal is to minimize any human causes of seedling mortality.

✔ **Monitor your plantation carefully.** Trees are not considered free-to-grow until they grow above competing vegetation. This could take three to five years in some cases. Monitor seasonally for problems and unusually high mortality, which could be caused by insects or rodents. Replant if necessary to achieve your goals. A good rule of thumb is to infill if survival rate is less than 65%.

BMPs FOR CHRISTMAS TREES AND TRANSPLANT STOCK

The practice of growing Christmas trees can be profitable. Tree crops can be grown on:

- land that's unsuitable or not used for other crops
- open space or areas surrounding a home – this may also benefit landowners by helping reduce wind speeds and provide energy savings.

Growing Christmas trees offers opportunities for additional income from the farm. Many "U-Cut" operations provide a unique experience for families who may come back to the same operation year after year.

Livestock producers often use larger transplant stock to hasten the establishment of shelterbelts around livestock facilities.

CHRISTMAS TREE SPECIES AND SITE PREFERENCES

CROP	SOIL	MOISTURE	SOIL FERTILITY
SCOTS PINE	sandy	dry sites	infertile sites
SPRUCE	sandy loam to clay loam	fresh/moist	fertile
BALSAM FIR	clay loam to clay	fresh/moist	fertile (acid soils)
FRASER FIR	clay loam to clay	fresh	fertile
CANAAN FIR	clay loam to clay	fresh	fertile

GROWING CHRISTMAS TREES AND TRANSPLANT STOCK

✔ **Plan your plantings for an annual harvest:**

- ► divide your available land into blocks and plant a block each year
- ► ensure a continuous harvest by having plantings, which have been established annually, over a period coinciding with the rotation length for the species.

✔ **Plan density** with these considerations:

- ► density varies with plantation layout, species type, as well as the planned spacing between trees and rows
- ► desired access around the perimeter of the planting block
- ► sufficient space for equipment, e.g., tractors, mechanized shearer
- ► densities can range 2000–3000 trees per hectare (800–1200/ac).

✔ **Meet fertilizer requirements** by:

- ► preparing a nutrient management plan
- ► being aware that the need for fertilizer amendments will depend on the tree type grown and soil fertility
- ► conducting a soil fertility test
- ► consulting with experienced growers and qualified specialists

✔ **Control pests** effectively and safely:

- ► ensure you have pesticide applicator certification or hire a custom operator
- ► control weeds to reduce competition for soil nutrients and moisture
- ► prevent damage caused by animal pests that live in weedy vegetation
- ► reduce the likelihood of a fire hazard
- ► make pruning and harvesting of trees easier
- ► monitor regularly for insect damage and diseases
- ► take measures to protect crop trees from mammals and birds.

✔ **Prune and shear:**

- ► prune to selectively remove entire branches
- ► shear to trim and shape the branch tips
- ► prune at different times of the year and according to species requirements
- ► prune to keep the base of the tree free of branches.

✔ **Time harvests according to targeted market:**

- ► cut and wrap trees for off-site sales in time for transport to market (late-November and all of December).

Planting in a sequence of "blocks" can help you produce a continuous harvest.

The goal of shearing is to trim the branch tips to shape the tree to the desired profile.

For more information, see the Christmas Tree Farmers of Ontario website at http://www.christmastrees.on.ca.

BMPs FOR ESTABLISHING HARDWOOD PLANTATIONS

Hardwood plantations offer unique agroforestry opportunities, and interest in them has been increasing since the 1960s. Generally, hardwood seedlings are more expensive than conifers, require higher quality sites, and are considerably more difficult to establish. As a result, most hardwood plantations tend to be only a few acres in size. These plantations, however, can exhibit good growth and have the potential for high-value forest products, such as sawlogs, syrup and edible nuts.

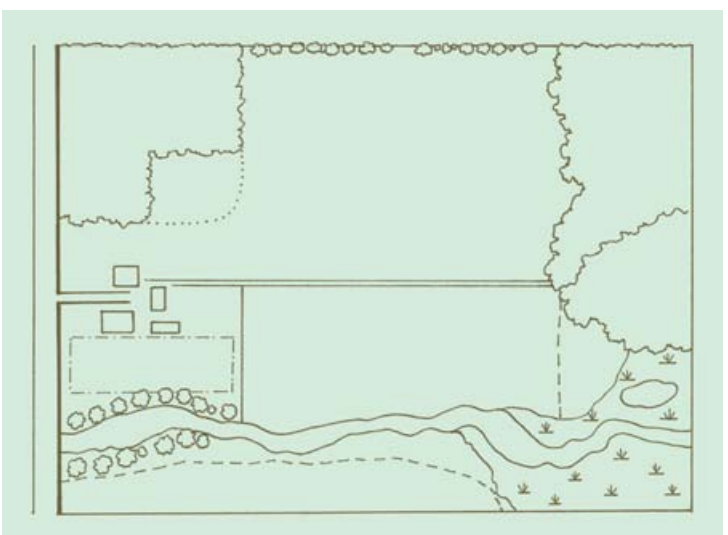
Hardwoods may be planted in plantations, with conifers in mixedwood plantings, or under thinned conifer plantations. Plantations with a mix of species may be less susceptible to outbreaks of disease and insects. However, the economic return from mixed plantings may be significantly less than that from a single-species plantation.

Hardwoods are more demanding in their site requirements. Carefully matching site conditions to species requirements is a must for establishment success. Failure to do so will inevitably result in mortality and higher establishment costs.

Hardwood trees most often prefer deep, fertile, moist but well-drained soils. In all probability these soils will also be the best agricultural croplands.

More productive (better) sites favour single high-value species planting. Lower quality, less productive sites favour a mixture of species.

This is a 15-year-old Black Walnut plantation on a highly productive site.



Check the soils information in your management plan. Hardwoods prefer deep, well-drained soils.

PREPARING AND MAINTAINING THE HARDWOOD PLANTING SITE

Weeds and other competition will need to be controlled for at least three years. When planting hardwoods, site preparation is most often required for effective weed control.

For best results, prepare the planting site in the fall or late summer of the year prior to planting. Chemical weed control applied two to three weeks prior to mechanical site preparation is usually quite effective. However, mechanical disturbance after chemical weed control can sometimes lead to unpredictable shifts in competing vegetation.

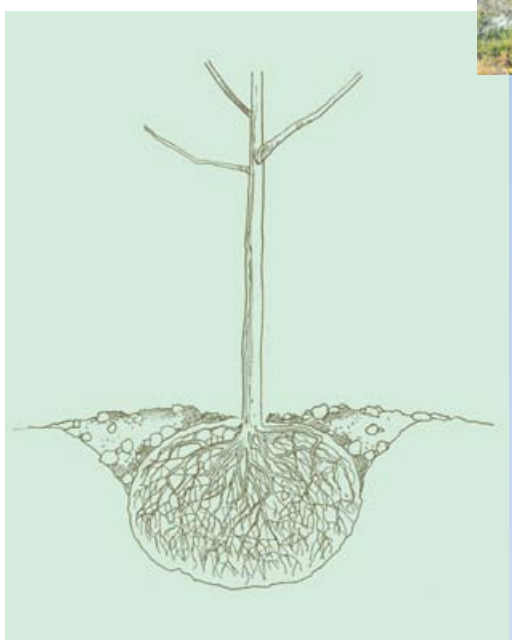
Chemical weed control alone can work, but isn't as successful as mechanical and chemical weed control in combination. Chemical weed control can include:

- ✔ **band spraying** on areas where ploughing and discing are not feasible
- ✔ **spot spraying** individual planting sites in areas where other forms of spraying and site preparation are not appropriate
  - ► kill the vegetation in a radius of at least 1 metre (3.3 ft)
  - ► larger areas have lower risk of stem girdling.

Planting success is directly related to planting stock quality and handling.

Transplant Stock

- ✔ Remember that **site preparation and tending** are still important.
- ✔ Consider **transplanting hardwoods** from existing nearby woodlots or fence rows
  - ► don't transplant low-vigour saplings from shaded areas.
- ✔ **Cut lateral roots** with a spade the season prior to transplanting to increase success.
- ✔ **Choose healthy trees** that are 1.2–2.4 metres (4–8 ft) high.
- ✔ **Transplant after leaves have dropped** in the fall or early spring when the frost is out of the ground.
- ✔ Expect some mortality and **replant as necessary**.



General recommendations are:

- **root ball width: 23–30 cm (9–12 in.) per inch of tree diameter**
- **root ball depth: 15–76 cm (6–20 in.) per inch of tree diameter.**

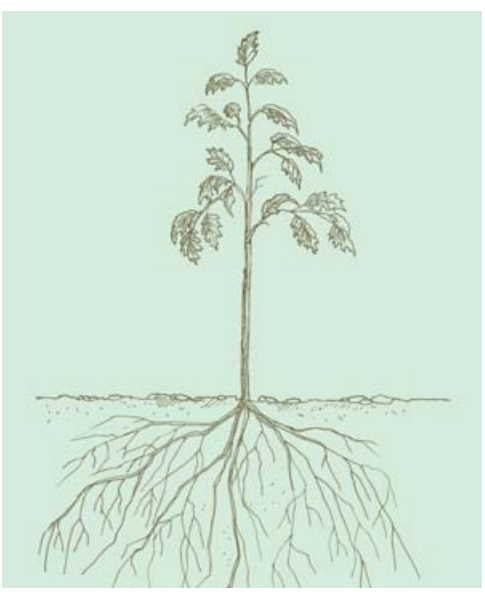
These Sugar Maple saplings were transplanted from a nearby woodlot in a leafless condition.

TRANSPLANT DIFFICULTY RATING BY SPECIES OF HARDWOOD (<5 cm or 2-inch in diameter – tree whips, i.e., branchless trees)	
EASY	Silver Maple, Sugar Maple, White Ash, Green Ash, Honey Locust, Elm, Poplar
MODERATE	Bur Oak, Birch, Hackberry, Red Maple, Hawthorn, Red Oak, Black Cherry, Kentucky Coffee Tree, Shumard Oak, Willow
DIFFICULT	Ironwood, Chinquapin Oak, Hickory, Sassafras, Tulip Tree, Walnut, White Oak, Staghorn Sumac, Beech

Nursery Stock

Seedling size is generally more important than seedling age. Trees should have a balanced *root-to-shoot ratio*. The root needs to be of sufficient size to support the upper portion as well as provide adequate water and nutrients. Typically, larger seedlings tend to do better than smaller ones.

SPECIES	PREFERRED MINIMUM STEM LENGTH	PREFERRED ROOT-COLLAR DIAMETER
BLACK WALNUT	30 cm (12 in.)	1 cm (0.4 in.)
BUTTERNUT	30 cm (12 in.)	1 cm (0.4 in.)
SUGAR MAPLE	60 cm (24 in.)	.8 cm (0.3 in.)
RED OAK	50 cm (20 in.)	.8 cm (0.3 in.)
BLACK CHERRY	50 cm (20 in.)	.8 cm (0.3 in.)

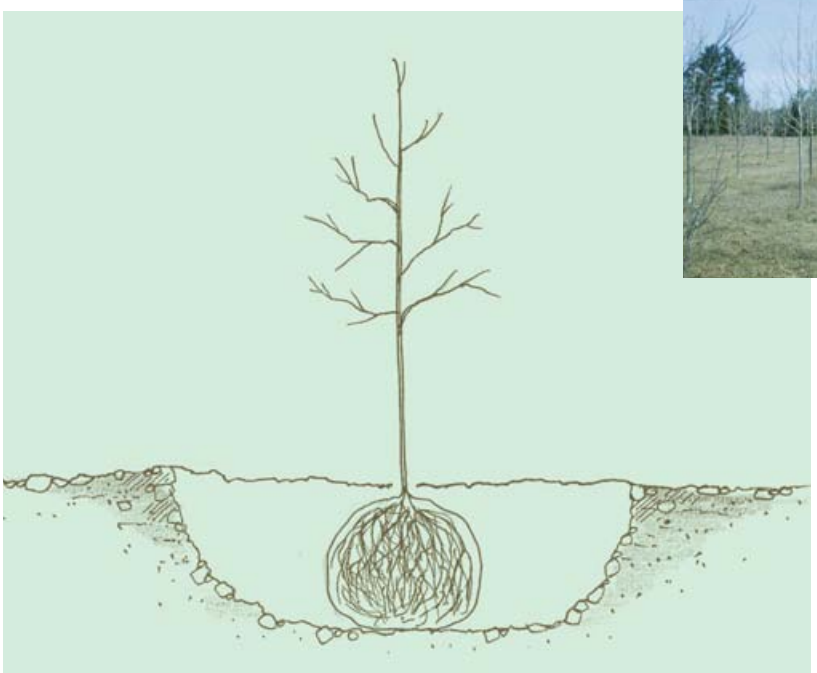


Seedlings can be purchased from a commercial nursery. Ensure that the ones you buy are healthy and stay healthy. Plant as soon as possible after purchasing. Do not let unplanted seedlings dry out.

Planting Hardwoods

On most sites, hand planting is preferable to machine planting, but it's not always practical. Machine planting can work, but ensure that the planter has been modified to handle larger hardwood stock.

- ✔ If furrows are used, **don't plant hardwoods in the bottom of furrows** (due to the potential for frost-heaving and excessive moisture).
- ✔ Take extra precautions to **plant vertically and ensure roots are buried** in as natural a position as possible.
- ✔ **Prune roots** if roots are longer than 15 cm (6 in.).
- ✔ **Use the wedge method** for hand planting.
- ✔ **Create larger holes** for transplant stock.



Proper planting is essential for tree survival. You will need to prepare a larger hole for transplant stock than nursery stock. Try to dig a hole that is double or triple the size of the root ball. If possible, moisten hole prior to planting to reduce the risk of post-plant water migrating away from the root ball. Cleanly cut any damaged roots to help healing.

Established Sugar Maple plantation.

This Red Oak plantation is thriving on land previously used to grow annual crops.

Pruning Hardwoods

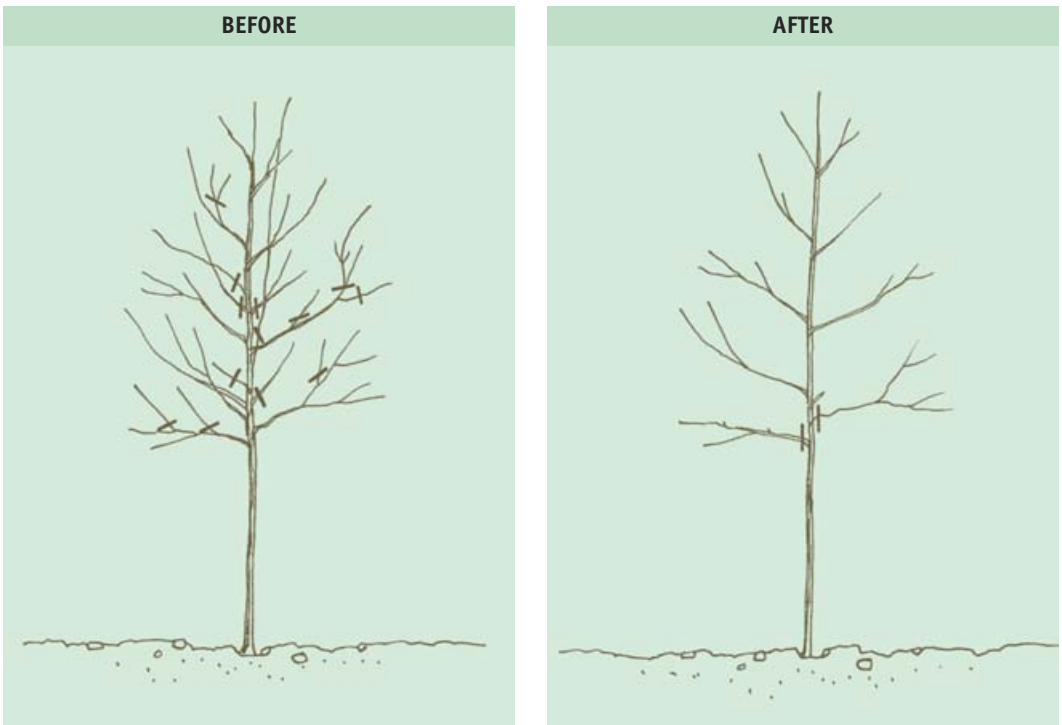
Pruning is necessary to promote height growth. Hardwoods that aren't pruned tend to develop large spreading crowns and forked leaders.

✔ **Prune often and lightly** as opposed to periodically and heavily:
- ► this will minimize impacts on diameter growth
- ► start in year 3 after planting
- ► remove the lower branches.

✔ **Prune multiple leaders** to one dominant stem.

✔ **Do not prune in the year planted.**

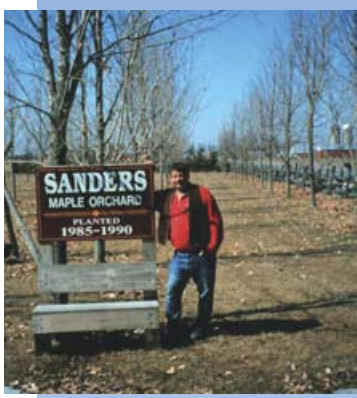
✔ **Prune during the dormant season** (for most species).



Hardwood trees need to be correctively pruned in order to promote height growth. In this diagram the tree on the left has a large, upwardly growing branch that should be removed. The lower branches on this tree should also be cut every two or three years.

BMPs FOR SPECIALTY TREE PLANTINGS

CASE STUDY: ESTABLISHING A MAPLE ORCHARD IN AN OLD HAY FIELD



This landowner successfully established a Maple orchard on a small field.

The landowner established a Maple orchard on a small unused hay field adjoining an existing Maple bush (approximately 2.4 hectares or 6 acres). In the fall of 1991 and 1992, approximately 600 Sugar Maple saplings were planted.

Stock

- transplant stock from edge of nearby woodlot – only healthy, well-growing trees were selected
- diameters were 1.25–2 cm (.5–.75 in.) and heights were 1.2–1.8 metres (4–6 ft)

Site Preparation

- field was not cultivated prior to planting – planting spots were prepared with herbicide prior to planting

Planting

- trees were hand-planted in the fall
- about 10% of the trees died and were replaced in 1995 – most died on the site with shallowest soils

Maintenance

- vegetation was controlled around the trees with herbicide – then grass between rows was cut once per year in the summer
- tree collars were installed to help reduce rodent damage

1995–2004

- trees were pruned
- some fertilizer was applied

Lessons Learned

- poorer quality sites are more susceptible to problems – the 2002 dry summer killed many trees in the driest section of the field, and irrigation may have saved the trees had this been feasible
- growth has been good on better areas – some trees have a diameter of 13 cm (5 in.)
- pruning is important to train the tree to grow up instead of out – you can prune right after the period of active sap flow in the spring
- ploughing and disking may have helped establishment and growth, and post-planting weed control

SILVER MAPLE

RED MAPLE

SUGAR MAPLE

Bark, key, leaf and twig of various Maples

Additional References

The Maple Orchard Directory for Ontario is an excellent reference for those interested in establishing a Maple orchard. This document includes inventory information on existing Maple orchards in Ontario as well as advice from experienced Maple orchard growers. It was assembled by the Ontario Ministry of Agriculture, Food and Rural Affairs, and the Ontario Maple Syrup Producers' Association.

ESTABLISHING HARDWOODS UNDER A JACK PINE COVER CROP

These hardwoods are growing under Jack Pine cover.

Since 1960 in eastern Ontario, many Jack Pine plantations have been planted to protect soils that were marginal for agricultural crops. Most of these plantations are ready for thinning or have been thinned. An existing conifer plantation with or without a hardwood understory can be an ideal location for establishing a plantation.

Jack Pine is a good cover crop because:

- in Site Region 6E, the species will establish and grow well on sand, sandy loams and loams. It also survives well on shallow soils over bedrock.
- the smothering of grass beneath the Pine trees and the buildup of Jack Pine needles form a good seedbed for hardwoods
- the sparse nature of the foliage enables light to get through to the forest floor – light is necessary for the survival and growth of young hardwood seedlings on the forest floor
- when thinned, Jack Pine does not respond by growing rapidly to fill in the openings – thus, the openings provide adequate growing space for young hardwoods, which begin to grow quickly following release.

Guidelines for Establishing a Sugar Bush with a Jack Pine Nurse Crop

- ✔ **Remove every other row in the Jack Pine plantation** (usually when it's 15–20 years old).
- ✔ About 8–10 years later, if satisfactory natural regeneration is present, **remove the remaining Jack Pine, leaving the Pines around the border for wind protection.** If the stand is well-protected by other forest stands, it wouldn't be necessary to leave a belt of conifers for wind protection.
- ✔ If natural regeneration of hardwoods is inadequate, **supplement by planting them!**

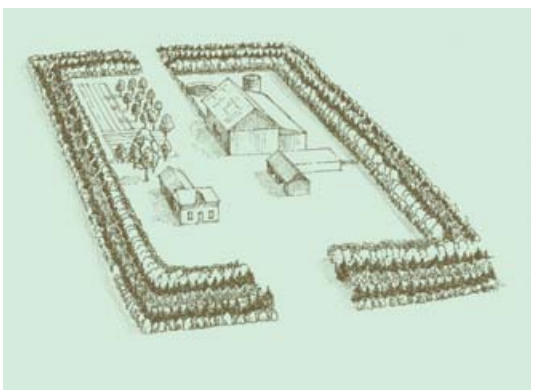
BMPs FOR WINDBREAKS, SHELTER-BELTS AND TREED FENCEROWS

Windbreaks, shelterbelts and treed fencerows are vegetative barriers that reduce or eliminate the undesirable impacts of excessive wind. They consist of one or more rows of trees or shrubs in open field areas or adjacent to buildings.

Properly designed and oriented, they benefit crop and livestock productivity. For example, they:

- shelter livestock from storms and cold winds – turning energy into meat instead of heat
- provide summer shade for grazing livestock
- increase crop productivity – protecting crops from storms, providing better growing conditions, and making more moisture available during droughty conditions.

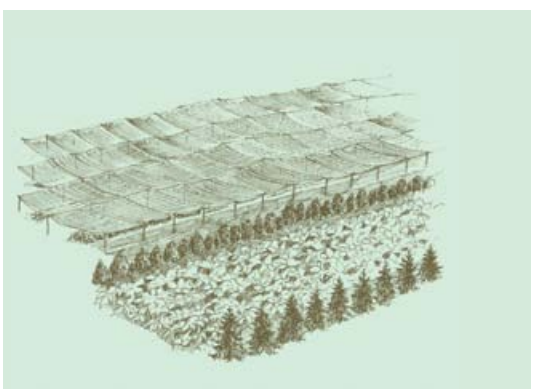
A windbreak consists of one to five rows of trees or shrubs. Shelterbelts have six or more rows.



Mixed shelterbelts, with rows of conifers and hardwoods, are planted around farmsteads to reduce energy costs.

Mixed shelterbelts are also planted along cropland boundaries to protect crops and connect natural areas.

Treed fencerows are described in detail in the first volume of this BMP series, *Woodlot Management*.



Conifer field windbreaks can be planted to protect high-value crops such as ginseng and tobacco.

Conifer windbreaks around cropland can improve crop yields and increase productive woodland acreage.

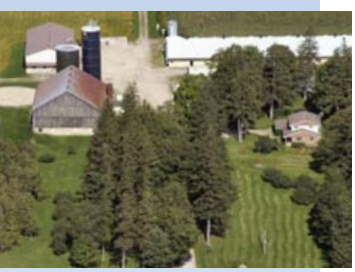
Windbreaks and shelterbelts more than make up for the loss of productive land they occupy. Additional wide-ranging benefits include:

- ► reduced soil erosion by wind and water
- ► reduced dust levels (e.g., from roads and farming activities)
- ► reduced noise from nearby road traffic
- ► increased rates of crop growth and yields
- ► improved moisture distribution over fields
- ► enhanced livestock health and performance
- ► increased odour control when planted around livestock facilities
- ► reduced home heating and cooling costs (i.e., 10–30%)
- ► improved snow management for roadways, driveways and farmyards
- ► some snow trapping, which can enhance water collection for ponds or aquifers
- ► increased economic opportunities (e.g., timber and firewood)
- ► enhanced wildlife habitat and biodiversity
- ► reduced greenhouse gas emissions through carbon sequestration.

Shelterbelts and windbreaks contain perennial plants. Careful planning should start one year prior to planting.

Treed Fencerow
- **natural**

Windbreak
- **5 rows or less of trees or shrubs**
- **planted**



Shelterbelt
- **6 rows or more of trees or shrubs**
- **planted**

Plan carefully: once windbreaks and/or shelterbelts are planted, they cannot easily be relocated.

PRINCIPLES OF WIND AND SHELTER

VEGETATION HEIGHT, POROSITY, DENSITY AND ORIENTATION

Windbreaks and shelterbelts reduce wind speed at the ground by lifting winds over the vegetative barrier and/or reducing wind speed as it penetrates and passes through the vegetation.

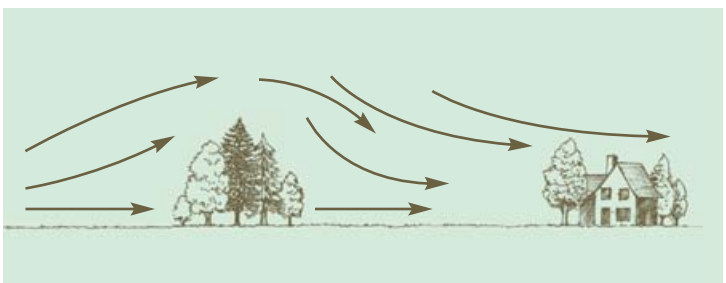
Vegetation height and *porosity* are the two main factors that influence the protected zone.

Height influences the distance over which the trees will have an effect. The planting will reduce wind speed and increase crop growth for a distance of 15–20 times the height of the trees. The height of the windbreak or shelterbelt is determined by the:

- species
- growing conditions
- age of the tree.

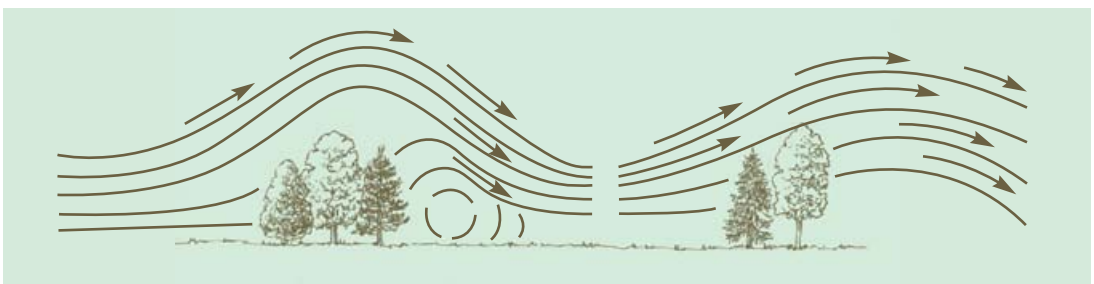
Porosity is the amount of air space in a cross-sectional view of a windbreak. The air space allows wind to move through the barrier.

Density is the opposite of porosity. For example, 60% density is 40% porosity.



The taller the windbreak, the greater the area it protects. Wind speed is reduced upwind to five times windbreak height, and downwind to 15 times windbreak height.

This single-row windbreak has been thinned to a desirable 50% porosity.



Windbreaks and shelterbelts that are too dense may create turbulence on the downwind side, which can cause crop damage and reduce yield. A barrier allowing some wind flow through it can have a zone of reduced wind speed that could stretch for many times (10–20 times) the total tree height. A porosity of 40–60% gives the longest shelter zone on either side of the windbreak.

Density and **orientation** determine how much a windbreak slows the speed of the wind and the size of the area protected. These:

- affect the kind of snow distribution that results from the windbreak
- are also determined by the type of tree and time of year
  - deciduous species tend to be less dense closer to the ground
  - the porosity of a conifer planting can be altered by pruning the lower branches in order to modify their effect on snow distribution
- are also affected by in-row and between-row spacing
  - typically in-row spacing can range from 1 metre (3 ft) apart for shrubs, to 2.4–3.6 metres (8–12 ft) apart for trees
  - between-row spacing can range 2.4–6 metres (8–20 ft).

For maximum effectiveness, you should orient your windbreak and shelterbelts at right angles to prevailing or most troublesome winds.

WINDBREAKS AND SHELTERBELTS FOR PROTECTION OF SOILS AND CROPS

Fine sands and silt soils with little crop residue cover are most vulnerable to wind erosion. When cropped with soybeans or silage corn, and when residue cover is insufficient, these soils are at even greater risk of eroding.

Field windbreaks and shelterbelts provide a zone of wind speeds that can extend 20 times the height of the windbreak or shelterbelt. By reducing wind speed, they help reduce soil erosion and trap eroding soil particles. Crop yields are improved up to 10 times the height of the windbreak or shelterbelt.

Wind erosion is a function of wind speed. A 10% reduction in wind speed can result in a 28% decrease in erosion. A 20% reduction in wind speed will reduce erosion by more than 49%.

Attaining optimal wind erosion control takes a concerted effort. Deploy a suite of BMPs, such as field windbreaks, residue cover and cover crops.

Wind erosion reduces soil productivity in the long term and damages crops in the short term.

Soil Erosion Factors

Reducing soil erosion takes a concerted effort and usually several BMPs, including windbreaks and shelterbelts where appropriate.

When establishing windbreaks or shelterbelts, remember these key factors:

- soil texture – fine-textured soils (fine sands and silts) are most vulnerable to soil loss
- soil moisture – drier soils are more vulnerable to erosion than wetter sites
- soil aggregation – soils with a mix of particle sizes are less vulnerable than non-aggregated soils
- vegetative cover – soils with a vegetative cover are protected from the effects of wind, rain and snow.

Land management practices such as conservation tillage leave more crop residue on the soil surface, which offers additional protection from the effects of wind.

Soil erosion can be controlled most effectively when a number of conservation practices are used as components of an overall strategy. Windbreaks and shelterbelts can play key roles to minimize wind-related erosion. See the BMP book, *Field Crop Production*, for more ideas.

Site Requirements

Windbreak and shelterbelt species have specific site requirements that should not be neglected when deciding what species to plant. As with crops, these factors play an important part in determining how successful your windbreak or shelterbelt will be in protecting crops and livestock.

Site requirements include:

- plant hardiness zone of species selected for planting
- soil texture class, pH and drainage
- plant species' height at maturity
- plant rate of growth
- crown width and root development
- shade and salt tolerances
- flood tolerance.

Sandblasting and the desiccation of specialty crops can be reduced by windbreaks. Thinning of the lower branches when the windbreak has reached the right height may reduce the risk of frost.

WINDBREAKS AND SHELTERBELTS FOR SENSITIVE CROP PROTECTION

The lighter soils of southwestern Ontario support valuable crops like tomatoes, which leave little crop residue. Sandblasted seedlings or transplants may be set back or killed. Spring windbreak protection is important in this case, and single-row *deciduous trees* may not provide enough early protection.

Sensitive crops especially benefit from greater wind protection. The benefits for fruit (including pollination) are greatest. Leafy crops (vegetable and forage) benefit also, as do root and grain crops to a lesser extent. Heat-loving crops (corn, peppers, and tomatoes) mature earlier because of higher heat units and reduced wind damage to leaves.

Wind-damaged leaves force the plant to waste resources to repair the damage. Quality may also be affected. For example, celery develops more fibre and grows tougher when subjected to more wind and sandblasting.

Crop yields are increased by windbreaks and shelterbelts for two key reasons:

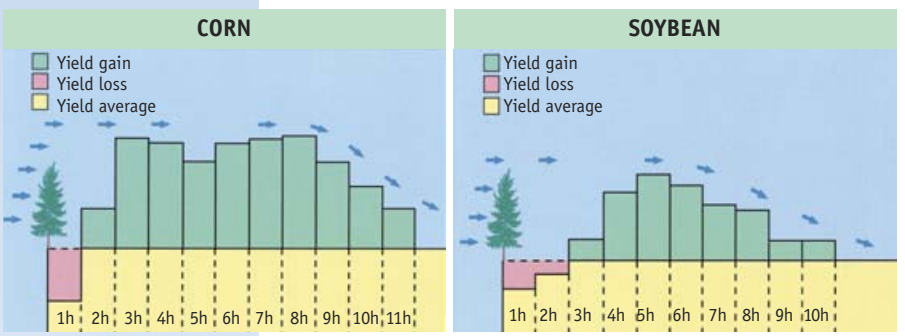
- an improved microclimate
  - ▷ reduced wind speeds and a corresponding increase in temperature
  - ▷ reduced desiccation of crops and soils
- extra moisture is available in the spring from trapped snow.

Yield benefits occur where windbreaks are present. Their significance relates to the type of crop grown:

- drought-tolerant crops like annual cereals show the lowest response
- forage crops show moderate response
- weather-sensitive and specialty crops like vegetables and and raspberries show the greatest response.

Field windbreaks and shelterbelts increase crop yields.

WINDBREAKS AND SHELTERBELTS FOR CROP YIELD INCREASES



LEGEND h = tree height

Observations at Ridgetown College in southwestern Ontario show that both corn and soybean yields increased on the downwind side of a windbreak over distances 8–12 times the height of the windbreak. Each bar represents the yield average over the distance, measured in multiples of windbreak height.

On the upwind side, yield increases were also seen 3–5 times the height of the windbreak. Yield losses were observed in the areas immediately adjacent to the windbreak. However, there was a net yield increase overall.

WINDBREAKS AND SHELTERBELTS FOR LIVESTOCK PRODUCTION

A well-thought-out and properly cared-for windbreak protects livestock in both the winter and summer and offers long-term economic benefits to you as landowner. The ideal location of a windbreak varies with the height of the trees and site-specific limitations. Prior to planting, get advice from a knowledgeable source regarding your unique situation.

Windbreaks and shelterbelts strategically placed around feedlots, livestock facilities, pastures and calving areas will reduce wind speed and:

- lower animal stress
- improve animal health
- increase feed efficiency
- protect the working environment in and around the livestock area
- screen noise and reduce odours associated with livestock operations.

Effective design for winter shelter for livestock should be:

- no more than 40% porosity
- 3–5 rows of shrubs, and 1–2 rows of dense conifers
- located approximately 30 metres (100 ft) upwind of the area needing protection.

✔ **Provide proper drainage for melting snow to reduce the level of mud in feedlot areas.**

✔ **Contain runoff from the feedlot away from the trees**, since high nitrate levels in the runoff may damage and eventually kill the windbreak.

Properly designed shelterbelts can reduce livestock feed energy requirements.

Windbreaks and shelterbelts play an important role in the protection of livestock, particularly for young animals and in areas with cold northerly winds during the winter and early spring.

The specific needs of animals dictate that special attention be given to access, snow storage, and drainage when planning a livestock windbreak. The time spent on layout, site preparation, weed control, and replanting is paid back many times throughout the life of a shelterbelt.

Caution: Horses eating wilted Red Maple (*Acer rubrum*) leaves can develop severe health problems and possibly die.

SHELTERBELTS FOR SNOW CONTROL

Windbreaks and shelterbelts are an effective tool for protecting laneways.

Shelterbelts can be designed for snow control and easier access to animals, buildings, and forage and grain storage facilities during the winter months. Windbreaks and shelterbelts can trap snow, preventing its movement toward laneways and buildings. Trapped snow occurs in deep, narrow drifts.

A well-designed shelterbelt system will:

- collect snow in low-use areas and keep it out of high-use areas
- save on fuel expenses
- reduce equipment wear
- save on the amount of labour required for snow removal and livestock feeding.

The distribution of trapped snow can be managed through shelterbelt design. More porous shelterbelt designs lead to a shallow and longer downwind distribution of snow. A less porous shelterbelt will result in a deep and short snow drift. Porosity can be managed by varying tree species and spacing between or within tree rows or by pruning.

Shelterbelts established at least 30 metres (100 ft) away from a building or farmstead make for an ideal living snow fence. Note that for buildings with natural ventilation, at least 60 metres (196 ft) should be left from the buildings to allow for adequate air circulation.

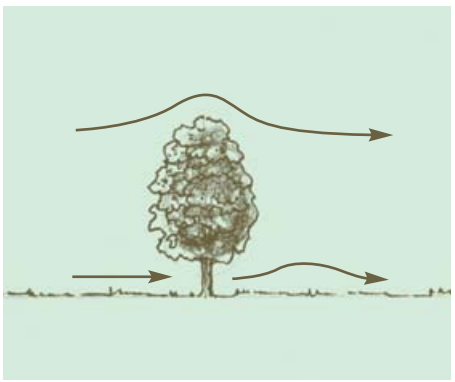
If trees are to be used to protect roads:

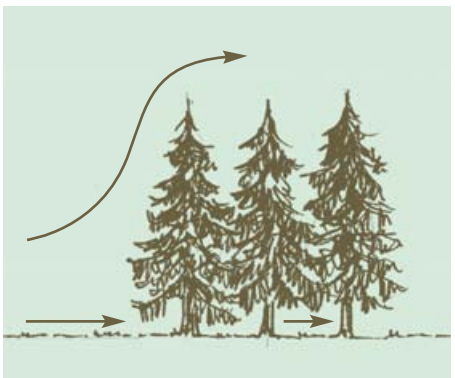
- use a dense shelterbelt placed at least 30 metres (100 ft) away from the roadway

OR

- create a scouring effect, which removes snow from a roadway, by locating the shelterbelt close to the roadway but removing the branches from the bottom 2 metres (6.5 ft). This forces more wind to move through the lower part of the canopy, and carry the snow beyond the road.

To increase the porosity of the shelterbelt, use deciduous trees and/or increase spacing between the trees.





Snow distribution patterns are affected by shelterbelt height, density, and bottom gap. In the upper illustration, a highly porous, deciduous, single-tree windbreak with a bottom gap will distribute snow evenly up to 35 times the height of the trees. This is a desirable feature when snow cover is needed to increase soil moisture, without the moisture being concentrated close to the shelterbelt.

In the lower illustration, a solid-fence effect is created by planting a very dense shelterbelt of a conifer, like Spruce, which has low-to-the-ground branch habits. This design will form snow drifts, with the majority of the snow depth being deposited within 5–8 times the height of the shelterbelt.

TREES FOR ODOUR CONTROL

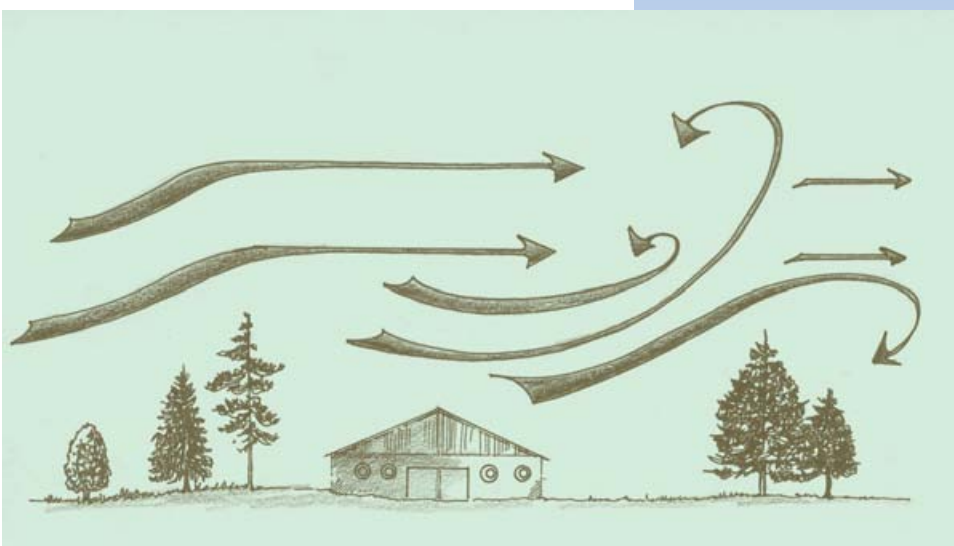
Farmyard dust and odour can be "screened" by windbreaks and shelterbelts. Levels of dust particles and odour carried by wind can be reduced by the trapping and mixing that results from windbreaks. Coniferous trees, with a large surface area provided by the many needles combined with a low porosity, are well-suited for this use.

Odour is also mitigated by windbreak placement and design. Windbreaks and shelterbelts help to control odour by:

- preventing odours from being distributed by absorbing them via leaf membranes and by micro-organisms living on plants
- reducing wind speed across manure storages, which prevents odours from being picked up by the wind and dispersed
- creating turbulence, which redirects odour plumes upward in the landscape.

Odour control should involve:

- designs that maximize wind turbulence (50% density and low porosity)
- a minimum of two rows
- a wedge-shaped design created by planting short dense shrubs with tall trees to create the wedge
- trees spaced within rows with a range of 2–6 metres (6–20 ft) and between rows of 3.5–7.5 metres (12–25 ft)
  - ▷ planting arrangement should maximize wind turbulence
- coniferous trees for year-round odour control and visual screening
- a well-landscaped livestock operation, because it's more acceptable to neighbours, possibly resulting in fewer complaints.

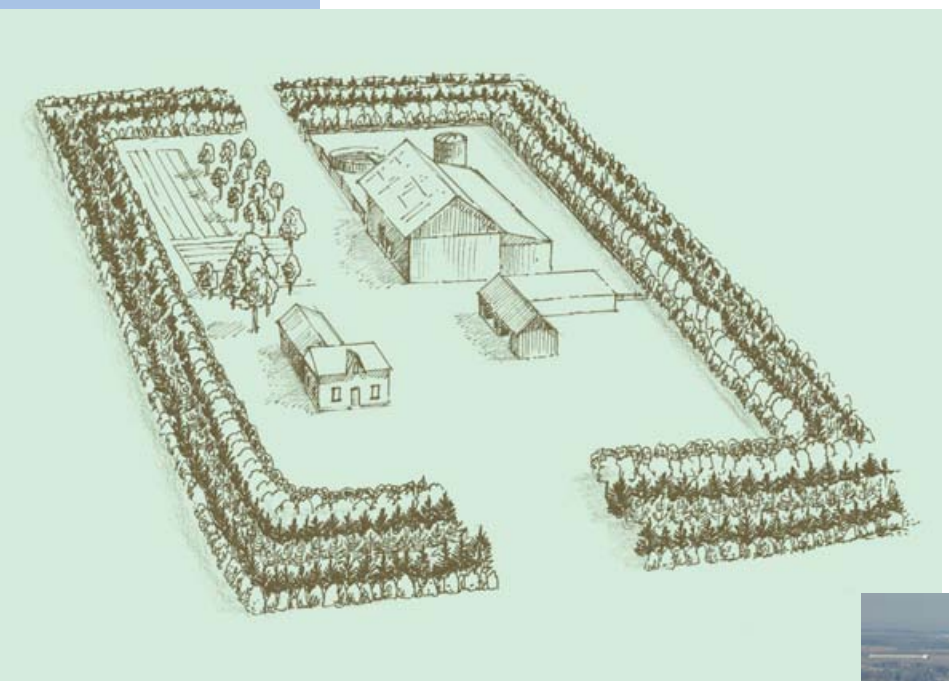


Well-planned windbreaks and shelterbelts can reduce odour by causing increased turbulence – which moves air and odour plumes up and away from the source.

SHELTERBELTS FOR PROTECTING FARMSTEADS AND REDUCING ENERGY HEATING COSTS

Farmstead shelterbelts should:

- ► trap blowing snow to prevent snow buildup in the yard or on driveways
- ► be at least three rows wide on the side(s) of the yard to protect against prevailing wind
  - ▷ where space is limited, reduce the number of rows instead of decreasing row spacing or planting closer to buildings
  - ▷ with careful management, fewer rows of healthy trees throughout may be as effective and take up less space



- ► be located so that the inside row is no closer than 30 metres (100 ft) from the main buildings and driveways to prevent snow buildup problems
- ► have the outside row of the shelterbelt planted with shrubs to act as a snow trap and the inside row planted with tall, dense, long-lived trees.

Tests in Canadian winters indicate that dense shelterbelts (two rows of conifers plus two rows of defoliated deciduous trees) reduce home heat losses by up to 25%. The amount of energy savings is proportional to the decrease in wind speed. Older homes, which allow for more air infiltration, are most sensitive to the kind of protection provided by farmstead shelterbelts.

PLANNING FOR WINDBREAKS AND SHELTERBELTS

There are eight essential steps for the design, establishment and maintenance of windbreaks and shelterbelts. The same principles also apply to planting new trees and shrubs in existing fencerows.

STEP 1 – DETERMINE YOUR OBJECTIVES

Decide which of these functions you want your windbreak or shelterbelt to perform:

- reduce soil erosion and increase crop yields
- beautify the farm and provide protection for the farmstead
- provide shelter for livestock and crops
- control odour
- reduce heating and cooling costs
- provide economic returns/opportunities.

You will often have more than one objective, which can make planning your windbreak more challenging. You may wish to consult a forestry professional.

STEP 2 – COMPLETE A SITE ASSESSMENT

A site assessment requires that you look at your soil type, the proximity of the windbreak/shelterbelt to the road and drainage, and the orientation of the wind direction.

When doing a site assessment, consider these important factors:

- continuity – no gaps if possible, because gaps create wind tunnels
- direction of prevailing winds – plant at right angles to prevailing or most troublesome winds
- distance from buildings and access lanes
- extension beyond buildings – should extend 30–60 metres (100–200 ft) beyond buildings to prevent side winds from reaching buildings
- planting a series of windbreaks – for complete protection
- soil and crop combinations to be used
- existing and possible field layouts
- desired width of sheltered zone and desired field width
- site/tree compatibility
- presence of ditches, field tiles (tile drainage) and utility lines and other obstacles
- available space
- proximity of neighbours, where odours are a factor.

STEP 3 – CHOOSE THE SPECIES AND CONFIGURATION TO MEET THE PLANNING OBJECTIVES

✔ Match tree species to site characteristics.

Select trees with the most suitable density, height and crown features. See the following charts for suggestions.

SPECIES SELECTION FOR WINDBREAKS AND SHELTERBELTS

SPECIES	HARDINESS ZONE	TEXTURE CLASS: SAND	SANDY LOAM	CLAY LOAM	CLAY	pH	DRAINAGE	DENSITY
TREES								
RED MAPLE *Acer rubrum*	3	✘	✘	✘	✘	4.5–7.5	Well to imperfect	MD
SILVER MAPLE *Acer saccharinum*	3b		✘	✘	✘	5.5–6.5	Moderately well to poor	MD
SUGAR MAPLE *Acer saccharum*	3b		✘	✘		5.5–7.5	Well to imperfect	VD
WHITE ASH *Fraxinus americana*	3b		✘	✘		6.1–7.5	Well to imperfect	MD
GREEN ASH *Fraxinus pennsylvanica*	2b		✘	✘	✘	6.0–7.5	Moderately well to poor	MD
BLACK WALNUT *Juglans nigra*	4b		✘	✘		6.6–8.0	Well to imperfect	LD
TAMARACK *Larix laricina*	1	✘	✘	✘	✘	4.8–7.5	Moderately well to very poor	MD
WHITE SPRUCE *Picea glauca*	1		✘	✘		4.6–8.0	Well to imperfect	D
NORWAY SPRUCE *Picea abies*	3a	✘	✘	✘	✘	4.6–8.0	Rapid to imperfect	MD
RED PINE *Pinus resinosa*	2b	✘	✘			4.6–6.5	Rapid to imperfect	MD
HYBRID POPLAR *Populus X*	2b		✘	✘		5.5–7.0	Well to imperfect	MD–D
RED OAK *Quercus rubra*	4a	✘	✘	✘		4.8–6.5	Well to imperfect	D
BUR OAK *Quercus macrocarpa*	4b	✘	✘	✘	✘	4.6–8.0	Well to poor	MD
EASTERN WHITE CEDAR *Thuja occidentalis*	3		✘	✘	✘	6.1–8.0	Well to poor	VD

DENSITY LEGEND: VD – Very dense, D – Dense, MD – Moderately dense, I – Intermediate, LD – Low density

SPECIES SELECTION FOR WINDBREAKS AND SHELTERBELTS

SPECIES	HARDINESS ZONE	TEXTURE CLASS: SAND	SANDY LOAM	CLAY LOAM	CLAY	pH	DRAINAGE	DENSITY
SHRUBS								
DOWNY SERVICEBERRY *Amelanchier arborea*	3b	✘	✘	✘	✘	6.1–6.5	Well to poor	D
NINEBARK *Physocarpus opulifolius*	2b	✘	✘	✘	✘	6.1–8.5	Very poor to excessive	D
RED CHOKE CHERRY *Prunus virginia*	4		✘	✘		6.1–7.5	Well to imperfect	I
AMERICAN ELDER *Sambucus canadensis*	3	✘	✘	✘	✘	6.1–7.5	Rapid to imperfect	MD
AMERICAN RED ELDERBERRY *Sambucus racemosa ssp. pubens*	3		✘	✘		6.1–8.5	Well to imperfect	MD
HIGHBUSH CRANBERRY *Viburnum opulus var. americanum*	2b		✘	✘	✘	6.6–7.5	Well to poor	D

DENSITY LEGEND: VD – Very dense, D – Dense, MD – Moderately dense, I – Intermediate, LD – Low density

Source: adapted from *Selection and Arrangement of Plants in Shelterbelts and Buffer Strips*, Andre Vezina, Pascal Desbiens and Nadine Nadeau, Institut de technologie agroalimentaire, La Pocatière Campus, 2007

Placing a windbreak too close to a roadway will result in a dumping of snow on the roadway, rather than a scouring effect. It's wise to consult your municipality before placing any windbreaks near roadways.

Two key characteristics to look for when selecting species are density and height.

Density determines how much a windbreak slows the speed of the wind and the size of the area protected. Deciduous species tend to be less dense lower to the ground. The density of conifers can be altered by pruning the lower branches to modify their effect on snow distribution.

Tree height influences the distance over which a shelterbelt will reduce the wind speed, reduce erosion, and increase crop growth. A shelterbelt will reduce wind speed and increase crop growth for a distance of 15–20 times the height of the windbreak.

STEP 4 – DEVELOP A PLANTING PLAN

✔ **Create a planting plan** on a map, diagram, or aerial photo:
- ► use the observations made in the site assessment
- ► include the species and the spacing.

Spacing, both within and between the rows, is an important part of good windbreak or shelterbelt design. Spacing greater than recommended will produce an "open windbreak," which will be slow or never "close," i.e., provide the desired protective effectiveness.

Spacings that produce a closed windbreak – one where spacing distances close too early – will produce small, weak trees that are more susceptible to damage from snow and ice loading.

Remember to consider:

- ► planning for the optimal height
- ► reducing competition from adjacent crops
- ► aiming for fast growth, winter hardiness, longevity, and resistance to windburn, insects, diseases, chemical injury, and salt sprays
  - ▷ Eastern White Cedar and Spruce meet many of these requirements.

A six-row field shelterbelt would provide multiple benefits. While many farmers in southern Ontario would be hard-pressed to accommodate a six-row shelterbelt, we present the ideal design configuration here for your consideration. (Species will vary with site type and personal preference).

Row 1: (windward side): shrubs such as Nannyberry or Wild Plum provide density low to the ground

Row 2: White Spruce or White Cedar for dense cover

Row 3: White Pine or Norway Spruce for height

Row 4: Basswood or White Ash for height

Row 5: White Spruce or White Cedar for dense cover

Row 6: shrubs (density close to the ground)

This design exploits density and height to maximize protection as well as aesthetics and recreational hunting opportunities.

STEP 5 – PREPARE THE SITE

The sketch map should include observations made in the site assessment, and indicate the location and type of planting to be planted. Note the locations of field tiles.

Site preparation is an essential step in the successful establishment of windbreaks and shelterbelts. Good site preparation techniques will help ensure that seedlings are easier to plant, and not stressed by excessive weed competition. Cover crops are extremely helpful in site preparation.

COVER CROPS: SEPTEMBER–OCTOBER

✔ **Establish a cover crop in the year prior to planting.** Cover crops are useful for preparing your site, if they're established in the year prior to planting.

Cover crops can:

► keep weeds down
► allow earlier access of machine tree planters into fields in the spring
► reduce maintenance after planting.

A good choice in cover crop is dwarf white clover, as it doesn't compete with trees for sunlight.

✔ **Prepare your planting site in the late summer and fall of the year before planting**
► springtime site preparation – just before the area is planted – is more difficult.

✔ **Mark the site in the field** with survey stakes or ribbons
► mark in-row and between-row spacings.

Some site preparation techniques include:

► mechanical methods – including tillage, mulching, cultivation and mowing
► an application of chemical herbicides – band or spot spraying
► cover crops.

TILLAGE: AUGUST–EARLY SEPTEMBER

✔ **Till soil in late August and early September**
► loosen the soil to a depth of 15–20 cm (6–8 in.) to allow for adequate root development and make easier the placing of plastic mulch, if it's going to be used.

Tillage width will differ according to the number of rows in your windbreak or shelterbelt:

► for a single row, till a width of 3 metres (10 ft)
► for a double row, till a width of 5 metres (15 ft)
► for a triple row, till a width of 8 metres (25 ft).

MULCH INSTALLATION: SEPTEMBER–OCTOBER

✔ **Stake the start and finish of each row.**

✔ **Ensure the between-row spacing remains constant**
► between-row spacing is usually 3–4 metres (10–13 ft).

✔ **Place black plastic mulch over the soil to control weeds**
► place mulch over the location of each tree row.

ORDER TREES: OCTOBER–NOVEMBER

✔ **Confirm number of trees for planting and place your order.**

MULTI-TREE WINDBREAK PLANTING

Site Preparation Plan

✔ Prepare site by tilling in late summer of year prior to planting.

✔ Broadcast white clover seed in tilled area.

✔ Once clover has established and before it goes dormant, spray 3 bands with Roundup, 3 metres apart in windbreak location.

Site Description

Topography: flat
Drainage: moderate to well
Soil: loam
Clover: clover with sprayed bands
Total hectares: 40

Planting

Plant west row with 535 White Spruce, 2-metre spacing between trees.

Plant centre row with 535 Hybrid Poplar, 2-m spacing between trees and shrubs, Sugar Maple, Ninebark, Highbush Cranberry: repeat 2-m spacing between trees and shrubs. Requires 268 Sugar Maple, 134 Highbush Cranberry, and 133 Ninebark. Total seedings to order: 1605.

Recommendation

Mulch seedling with woodchips after planting to help retain moisture during dry periods. Wood chips shouldn't touch the trunk of the tree as this may cause decay. Create a doughnut with the mulch.

STEP 6 – ORDER THE TREES

✔ **Order at least six months in advance.**

✔ **Buy plant materials from the correct seed zone** to ensure good survival and optimum growth
► consult your local conservation authority to determine your seed zone.

Commercial nurseries, some conservation authorities, and county nurseries are good sources for trees.

STEP 7 – PLANT THE SITE

Planting: Mid–April to early June

The long-term success of your shelterbelt depends on how well you plant your trees.

✔ **Begin to plant as soon as the soil can be worked, and before the tree leaves emerge**
► in southwestern Ontario, this may be as early as the beginning of April
► in eastern Ontario, this may be as late as mid-May.

✔ **Monitor the weather and soil conditions to determine start date**
► check with local planting agencies to see when they recommend starting planting.

✔ **Follow your design by carefully laying out the planting site in advance**
► use a line, or in some way mark a straight line, to ensure straight rows and make future maintenance easier.

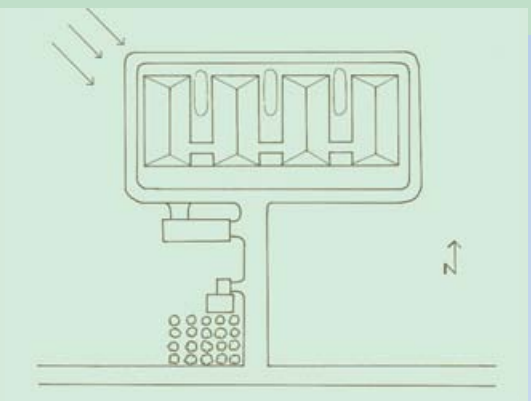
✔ **Handle stock with care**
► reduce exposure and keep seedlings moist.

✔ **Plant only as many trees as you can care for.**

✔ **Ensure planting holes are properly excavated and no roots are left exposed after planting.**

✔ **Protect trees from livestock** as they may eat or trample newly planted trees
► fence off planting areas if necessary.

BEFORE



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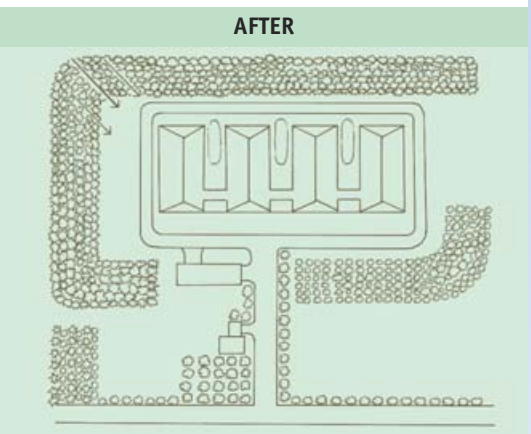


These are before-and-after views of a shelterbelt and windbreak designed to protect a greenhouse operation. A combination of conifers and hardwoods is planned for the north and west sides for maximum protection from heat loss and snow loads. Deciduous trees are planted on the south and east sides to prevent winter shading of the greenhouse.

STEP 8 – MAINTAIN THE PLANTING

A windbreak or shelterbelt is considered successfully established when it can perform its desired function(s). Most will require some degree of maintenance after they are established and while they are growing.

✔ **Replace dead or damaged trees promptly.**

✔ **Cultivate for no more than three seasons** to protect expanding root systems
- ► mow after three years to reduce weed competition and control noxious weeds.

✔ **Irrigate during dry periods**
- ► in some cases, watering may not be feasible and poor survival may require refilling.

✔ **Prune to create some desired effects on snow distribution**
- ► removal of lower branches of some conifers can help create a more even distribution
- ► shelterbelts can be pruned to produce high-quality timber.

✔ **Inspect regularly for damaging agents such as disease and insects.**

✔ **Thin trees if necessary** after at least 10 years of growth, e.g., a Spruce windbreak planted at 2.5-metre (6-ft) spacing should have every second tree removed provided that the remaining trees are of good health and vigour

✔ **Control weeds through spot spraying and/or mulches**
- ► crop protection chemicals can damage or kill your planting – use practices that minimize spray drift so that herbicides don't make contact with your windbreak or shelterbelt
- ► in place of, or in addition to, chemical weed control, add wood chips or other organic mulch, 10 cm (4-in.) thick in a 1-metre (3.3-ft) radius from the base of the seedling.

Windbreaks and shelterbelts can be used to provide corridors that allow wildlife to move easily between forested areas. Forested areas provide the majority of their habitat requirements, including important food sources, bedding areas, and thermal cover for some areas. They can provide excellent viewing and hunting opportunities.

Thin and prune windbreaks to attain proper porosity.

Strategically placed birdhouses will be occupied quickly.

Electric fencing will help protect plants from browsing livestock and white-tailed deer. Repellents for rodents may be used and should be applied on tree trunks. A plastic spiral is also effective for protection from rodents and deer. Plastic spirals should be removed before the active growing season.

HARVESTING TREE PRODUCTS FROM WINDBREAKS

Your criteria for selecting species to plant in a windbreak should include not only form and function, but economic opportunity as well. Many of the agroforestry opportunities covered in this book can be attained in a windbreak.

Planting nut trees in your windbreak can yield economic as well as environmental benefits.

Field windbreaks with valuable hardwoods can be harvested at maturity for sawlogs.

Hardwoods that produce high quality timber will require more care than coniferous species. Hardwoods such as Oak, Sugar Maple, White Ash and Yellow Birch can produce quality timber if shearing and pruning are done properly.

Species such as Hybrid Poplar, Green Ash and Silver Maple are fast-growing sources of fuelwood.

Scots Pine, White Spruce and Balsam Fir are among the conifers grown for Christmas trees.

These trees are being grown in a field windbreak as transplant stock.

BEES IN THE TREES

Some species of trees and shrubs are excellent nectar producers and are important to beekeepers for honey production. However, they are often too far away from hives to be used for foraging by domesticated bees.

One way to increase honey production for beekeepers involves establishing bee trees and shrubs in windbreaks and shelterbelts surrounding crop fields. Growing trees such as Basswood or flowering shrubs with groundcover crops for nectar production is an intriguing land use concept that will increase honey production and produce other valuable agricultural and forest tree crops – making the plantings more feasible.

Planting bee-friendly trees and shrubs in windbreaks and shelterbelts can increase honey production.

BMPs FOR TREED BUFFER STRIPS

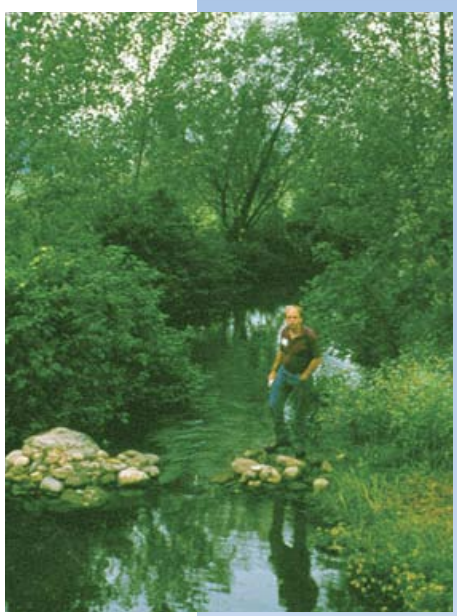
Buffer strips come in all shapes and sizes, and for good reason. Wide buffers are needed for wildlife habitats, whereas narrow buffers are perfectly adequate for simple setbacks from cropland.

Local site conditions also affect buffer strip design. On steeply sloping land, for example, buffers need to be wider to be effective in reducing cropland runoff to water.

Once established, a young treed buffer provides cover and protects the riparian area.

A mature treed buffer performs most of the functions of a naturally forested riparian area.

Riparian areas consist of banks or shores, floodplains and ravine slopes.



The key to a successful riparian buffer is to match design with desired function.

Look for multi-function when designing a buffer strip. Link natural areas wherever possible.

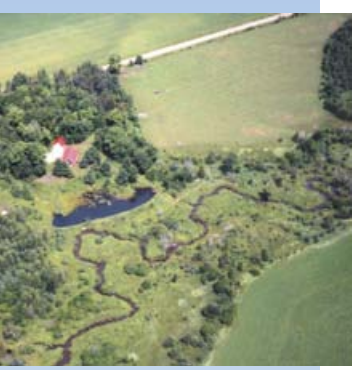
In this section, we'll look at:

- ► function – what you want your treed buffer strip to do
- ► design – the site features and considerations that will make the most effective design for your property
- ► plants – which trees, shrubs and grasses will work best in your buffer strip
- ► establishment – what steps to take to get your buffer strip in place.

Grassed buffers provide range habitat, while planted tree buffers provide more diverse "edge" habitat for mammals, beneficial birds and insects. ("Edge" is the transitional area between two habitats, and generally features greater overall diversity of plants and animals.)

Buffers make ideal wildlife corridors, which are important for survival. For wildlife, wider is better.

Shaded buffers are particularly important to cool- and cold-water fisheries.



Tree and shrub roots provide more bank stability. A minimum buffer width of 5 metres (16.5 ft) is recommended. In this buffer, the entire floodplain was planted.

As we get into the details, please remember: buffer strips are not stand-alone measures. In agriculture, buffer strips should be considered as part of a cropland conservation plan. To repeat, **buffers are intended as the <u>last</u> (not the only!) line of defence against erosion and runoff.**

This is a before-and-after example of a treed buffer planted on the side of a drainage ditch. The intent is to integrate the principles of improved fish habitat with practicality in a buffer design.

FUNCTION

Have a clear idea of what key functions (or benefits) you're seeking. The functions will affect width, cover types, species selection and special features or concerns.

For example, say you want a buffer strip to act as a setback and offer some sediment control on flat, clayey intensive cropland. Your buffer strip will probably be narrow and grassed with a single row of fast-growing trees.

Treed buffer strips are the most effective choice for most riparian functions.

RELATIVE EFFECTIVENESS OF RIPARIAN TYPES BY FUNCTION*

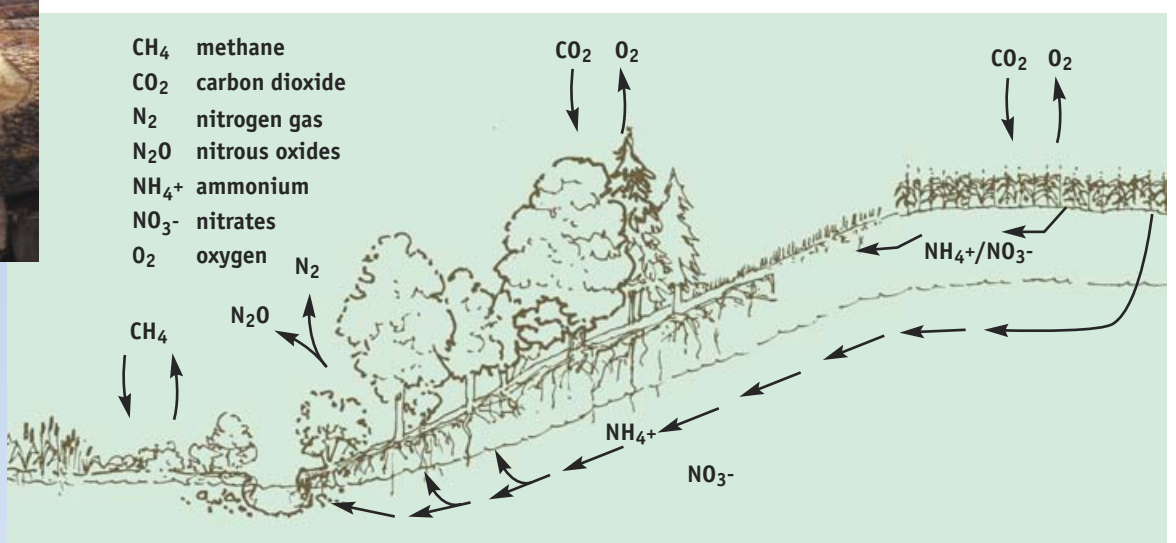
FUNCTION	VEGETATION TYPE		
	GRASS AND FORBS	SHRUBS	TREES
BANK/SHORE STABILITY	Low/Medium	Medium/High	High
FILTRATION OF SEDIMENT	High	Low/Medium	High
FILTRATION OF SOIL-BOUND NUTRIENTS, PESTICIDES, BACTERIA	High	Low/Medium	High
RETENTION OF SOLUBLE NUTRIENTS, BACTERIA, PESTICIDES	Low	Low	Medium
WATER STORAGE	Low	Medium	High
FLOOD PROTECTION	Low	Medium	High
FISH HABITAT	Low	Medium	High
WILDLIFE HABITAT	Medium	Medium	Medium
FOREST HABITAT	Low	Medium	High
GREENHOUSE GAS REDUCTION/ CARBON SEQUESTRATION	Low	Medium	High
NITRATE UPTAKE	Low	Low	Medium/High
PHOSPHORUS	High	Low/Medium	High
ECONOMIC PRODUCTS	Medium	Low	High
VISUAL DIVERSITY	Low	Medium	High

* Adapted from Tjaden and Weber, 1998, Riparian Buffer Systems, MCU Extension Fact Sheet 733

Soils in treed buffers have the porosity and structure to store floodwaters.

Treed buffers moderate water temperatures, provide food for aquatic life, offer cover for wildlife, and filter nutrients and contaminants.

Treed buffer strips can produce high-value timber products.



Treed buffers are important BMPs to reduce agriculture's impact on climate change. Plants and soils sequester some key greenhouse gases, such as carbon dioxide. Methane can also be fixed by riparian soils. Emissions of nitrous oxides can be reduced when riparian vegetation intercepts cropland nitrates and ammonium as they move with groundwater to watercourses.

DESIGN

One of the most important steps in planning an effective buffer strip is your design choice. Consider the following criteria to help you identify the best one for you.

SITE CONDITIONS AND FEATURES

A site assessment should help determine features such as soil types, slope, surrounding land use, and riparian type (e.g., stream vs. river). These features affect design in the ways summarized in the next chart.

EFFECT OF SITE AND LAND USE FEATURES ON DESIGN OF TREED BUFFERS

FEATURE	IMPLICATIONS
SOIL TYPE (SAND, LOAM, CLAY)	• runoff is greatest on clayey soils ○ the design should prevent or manage this (e.g., drop structures, grassed waterways) • loamy soils are most erodible ○ special features may be needed for sediment control in the design and during construction (e.g., silt fences) • soil drainage will affect tree, shrub and grass species suitability (e.g., flood tolerance)
SLOPE	• the steeper the slope, the greater the rates of erosion and runoff ○ buffer type and width plus in-field BMPs must be designed to address this • slope length and slope segments will affect the cover type and the species selected (e.g., if the slope is too steep, it may be unsuitable for hay cropping but not for trees and shrubs)
SHAPE	• in some riparian areas, the banks follow a straight path (drains, shores) and the floodplain width is uniform ○ the same design should work throughout the length of the proposed buffer strip (here, overall length is important) • in other areas, the watercourse meanders, the floodplain width varies, and the slopes of the ravine are deeply cut ○ this causes irregularly shaped field borders for the cropland or pasture adjacent to the riparian area – buffer strip planting design should adjust to these influences on shape
LAND USE	• adjacent land uses could be residential, agriculture, natural areas, etc. ○ e.g., the nature of impacts from cottages (such as removal of shoreline wetlands) differs from farm operation impacts on croplands in lakeshore areas – designs should recognize this • within agriculture, a buffer strip beside an orchard differs from one beside steeply sloping cropland
RIPARIAN TYPE	• lakeshore buffer strips differ from small stream buffers, in terms of species selection plantings and additional erosion control needs • similarly, a simple, narrow, grassed buffer strip with a single row of trees may work for a municipal drain, while a multiple-row planting would be more suitable for a deeply cut, meandering stream through hilly cropland

Assuming land function is the same on both sides of a watercourse, buffers on either side should be approximately the same width.

WIDTH

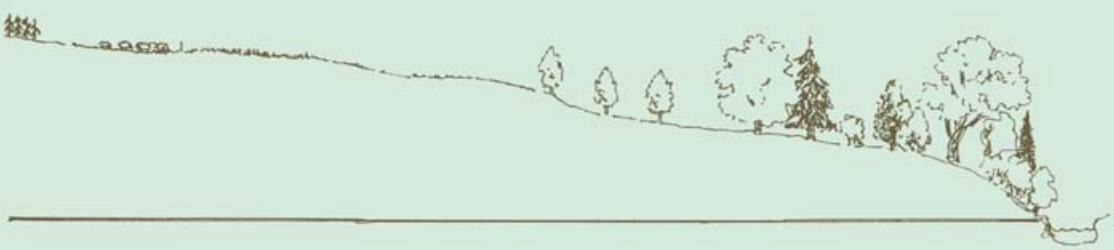
Width is a key design factor. Wider buffers are more effective at filtering contaminants, encouraging infiltration and providing diversity of habitat.

Effective width varies with soil type, slope, adjacent watershed size, function and cover type. The following illustration is an attempt to specify the range of widths by function. **Please note that it assumes bare soil conditions in the adjacent land upslope from the buffer area and less than 10% slope conditions.**

Once again, width alone will rarely replace the benefit of upland soil and water conservation BMPs.

How to Measure Buffer Strips

Buffer strip width is the distance from the top of a bank to the edge of a field. Where streams meander, take the average of three measurements.



Bank stability, 5+ metres (16+ ft.)

Sediment removal, 10–30 metres (33–98 ft.)

Soil-bound nutrients, 10–30 metres (33–98 ft.)

Soluble nutrients, 15–50 metres (50–164 ft.)

Aquatic habitat, 15–30 metres (50–98 ft.)

Wildlife habitat, 10–300 metres (33 ft.–327 yds.) – >50 m (164 ft.) if for nesting waterfowl

Wider buffers perform a greater number of functions more effectively. However, if the recommended buffer width is impossible, don't despair. Smaller buffers still offer some environmental benefits.

CONCENTRATED FLOW

Buffer strips are intended to manage *sheet flow* from adjacent land use. They are not meant to manage concentrated or channel flow of runoff to riparian areas, as seen with draws, *rills*, and gullies that "short-circuit" buffer strips. Concentrated flow is faster and will cut a deeper channel if unmanaged.

Soil and water conservation BMPs and structures should prevent this flow from entering riparian areas unchecked. But in some cases, more effort is required. This should be part of the overall design of the buffer strip.

For more information on managing concentrated flow, please see the BMP book, *Buffer Strips*.

Several erosion control measures are often required to control sheet and rill erosion.

BANK AND SHORELINE EROSION

Buffer strip designs should provide for any bank or shoreline stabilization work. The nature and extent of the problems (including slumping) should be determined in the site assessment. See BMP *Buffer Strips* for further details.

Buffers strips are intended to manage sheet flow – not concentrated flow – from cropland.

Plant trees. Wide, treed buffers are the most functional cropland buffer strips.

PLANTS FOR BUFFER STRIP ESTABLISHMENT

This book focuses on establishing primarily treed buffer strips, although buffer strips can also be planted to grass and wildflowers – often a mix of all of the above. Whether trees or grasses or flowers, plants should be selected according to the desired buffer function and also the plants' suitability to local site conditions, including climate, soil, soil drainage, soil pH and risk of flooding. Avoid invasive, non-native species, wherever possible.

Plants can be established in many arrangements and mixtures to suit design needs. For more information about suitable non-tree plants for buffer strips, please see the BMP book, *Buffer Strips*.

TREES AND SHRUBS FOR RIPARIAN AREAS

Base your selection of trees and shrubs for buffer strip plantings on the following criteria:

- **climate** – think globally and plant locally by using plants suited to the region
- **soil drainage** – promote survival and growth by matching trees to site conditions
- **flood tolerance** – ensure any trees in floodplains are flood-tolerant
- **shade tolerance** – ensure slower-growing trees and shrubs, or ones that are likely to be in the shade for most of their existence, are shade-tolerant
- **growth rate** – plant fast-growing trees if you need to create shade as soon as possible
- **wildlife value** – determine which trees will provide cover, shelter and food
- **economic value** – be aware that some of our most valuable trees grow very well in riparian areas.

This planting on Washington Creek demonstrates that on productive riparian sites, fast-growing hardwoods like White Ash can fully shade narrow channels within 10 years.

Stream bottomlands are ideal sites for valuable hardwoods like Black Walnut.

Group or block plantings create excellent tree-growing environments and wildlife cover.

Introducing evergreens like White Cedar in row plantings along the edge of a buffer strip creates an ideal travel corridor.

Mature Cedar creates ideal wintering sites for a wide range of wildlife.

SUGGESTED HARDWOOD TREES FOR BUFFER STRIP PLANTINGS

SPECIES	SILVER MAPLE	GREEN ASH	BLACK WILLOW	COTTON-WOOD	BLACK WALNUT	WHITE ASH	RED OAK
FEATURES							
HARDINESS ZONE	4–9	3–9	5–9	7–9	7–9	3–9	3–9
SOIL TYPE	All	All	All	Loamy to sandy	Loam to clay loam	All	Sandy to loamy
DRAINAGE	Imperfect to very poor	Imperfect to very poor	Poor to very poor	Poor to very poor	Well to imperfect	Well to imperfect	Well to imperfect
FLOOD TOLERANCE	High	High	High	High	Medium	Medium	Medium
ROOTING	Shallow	Shallow	Shallow	Shallow	Taproot	Moderate lateral	Deep lateral
GROWTH RATE	Medium	Very fast	Very fast	Very fast	Medium	Fast	Fast
HEIGHT	Medium	Tall	Medium	Tall	Tall	Tall	Tall
SHADE TOLERANCE	Medium	Low to medium	Low	Low	Low to medium	Low to medium	Low to medium
WILDLIFE VALUE	Low to medium	Low to medium	High	Low	Medium	Low	High
ECONOMIC VALUE	Low to medium	Moderately high	Very low	Very low	Very high	High	Very high

SHRUBS FOR BUFFER STRIP PLANTINGS

SPECIES	NINE-BARK	ELDER-BERRY	RED OSIER DOGWOOD	STAGHORN SUMAC	ALTERNATE-LEAVED DOGWOOD	NANNY-BERRY	HIGHBUSH CRANBERRY
FEATURES							
HARDINESS ZONE	3–9	2–9	2–8	2–9	3–9	3–9	3–9
SOIL TYPE	Wide range	Loams to sandy loam	Wide range	Sandy and gravelly	Most soils	Most soils	Fertile soils
DRAINAGE	Imperfect to very poor	Imperfect to very poor	Poor to very poor	Rapid to imperfect	Well to imperfect	Well to poor	Well to imperfect
FLOOD TOLERANCE	High	High	High	Low	Low	Moderate	Moderate to low
ROOTING	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow
GROWTH RATE	Fast	Fast	Fast	Fast	Medium	Medium	Medium
HEIGHT	2–4 m (6.5–13 ft)	1–5 m (3.3–16.5 ft)	<2 m (6.5 ft)	1–5 m (3.3–16.5 ft)	2–4 m (6.5–13 ft)	5–10 m (16.5–33 ft)	2– 4 m (6.5–13 ft)
SHADE TOLERANCE	Low	Moderate	Moderate	Low	Moderate	Moderate	Low
WILDLIFE VALUE	High	Very high	High	High	Very high	High	High

SUGGESTED CONIFER TREES FOR BUFFER STRIP PLANTINGS							
SPECIES	**WHITE CEDAR**	**TAMARACK**	**WHITE SPRUCE**	**WHITE PINE**	**RED PINE**	**HEMLOCK**	**RED CEDAR**
FEATURES							
HARDINESS ZONE	1–8	0–9	1–5	2–9	2–5	3–9	4–9
SOIL TYPE	All	Sandy to loamy	All	Sandy to clay loams	Sandy to sandy loams	Loamy	All
DRAINAGE	Well to very poor	Imperfect to very poor	Rapid to poor	Rapid to imperfect	Rapid to imperfect	Well to imperfect	Well to imperfect
FLOOD TOLERANCE	High	High	Medium to high	Low to medium	Low	Low to medium	Low to medium
ROOTING	Shallow	Shallow	Shallow	Deep lateral	Deep lateral	Shallow	Shallow
GROWTH RATE	Slow	Fast	Medium to slow	Fast	Fast	Slow	Slow
HEIGHT	Short	Medium	Medium to tall	Tall	Tall	Tall	Short
SHADE TOLERANCE	Medium	Low to medium	High	Medium to high	Low to medium	Very high	Low
WILDLIFE VALUE	Very high	Low	Medium	Medium	Low	High	Medium
ECONOMIC VALUE	Medium	Medium	Medium	High	Medium	Medium	Low

Green Ash, Black Walnut, White Cedar, Tamarack, Ninebark and Dogwood may be suitable for riparian buffers.

THREE-ZONE BUFFER

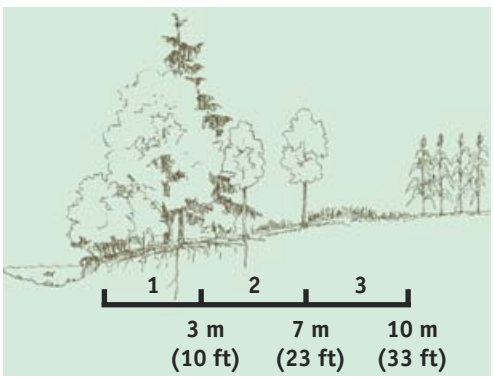
In the three-zone treed buffer design, each zone has its distinct place and function. The trees in Zone 1 shade the water and stabilize the banks. Zone 2 soils and vegetation help to filter sediments, and help with infiltration and floodwater storage. Zone 3 filters cropland runoff and serves as a field buffer.

TREED BUFFER DESIGN

FEATURE	SINGLE-ROW DESIGN	THREE-ZONE DESIGN	MULTI-ROW DESIGN
DESCRIPTION	• row of single trees and narrow grassed buffers established along drains	• a wide buffer design that consists of three zones (minimum total width 10 m [33 ft]) • Zone 1: trees closest to the bank or shore • Zone 2: shrubs/trees/mixture • Zone 3: grasses/legumes	• a wide buffer that follows landscape features (e.g., ravine and floodplain (usually >10 m [33 ft]) • wide range of species combinations – pure conifer/ pure hardwood/mixes/ wildlife habitat
FUNCTIONS	• setback from top of bank • ditchbank stabilization • sediment and nutrient filtering • leaves provide some nutrients for aquatic life • woody debris helps maintain sediment load • shade for stream and fish • nitrate removal from groundwater	• bank and shore stability • filtering of runoff • leaves provide nutrients for aquatic life • woody debris helps maintain sediment load • shade for stream and fish • some nitrate removal from groundwater • some carbon sequestration • wildlife corridors • wood and food products	• bank and shore stability • filters and promotes infiltration • provides nutrients for aquatic life • woody debris helps maintain sediment load • shade for stream and fish • nitrate removal from groundwater • carbon sequestration • wildlife habitat and corridors • wood products
SUITABLE FOR:	• municipal drains • intensively grazed areas where livestock have been excluded • low-order, shallow and deep-channel streams • lakeshores and ponds	• wide-channel streams • narrow watercourses with small floodplain plus steep short banks • highly erodible or fragile lands • gently sloping shorelines and river banks	• large ravine systems with steep slopes that are also of marginal economic importance for crop production or grazing, such as ravines • gently sloping shorelines and river banks
UNSUITABLE FOR:	• slopes >10% • natural riparian areas • deep ravines with broad floodplains	• intensively cropped prime farmland • wetlands (unless geese are troublesome)	• low-order, shallow and deep-channel streams

TREED BUFFER DESIGN

FEATURE	SINGLE-ROW DESIGN	THREE-ZONE DESIGN	MULTI-ROW DESIGN
DESIGN CONSIDERATIONS	• width: minimum of 5 m (16 ft) for most situations • establish sod cover on buffer strip • place trees 2–3 m (6.5–10 ft) back from edge of bank	Zone 1 • use water-tolerant trees if floodplain floods frequently • select fast-growing trees • space trees between trees and rows (2–3 or 6.5–10 ft) Zone 2 • use high-value hardwoods best suited to the site • select suitable shrub species Zone 3 • could be used as turning area for cropping equipment	For floodplain • use water-tolerant trees if floodplain floods frequently • select fast-growing trees nearest top of bank



In the three-zone treed buffer design, each zone has its distinct place and function. The trees in Zone 1 shade the water and stabilize the banks. Zone 2 soils and vegetation help to filter sediments, and promote infiltration and floodwater storage. Zone 3 filters cropland runoff and serves as a field buffer.

Single-row design: A combination of grass and fast-growing trees can provide considerable protection for waterways without taking up much valuable cropland.

Multiple-row design: Several rows of trees and shrubs are more suitable for sites with wide valleys and steep ravine slopes.

HOW TO DEVISE A BUFFER STRIP PROJECT

The most effective buffer strip projects are planned. Keeping in mind the principles we've covered, you're ready to undertake your own project. Here are some planning how-to's:

Step 1. Assess existing conditions in your riparian area(s), e.g., instream conditions, water quality, and vegetation quality. Draw a map showing soil types, slopes, existing vegetation, adjacent croplands, and other riparian and natural areas. Complete a Grazing Management Plan if appropriate.

Step 2. Predict the benefits of a well-maintained, planted buffer strip. Put your list of desired benefits together with other related management goals and objectives. Consult with a conservation authority to discuss risk assessment and identify opportunities. Select functions for the buffer strips. Talk to neighbours.

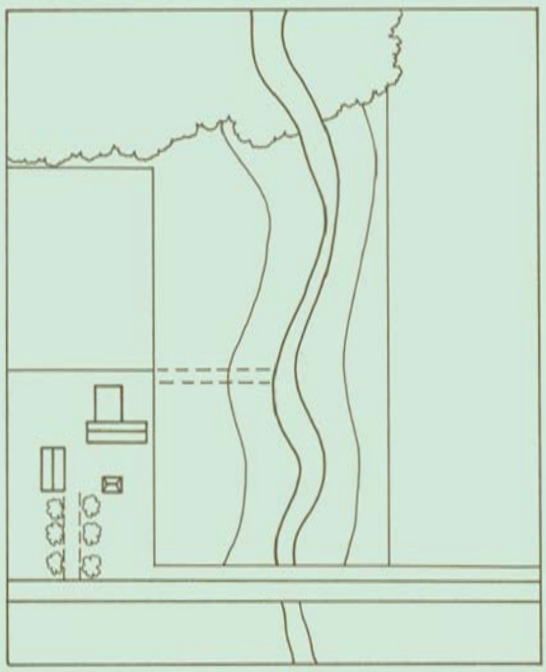
Step 3. Assess upslope conditions on the farm. Ask yourself whether additional soil and water conservation BMPs would enhance the effectiveness of your buffer strip(s).

Step 4. Examine and select options. Which BMPs will do the job? Do the advantages outweigh the disadvantages? Which options require approvals, permits and technical assistance? Which agencies offer financial assistance?

Step 5. Design and implement. Refer to the designs in this book and other references. Seek technical advice from a conservation authority and other agencies, and from experienced landowners. Obtain permits and approvals where necessary. Create an action plan: outline your resources, your time, and a schedule of activities. Remember that the project can be phased in over several years.

Step 6. Maintain, monitor and evaluate. Maintain planted vegetation by irrigating, sampling the soil, fertilizing, pruning or clipping, replacement and weed control. Confirm survival rates of planted grasses, shrubs and trees. Look for washouts and rill cutting across the buffer strip. Determine if the project is fulfilling its intended functions. Assess whether additional BMPs would improve its effectiveness.

SAMPLE RIPARIAN MAP



Consult with your local conservation authority to discuss risk assessment of the riparian area and identify opportunities.

Single-row, treed, narrow buffer strip designs are most suitable along drains.

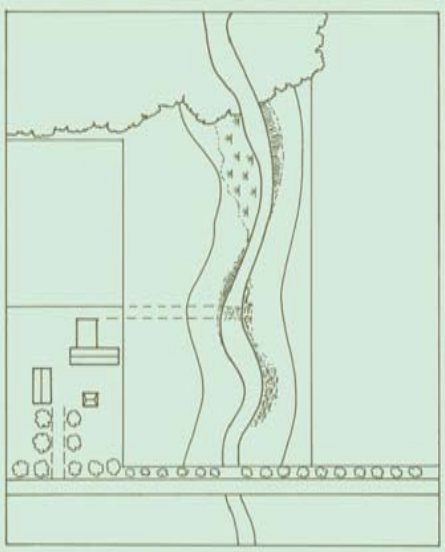
Layout

- ✔ **Sketch buffer strip plan on map** or aerial photograph.
- ✔ **Soil test** to ensure phosphorus and potassium (P and K) levels are suitable for early growth – don't apply nitrogen.
- ✔ **Tie in fencerows and natural areas** – where possible.
- ✔ **Consider setting aside odd-shaped areas** – where site features or land use change.
- ✔ **Fence livestock away from treed buffer** – if buffer strip is part of a livestock exclusion project.

Trees

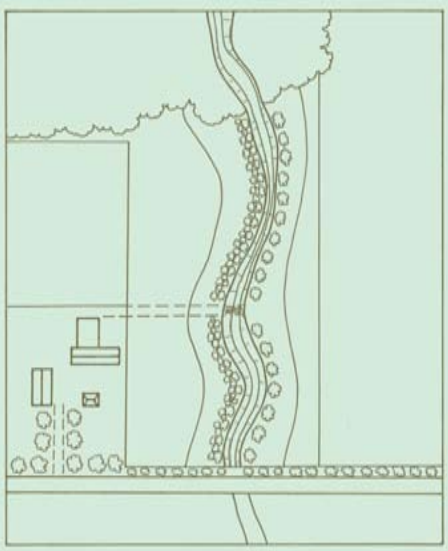
- ✔ **Determine whether you want the buffer width to be uniform or vary** with stream meandering, i.e., whether you want to straighten edge of field (see illustration).
- ✔ **Clearly distinguish zones:** Zone 1 from Zone 2 (or Zones 1 and 2 from Zone 3 if three-zone design) – if trees are to be planted into old sod before establishing Zone 2
- ✔ **Use stakes to mark desired location of larger stock trees** – if part of the plan.

BEFORE



The sketch on the left is the "before", and the sketch below shows the planned projects for an on-farm riparian area. Cropland erosion is evident from the sloping field on the left of the stream. Bank degradation from intensive livestock access is noted on the right side of the stream.

PLANNED PROJECTS



Soil and water conservation measures, including a cropland buffer strip, are planned for the sloping field. Intensive grazing management, fencing and alternative water sources are planned for the grazing area adjacent to the treed buffer.

ESTABLISHMENT AND MANAGEMENT OF TREED BUFFERS

SITE PREPARATION

Trees and Shrubs

If site is to be tilled:

✔ **reconsider and use spot herbicide treatment in Zones 1 and 2** in exact spots where trees are to be planted. Tree and shrub plantings are easier into killed sod.

If site is already tilled:

✔ **consider using a spring cereal cover crop** to reduce over-winter erosion and suppress weed growth
▶ begin site preparation in the fall before planting, ideally.

If the area is already sod and is not to be used for grazing or forage, leave it.

Planting

For tree establishment:

✔ **ensure all weeds are controlled prior to planting**

✔ **use saplings where affordable and available**
▶ survival and growth rates are better than with seedling stock

✔ **handle trees with care**
▶ avoid exposure of roots to sun and wind

✔ **order about 10–20% more seedlings than are needed to plant**
▶ heel in the extra seedlings in a temporary "nursery" for replanting, after assessing first-year survival

✔ **trample all soil around planted trees** to reduce air spaces in disturbed soil.

Trample all soil around planted trees to reduce air spaces left by disturbed soil.

Handle trees with care. Avoid exposing roots to sun and wind.

MAINTENANCE

Weed Control

✔ **Control weeds around trees during the first year** of establishment
- ► mulching is the best method
- ► if you choose to clip, do so before weeds reach 30 cm (12 in.).

✔ **Use selective herbicides** according to OMAFRA recommendations contained in Publication 75, *Guide to Weed Control*.

✔ **Mow regularly and maintain fertility levels** to help ensure stand composition.

Monitoring

✔ **Repair and replant damaged areas** – check tree and shrub survival.

✔ **Water trees regularly for the first year after planting**, unless conditions are wetter than normal.

✔ **Prune crop trees and thin out poor quality trees** as buffer matures – usually about 10–25 years after planting.

As with all natural or non-crop areas, buffer strips can be sources of weeds and other pests. Consider pest pressures from these areas as part of a pest-monitoring program.

Mulching and tree shelters are an excellent combination to protect valuable shade trees from weeds and rodents.

Use large tree stock and saplings rather than seedling tree nursery stock where feasible in riparian plantings. Survival and growth rates are better in these densely weeded environments.

BMPs FOR INTERCROPPING

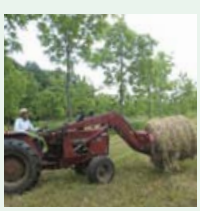
The term *intercropping* refers to planting two or more crops on the same parcel of land at the same time.

Incorporating trees and shrubs into a cropped field creates new challenges and opportunities for the landowner.

Intercropping, also known as alley cropping, is defined as the deliberate incorporation of trees and crops in relatively close proximity on the same parcel of land.

Intercropped plantings protect soil and water resources, sequester carbon, provide habitat, and increase revenues from cropland.

Strip cropping, which involves planting crops in narrow bands across the slope of the land, reduces soil erosion. Trees can be planted along the edge of the strips to transform this BMP to intercropping.

BENEFITS OF INTERCROPPING			
CATEGORY	**DETAILS**		
ENVIRONMENTAL			
SOIL AND WATER	• trap nitrates • help nutrient cycling • reduce erosion and runoff • reduce wind erosion		**Strip cropping and intercropping can reduce the environmental impacts of farming.**
ATMOSPHERE	• sequester carbon in wood and soil • prevent denitrification		
ECOLOGICAL			
HABITAT	• provide habitat for beneficial insects and wildlife • diversify ecosystems in landscape		**Adding trees and shrubs provides wildlife habitat.**
AESTHETIC			
PERSONAL ENRICHMENT	• enjoy scenic rural landscapes • view wildlife		
ECONOMIC			
PRODUCTION	• increase yields (with alley cropping) • prevent desiccation of high-value crops		**Intercropping can diversify income through the sale of products such as timber (walnut veneer pictured here), fibre, and food.**
INCOME	• sell trees, fruits and nuts • sell special forestry products • increase real estate value		**Planting trees and shrubs can offset the loss of income when retiring *marginal land* from active production.**
RURAL ECONOMIC DEVELOPMENT	• diversify tourism and rural economy		

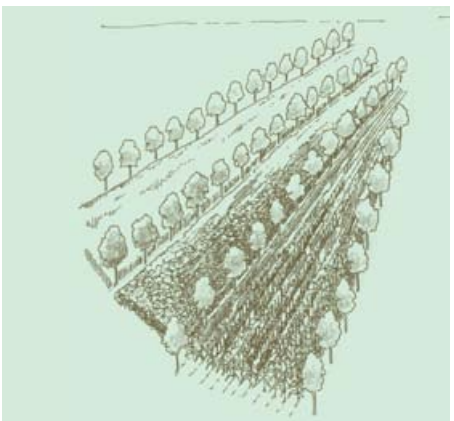
INTERCROPPING OPTIONS

Depending on the suitability of your land for crop and tree production, you have several options. The Canada Land Inventory has summarized land suitability information, and can be accessed at http://geogratis.cgdi.gc.ca/CLI/index_agriculture.html.

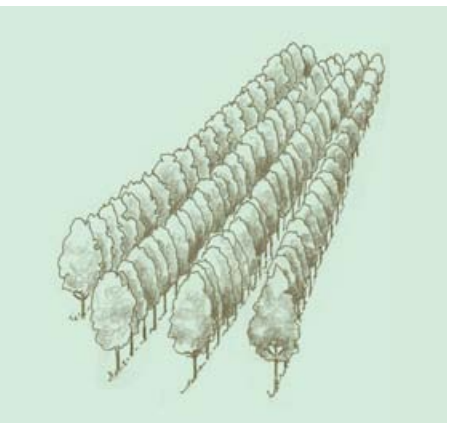
For agriculture, the CLI has seven classes, where Class 1 has no significant restrictions to production and Class 7 is not suitable for any agriculture.

INTERCROPPING SYSTEM	CLI CLASS 1–2	CLI CLASS 3–4	CLI CLASS 5
HIGH-VALUE HARDWOODS	• tree rows widely spaced • crop production continues for many years	• tree rows closely spaced • crop production changes to shade-tolerant crops or ends	• not recommended
ENERGY PLANTATION	• not recommended	• tree rows widely spaced • crop production continues for many years	• tree rows closely spaced • crop production changes to shade-tolerant crops, cool-season grasses or ceases
NUT/FRUIT/ MAPLE ORCHARD	• tree rows wide or closely spaced • crop production ends as tree canopy matures • possibility of growing shade-tolerant crops where pesticide use does not conflict	• tree rows closely spaced • crop production ends as tree canopy matures • possibility of growing shade-tolerant crops where pesticide use does not conflict	• suitable for Maple orchard only – provided the reason the site is Class 5 is due to topography and surface stoniness • not recommended for fruit and nut production • tree rows closely spaced
AFFORESTATION	• not recommended	• recommended for fragile soils • trees closely spaced • crop production ends as tree canopy matures	• recommended for degraded or fragile soils • tree rows closely spaced • crop production ends as tree canopy matures or permanent cover crop is established with trees
INTEGRATED NURSERY PRODUCTION	• possible on all soil types	• possible on sites with adequate drainage, rooting depth and few stones	• not recommended
SPECIALTY CROP PRODUCTION (e.g., ginseng, golden seal)	• possible on all soil types • crop must be carefully selected to match site	• possible on all soil types • crop must be carefully selected to match site	• not recommended

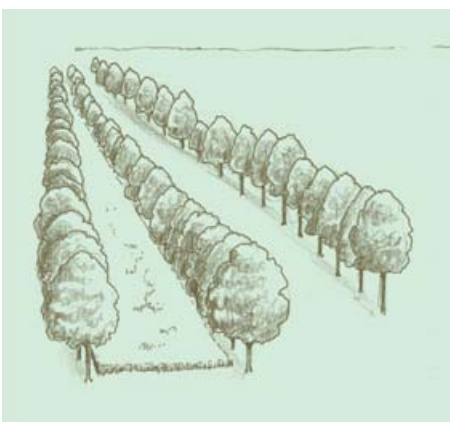
Intercropping with high-value hardwoods on Class 1–3 lands.



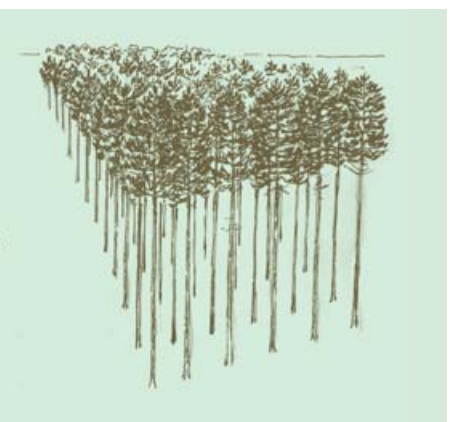
High-value hardwoods



Energy plantation



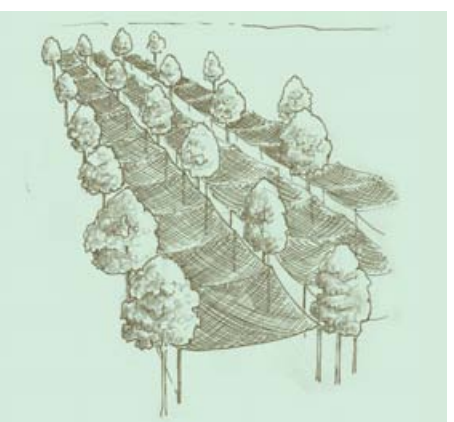
Nut/Fruit/Maple orchard



Afforestation

Growing specialty forest products such as shiitake mushrooms is quite compatible with intercropping.

Intergrated nursery production



Specialty crop production

SELECTING A SYSTEM

The decision to adopt intercropping will depend at least in part on your available capital and the length of time before a return on the investment is required. Large-diameter trees take a long time to grow – perhaps 60 years or more depending on species and site.

SHORT-TERM (<10 YEARS) ECONOMIC RETURN REQUIRED		LONG-TERM (>10 YEARS) ECONOMIC RETURN ACCEPTABLE	
AVAILABLE CAPITAL ($ AND LABOUR) LOW	AVAILABLE CAPITAL ($ AND LABOUR) HIGH	AVAILABLE CAPITAL ($ AND LABOUR) LOW	AVAILABLE CAPITAL ($ AND LABOUR) HIGH
energy plantation • 3–5-year rotation, typically using fast-growing Poplar or Willow	**specialty crops** (ginseng, golden seal, mushroom) • in narrow alleys, typically associated with hardwoods	**afforestation with conifers** (land retired from farm production) • revenue depends on future value of standing tree crop	**high-value hardwood plantation** • intercropped with annual cash crops
fibre production • 5–10-year rotation, typically using fast-growing Poplar for OSB* and other building materials	**nursery production** • a variety of crops may be grown unless pesticides that are incompatible with food crops are required	**afforestation with valuable hardwoods** • revenue depends on future value of standing tree crop	**orchard production** (nut/fruit/maple) • intercropped with cash crops until the tree crop becomes profitable

*oriented strand board

The intercropping planting on the left will mature as a hardwood plantation as shown on the right. While this is a long-term investment, intercropping with row crops and forages provides annual cash-flow.

PLANNING FOR INTERCROPPING

Just like other agroforestry practices, it is very important to carefully plan and design your new intercrop plantation. You have many options.

✔ **Base your plan on**:
- ► your goals and objectives
- ► the climate, geography and soil capabilities
- ► the amount of effort you're willing to devote to the project
- ► the cost of changing agricultural practices.

✔ **Consider your long- and short-term goals.**

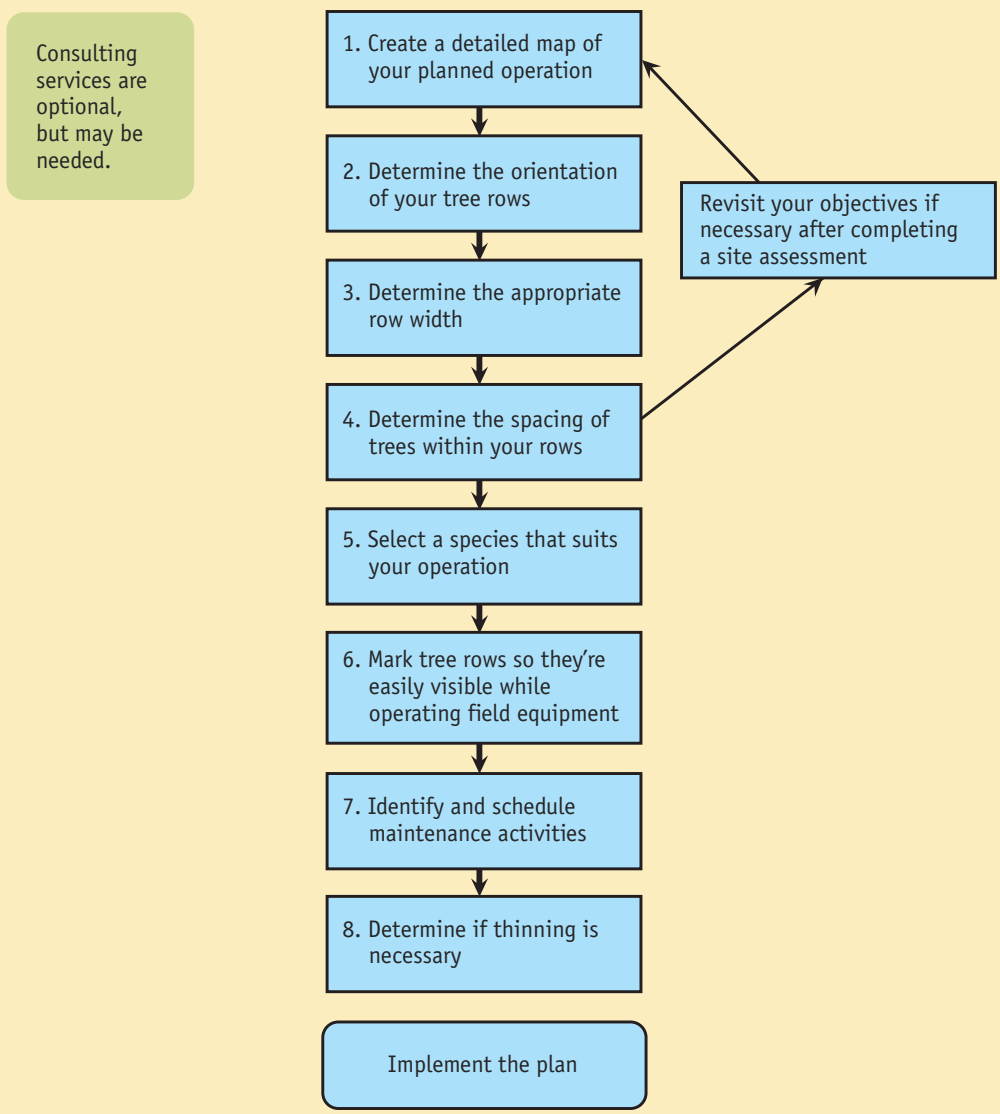
For example, do you want to continue growing cash crops over many years or do you intend to eventually retire the land from crop production altogether? You may wish to consider growing shade-tolerant crops such as cool-season forage grasses or ginseng once the tree canopy starts to close.

Keep asking yourself questions and discuss your ideas with others until you're confident that you have made the best decisions.

Make a map of your intercropping plan before you take action. This will prevent or at least minimize tillage or harvesting equipment clearance issues. Create a legend for your map, including a map scale, symbols used, and magnetic north. Identify other topographic features such as slopes, streams, and water features.

8-STEP PLANNING

INTERCROPPING WITH TREES – PLANNING STEPS



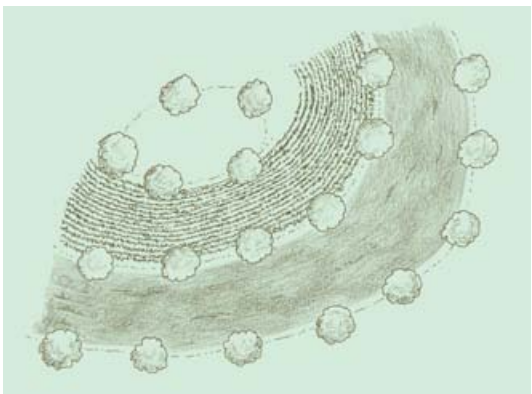
STEP 1 – CREATE A DETAILED MAP OF YOUR PLANNED OPERATION

✔ **Make it detailed** so you can identify potential problems before you begin planting.

✔ **Indicate any known problem areas**
- ► these might include very wet or dry areas where yield is low or the land is difficult to work.

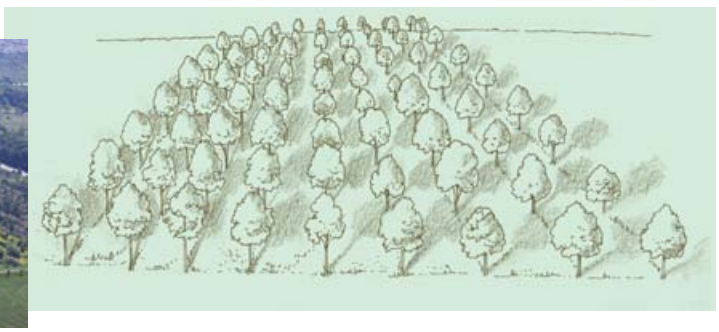
✔ **Indicate location of any tile drains** and whether they're still operational
- ► also identify hydro lines, services and right-of-ways, as well as access roads present and planned.

STEP 2 – DETERMINE THE ORIENTATION OF YOUR TREE ROWS



On sloping land, it's best to plant the trees following the contour of the land. The permanent cover within the tree rows will act as traps for soil moving by sheet erosion.

Plant trees perpendicular to the dominant slope or along contours where possible. Take care to ensure the safe and efficient operation of farm machinery.



University of Guelph studies have shown that on level ground, the trees should be oriented to maximize the amount of light reaching the understory crop. Typically, planting in a north-south orientation will maximize the amount of afternoon sun reaching the annual crop. This will facilitate the growth of crops that require a lot of sunlight. If a shade-tolerant understory crop is desired, then planting the tree rows in an east-west orientation will maximize the shade.

STEP 3 – DETERMINE THE APPROPRIATE ROW WIDTH

✔ **Consider the light demands** of the crops you plan to grow in the alleys.

✔ **Plant rows of orchard trees 5–15 metres (16.5–49 ft) apart.**

✔ **Plan the row widths for equipment** that you currently own or are planning to buy in the near future

- ► consider the width of all planting, harvesting, and spraying equipment
- ► the minimum row width is equal to the width of the largest piece of equipment you have – or multiples of this width (e.g., 2X width, 3X width).

✔ **Remember to add enough space to accommodate the growing trees**

- ► at maturity, trees will require a row width of 2 metres (6.5 ft) or more
- ► trees grown for fruit, nut or sap production will be more productive with a large crown, and will require a larger row width (up to 5-metre or 16.5-ft width at maturity)
- ► trees grown for timber or veneer can be pruned to have more compact crowns and may occupy less space.

Tree rows should be widely spaced for crops with high light demands.

Tree rows should be close together for shade-tolerant crops.

Try to make the row width evenly divisible by the width of all your equipment.

STEP 4 – DETERMINE THE SPACING OF TREES WITHIN YOUR ROWS

✔ **Base within-row spacing on selected species, your budget, and stated goals**

- ► where environmental considerations or short-term profits are the most important factors, you can plant fast-growing trees closer together
- ► if you want to maintain high annual crop yields, or are trying to lower initial project costs, then fewer trees planted farther apart is appropriate.

STEP 5 – SELECT A SPECIES THAT SUITS YOUR OPERATION

Choosing the right tree for your operation is a matter of balancing your objectives with the physical characteristics of the site, and the growth characteristics of the tree species. The characteristics of an ideal tree species for intercropping are:

- ► high value or multiple values
- ► fast-growing
- ► creates minimal shade
- ► deep-rooted with few large lateral roots near the soil surface
- ► does not produce chemicals toxic to other plants or animals
- ► tolerant of a variety of site conditions
- ► disease- and insect-resistant or tolerant.

There are very few trees that meet most of these criteria.

Honey Locust has a sparse canopy, few large lateral roots, and will grow well under a variety of conditions. However, the wood is of relatively low value.

White Ash is deep-rooted with a relatively compact canopy. The wood is valuable, but the branches are brittle and susceptible to wind and ice damage when grown in the open.

INTERCROPPING PLANTATION TYPE	EXAMPLE TREE SPECIES	MINIMUM WITHIN-ROW SPACING	IDEAL WITHIN-ROW SPACING
ENERGY	Poplar, Willow	1 metre (3.2 ft)	1–3 metres (3.2–10 ft)
CONSERVATION	Willow, Spruce, Pine, mixed	1 metre (3.2 ft)	1–3 metres (3.2–10 ft)
ORCHARD	Maple, Walnut, Pecan	3 metres (10 ft)	3–5 metres (10–16.5 ft)
HARDWOOD	Maple, Oak, Ash, Walnut	3 metres (10 ft)	5–7 metres (16.5–23 ft)

Black Walnut has very valuable wood and nuts, but produces a hormone, juglone, that kills other plants. Juglone does not affect monocots (e.g., corn, wheat, barley and other grasses) and does not appear to harm soybeans. Juglone is very toxic to tomatoes. If Black Walnut is being considered, consult a crop compatibility list.

THE SELECTION PROCESS

- ✔ **Make a list of species suitable to growing conditions**
  - ► consider soil, climate, aspect, slope, etc.
- ✔ **Determine species compatibility with planned understory crops.**
- ✔ **Select candidate species based on your goals.**
- ✔ **Select best candidates based on other values** (e.g., disease tolerance, secondary values, etc.).

STEP 6 – MARK TREE ROWS SO THEY'RE EASILY VISIBLE WHILE OPERATING FIELD EQUIPMENT

Relatively little land is required to establish the trees. Row widths of a metre or less are sufficient. Allow enough space and clearly mark the tree rows so that they're visible to someone driving a tractor or combine.

As the trees mature, more land will be lost from crop production. The desired crown size and shape, and your ability to prune the trees in a timely manner will dictate how close to the tree row you can operate farm machinery.

STEP 7 – IDENTIFY AND SCHEDULE MAINTENANCE ACTIVITIES

Most maintenance activities required for tree care will fit very nicely with those for managing a cash crop.

Young Trees

- ✔ **Take extra care while young trees are becoming established to ensure pesticide applications do not harm them**
  - ► trees with thin bark may be susceptible to herbicides before the leaves emerge in the spring
  - ► spray herbicides only when conditions are favourable to minimize drift
  - ► use a curtain on the spray boom or use a backpack sprayer or wick weeder to control weeds around young trees.

White Ash is commonly used for intercropping.

Black Walnut can be toxic to some other crops. Check first before planting.

PLANNING FOR INTERCROPPING:

Step 1. Create a detailed map of your planned operation

Step 2. Determine the orientation of your tree rows

Step 3. Determine the appropriate row width

Step 4. Determine the spacing of trees within your rows

Step 5. Select a species that suits your operation

Step 6. Mark tree rows so they're easily visible while operating field equipment

Step 7. Identify and schedule maintenance activities

Step 8. Determine if thinning is necessary

✔ **Place 2–3 inches of organic mulch (straw, wood chips) or a sheet of plastic mulch around the tree** to reduce weed pressure to acceptable levels.

✔ **Use tree shelters** to protect young trees from herbicide damage as well as injury from rodents.

✔ **Avoid pruning at the time of planting** as this can have adverse effects on early root development.

✔ **Remove only damaged branches** for the first few years.

Larger Trees (post free-to-grow)

With larger trees, the need for weed suppression is reduced.

✔ **Prune regularly**
- ► prune live branches to a height that will allow access by machinery without damage to the trees
- ► prune in early spring, fall or winter.

✔ **Prune no more than one-quarter of the live crown at any one time**
- ► leave one-third to one-half of the height of the tree with the crown intact.

✔ **Train young trees to grow straight**
- ► multiple leaders should be removed to leave a single straight leader
- ► large side branches can be removed.

✔ **Remove the growing tips (tip pruning) of lower branches**
- ► this will create the necessary clearance to operate machinery while maintaining leaf area
- ► as the tree matures, these lower branches can be removed altogether.

Plastic mulch can be used to control weeds.

STEP 8 – DETERMINE IF THINNING IS NECESSARY

Thinning may not be necessary. Many intercrop plantations are established at their final density.

✔ **Every year, replace trees that die.**

✔ **If wild stock of unknown parentage is used:**
- ► consider planting additional trees
- ► increase the number of trees planted by 20% or more
- ► select superior trees from the surviving stock.

TREE–CROP INTERACTIONS

Many interactions occur between crops and trees. Your challenge is to maximize the positive interactions while minimizing the negative.

POSITIVE INTERACTIONS	NEGATIVE INTERACTIONS
• improved soil physical characteristics – such as lower bulk density, increased infiltration, better tilth	• increased competition for resources, especially light
• improved nutrient characteristics	• improved habitat for herbivores
• greater biological activity and improved habitat for birds and other insectivores	• increased weed and pest pressures

CROP CONSIDERATIONS

The crops you plant in the alleys between the rows of trees will probably change over time as the trees grow.

Young Trees

Any crop can be grown, regardless of alley width.

Small trees can benefit from the protection of taller crops. However, crops that compete directly with the trees for water and nutrients can retard early growth and survival.

Cool-season crops such as winter and spring grains have high demands for water and nutrients very early in the growing season. These crops should be avoided for the first two to three years after planting.

Warm-season crops such as corn and soybeans have high resource demands at a time when the trees have relatively low demands.

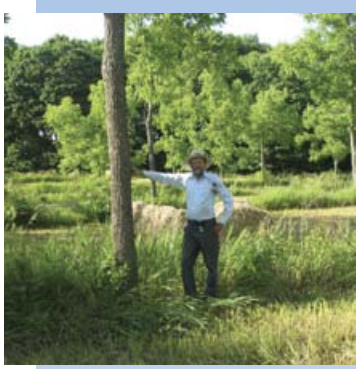
Forage crops may out-compete young trees for water and nutrients.

Larger Trees

Mature trees can produce significant amounts of shade. This means that the planting area available for sun-loving crops may be reduced. Narrow alley widths may reduce the amount of space available for sun-loving crops. However, yields in the middle of the alley may be higher than normal due to the beneficial climate created by the trees.

✔ **Plant cool-season and shade crops close (1 metre or greater) to the trees** (if desired)

► winter and spring cereals will complete a significant portion of their life cycle even before the tree leaves are fully expanded and cast a shadow.



Cereals and forages can be grown successfully as the intercrop planting matures.

This intercrop row is showing natural mortality.

✔ **Plant other crops at a distance of 2–4 metres** (6.5–13 ft) from the trees.

✔ **Prune lower branches** to create warmer and sunnier conditions close to the tree row.

✔ **Adjust for the presence of large surface roots** that may interfere with machinery:
- ► if large surface roots are present, increase planting distance
- ► if large surface roots are not present, decrease planting distance
- ► large roots will not develop if a 50-cm (20-in.) disk is used to prune roots each year.

Lower branches of theses intermediate-aged trees in alleys are being pruned.

Forage crops can be successfully grown as an intercrop with larger trees. Acceptable forage crops or mixes include timothy, orchard grass, tall fescue, alfalfa, red and white clover, and birdsfoot trefoil, among others.

Nitrogen-fixing legumes may benefit tree rows.

Specialty Crops

Niche market crops can be successfully grown in the alleys. Ginseng, Solomon's seal, and a variety of mushrooms, for example, have ready markets throughout North America and around the world.

Shade-tolerant landscape plants (dogwood, redbud, hosta, euonymus) may also be grown where local markets exist or a contract with a distributor can be negotiated.

POSSIBLE CONSTRAINTS OF INTERCROPPING

Tree roots may interfere with farm machinery and planned tillage practices. Tillage equipment may have to be modified to deal with problem roots. Coulters should be well-maintained, and extra weight on the plow will help to sever roots.

The roots of some tree species can invade a perforated or damaged tile drain. Plant the tree rows at the midway point between tiles.

Intercropped plantings can be ideal sites for specialty forest crops such as herbs, medicinals and ornamentals.

Weeds and other unwanted vegetation can thrive within the tree row and spread to the alley crop areas. Careful weed control is required to avoid weed and pest pressure.

INTERCROPPING CASE STUDY

A long-term study by the University of Guelph set out to better understand the ecological interactions between trees and crops. In 1987, researchers established a large field experiment on 30 ha of prime agricultural land in southern Ontario. This land had been cash cropped for a number of years, and sheet and rill erosion had become a significant problem.

A variety of tree species were planted, including Spruce, Cedar, Black Walnut, Oak, Ash and Poplar. Two between-row spacings (12.5 m, 15 m) and two within-row spacings (5 m, 6.25 m) were used in conjunction with three agricultural crops: soybeans, corn and either winter wheat or barley.

The summer after the trees were planted was very dry. Many trees were lost to drought despite efforts to irrigate. In hindsight it would have been better to spread the work over two or three years and provide more intensive care for fewer trees each year.

Investigations over the last decade have revealed several beneficial (complementary) interactions as a result of ideal tree-crop establishment combinations. Here's a list of key findings:

- soil organic carbon adjacent to tree rows increased by over 1%, largely as a result of tree litterfall inputs
- yields of soybeans and wheat intercropped with trees, as well as growth of trees, did not differ from those in corresponding conventional systems of crop management
- the abundance and distribution of earthworms were higher closer to the tree rows, indicating improved soil health
- bird diversity (10 times more) and usage increased within the intercropped area as compared to monocropped adjacent agricultural areas
- increases in small mammal populations were recorded
- the carbon sequestration potential of intercropping systems based on fast-growing trees (Hybrid Poplar) was four times more than that reported for conventional agricultural fields in the region
- it was estimated that intercropping reduced nitrate loading to adjacent waterways by 50%
- because of reduced fertilizer use and more efficient N-cycling, the tree-intercropping systems could also lead to the reduction of nitrous oxide emissions from agricultural fields by about 0.7 kg ha/yr.

Weed control and in some cases irrigation are required to help trees reach the free-to-grow stage.

Intercropped trees should be pruned regularly before reaching crown closure within the row.

Shade-tolerant crops and controlled grazing are suited to the shaded conditions found when the stand reaches crown closure over the alley crop row.

Careful site investigations and planning are required prior to intercropping to make the planting a success.

Monitor carefully for drought stress during the year of planting.

BMPs FOR SILVIPASTURE

Silvipasture refers to the introduction of trees into a traditional pasture system or the controlled grazing of a recently established forest plantation. Silvipasture areas can be established:

- in an open field through planting trees and establishing forage in the understory, or
- by planting trees into an existing pasture.

With appropriate management, this system can be expected to have a combined yield (through, nuts, wood, fibre, livestock, etc.) greater than if each were managed separately.

Trees planted in pastures offer livestock shelter and shade.

The presence of trees on a farm increases the visual appeal of the farm and may reduce conflicts between farmers and non-farm rural residents. A different and pleasing landscape may also attract additional customers if farmgate sales are part of the operation.

Done properly, silvipasture can:

- diversify income
- improve structure and nutrient characteristics of the soil
- enhance source water protection
- increase animal comfort and productivity by reducing environmental extremes
- decrease a farm's greenhouse gas emission levels
- increase a farm's ecological diversity and aesthetics.

All trees sequester carbon from the atmosphere. Individual fast-growing Hybrid Poplars can remove approximately 25 kg of CO_2 per year from the atmosphere. If trees are planted in a 10x10-m grid, there would be 100 trees per hectare which, in combination with the pasture production, can remove 2.5 tonnes of carbon per hectare per year. Pasture alone can remove approximately 1 tonne of carbon per hectare per year.

CONSIDERATIONS

LAND SUITABILITY

The following land uses and conditions are suitable for silvipasture:

- improved pastures
- forage/pasture systems
- fragile lands – erodible soils that would benefit from permanent cover
- marginal lands – steeply sloping cropland, irregular topography and ravines
- riparian zones where access to open watercourses is restricted.

FORAGE PRODUCTION AND REQUIREMENTS

Introducing trees into your pasture will affect the amount of forage (browse) produced. As the trees grow, the amount of available light needed to grow the understory forages decreases.

Carefully consider the impacts on forage production before you plant your pasture land. Here are some key impacts:

- young trees will have no immediate effect on the amount of forage produced
- forage production declines with the increasing shade from growing trees, and more shade-tolerant pasture species will start to dominate
- the number of trees planted per hectare as well as the species of tree will greatly influence the amount of forage produced
  - ▷ most conifers and hardwoods pruned to maintain a compact canopy will have less of an impact on forage production than trees with a broad, dense canopy
- management-intensive grazing practices are well-suited to silvipasture establishment (see the BMP book *Streamside Grazing* for more information).

SOIL, NUTRIENT AND WATER MANAGEMENT

Trees benefit soil nutrients, contaminants and water movement. This can improve the soil's overall productivity with no additional effort required on your part.

Tree **roots**:

- reach down below the rooting zone of most crop species to improve internal drainage and soil structure
- capture nutrients and contaminants that may otherwise filter into the groundwater or move into streams and ponds
- promote microbial populations that can use potential contaminants, pesticides and excess nutrients, as a source of food
- recycle nutrients through root turnover.

Tree **leaves**:

- recycle nutrients through leaf fall and decay
- release these nutrients slowly.

It's important to ensure there is an even distribution of shade. Otherwise, one area of the pasture will suffer from excessive grazing and compaction. This area may also receive an excessive amount of nutrients in the form of manure and urine. It may not recover within the normal rotation period and require additional rehabilitation efforts.

ANIMAL WELFARE

Trees may provide many benefits to the pasture's microclimate. Trees can improve the survival, comfort and health of young animals in particular, for these reasons:

- on cold nights, the tree canopies can act as an insulating blanket, reducing heat loss
- trees interrupt windflow and may help to reduce convective heat loss from the pastured livestock
- on hot days, trees provide shelter from the direct sun.

OPTIONS

BIOENERGY

Planting fast-growing, short-rotation trees for *bioenergy* production can reduce the cost of silvipasture while still providing some of the benefits.

Hybrid Willows and Poplars are most commonly used for biomass plantations. Trees are harvested on a three- to five-year cycle to provide regular and predictable revenue.

To be economically successful, obviously a local market is preferred. If no local market exists, much of the woody biomass can be used on the farm as fuel for crop driers or heating buildings or as bedding material. There may also be a market for planting stock (cuttings) from the established plantation.

FRUIT AND NUT PRODUCTION

It's possible to grow fruit- and nut-producing trees in a silvipastural system, although there are a number of precautions that may make it incompatible under most circumstances:

- requirements for pesticides and fungicides may be incompatible with livestock
  - ▷ in a pesticide-free or organic cultural system, this is not an issue
- fruits or nuts that fall to the ground should not be collected and marketed for human consumption
- livestock should be excluded during establishment.

Conifer trees in silvipasture are not heavily browsed.

SPECIES SELECTION

As always, selecting appropriate species is key to success. Here are some pointers.

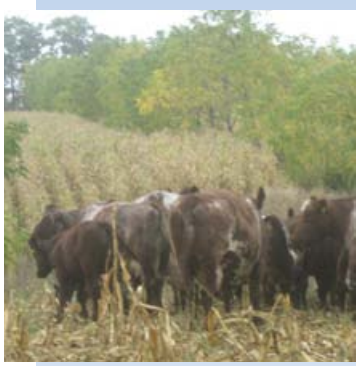
CONIFERS

- conifers may lower pasture production
- Pine and Spruce tend to be less palatable feed, and will usually suffer less browsing
- some conifers will maintain live foliage at or near ground level; therefore, regular pruning is required to raise the crown and improve future wood value
- branches should be removed from the pasture

Tree shelters provide some protection for hardwoods in inter-cropped plantings.

HARDWOODS

- may provide alternative browse for livestock
- casual browsing can reduce the future value of a tree
- trees should be protected until they've grown beyond the animals' reach
- Honey Locust is an excellent choice for a silvipasture system because the sparse canopy allows maximum light to penetrate to the ground level, and seed pods are an excellent feed supplement



Black Walnut and Ash species also allow significant amounts of light to reach the ground.

IMPLICATIONS FOR LIVESTOCK

A number of tree species are known or suspected to be incompatible with some species of livestock – largely due to the toxins that are produced by the species listed below.

TREE AND LIVESTOCK INCOMPATIBILITY

SPECIES	PIG	SHEEP/ GOAT	DAIRY	BEEF	HORSE
WALNUT/BUTTERNUT (*Juglans spp*)					X
RED MAPLE (*Acer rubrum*)					X
CHERRY (*Prunus spp*)	X	X	X	X	X
BLACK LOCUST (*Robinia pseudoacacia*)	X	X	X	X	X
OAK (*Quercus spp.*)			X	X	X

ESTABLISHMENT AND MAINTENANCE

LAYOUT

✔ **Plant hardwoods at densities of 200–600 trees/ha** (80–250 trees/ac) to minimize pasture production losses.

✔ **Plant conifers at higher densities,** because they have more compact crowns.

✔ **Ensure an even distribution of shade** to avoid problems associated with animals standing and grazing in one area – planting pattern may be random or follow a grid layout.

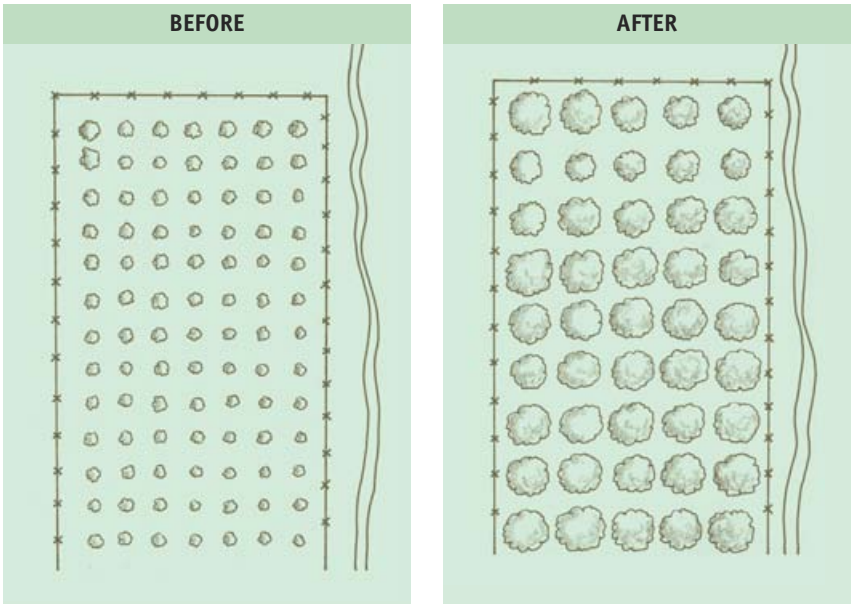
✔ **Thin plantations over time to a final density of 100–300 trees/ha** (40–125 trees/ac).

MAINTENANCE

Weed control is generally not required due to livestock grazing.

✔ **Use fencing and tree shelters** to protect young trees from livestock.

✔ **Prune regularly** to increase the future value of the trees.



Hardwoods can be planted at lower densities to minimize pasture production losses, and later thinned to remove poorer quality trees.

POTENTIAL PROBLEMS

- reduced forage production may require changing grazing management practices
- some tree species are incompatible with some livestock – consult with your veterinarian before planting
- tree protection can be costly
- livestock may congregate – leading to greater risks of disease

Protect trees from grazing, rubbing and trampling (especially young trees) using electric fencing, plastic tree shelters or a repellent.

SILVIPASTURE CASE STUDY

A farmer with 100 ewes sectioned off 20 hectares of pasture and divided this into four 5-hectare paddocks suitable for rotational grazing. An additional 10 ha of pasture was available but not planted with trees.

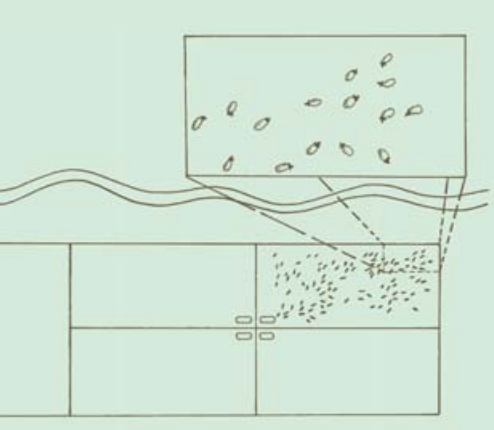
The White Spruce was planted at a density of 400 stems per ha (5x5-m spacing) with an expected final density of 200 stems per ha. The hardwoods (Sugar Maple and White Ash) were planted at 250 stems per ha (5x8 m spacing) with a planned final density of 100–125 stems per ha. The planting site was carefully laid out with each planting spot clearly marked. Two weeks prior to planting, each tree location was sprayed with a contact herbicide to eliminate vegetation within a 0.5 m radius. All trees were planted by hand.

In the first year after planting, the animals were not allowed on the land where the hardwoods were planted to avoid browsing and trampling. The forage crop was harvested and fed to the animals as required. The animals were introduced into the paddocks planted to Spruce in late summer. By this time the trees had set bud and the foliage was mature. At this stage, the trees are less palatable to sheep and more tolerant of casual browsing.

The following spring, the young hardwood trees were fenced off with a single strand of electric fence. The sheep were introduced into the first paddock when the ground was firm and not subject to compaction by the animals. The animals were allowed to graze in each paddock until the average height of the pasture was less than 10 cm, then moved to the next paddock. This was done for several years until the tree canopies were above the reach of the animals.

Over the next few years, the trees were monitored for damage, disease and insect problems. Severely damaged or diseased limbs were removed. Once the trees had reached a height of 2–3 m, a regular program of pruning and culling began. Lower branches were removed to one half the height of the tree. This is done every two or three years and no more than 25% of the live crown is removed in any one year.

When the trees mature, there will be a number of potential markets for the products. The Maple trees may be tapped for sap. The Ash will likely be sold to a local saw mill, while the Spruce may be sold or used on farm.



This pasture was divided into four 5-hectare paddocks. White Spruce and Sugar Maple were planted at wide spacings between trees and rows to facilitate grazing and pasture management.

GLOSSARY

Abiotic – Non-living components of the environment such as air, rocks, water, peat and plant litter.

Afforestation – Establishment of trees on an area that has lacked forest cover for a very long time (at least 50 years).

Agroforestry – The practice of integrating trees with agricultural crops and/or livestock.

Bioenergy – Energy produced from renewable biological sources such as plant biomass.

Biotic – Living components of the environment or ecosystem such as plants, animals, insects and fungi.

Buffer strip – A strip of vegetation – usually a mix of trees, shrubs and grasses – planted alongside natural areas, e.g., water-courses, to protect them from surrounding land uses.

Cambium – Single layer of cells between the woody part of the tree and the bark. Division of these cells results in diameter growth of the tree through the formation of wood cells (xylem) and inner bark (phloem).

Carbonates – Free calcium carbonate in the soil profile. Can interfere with nutrient uptake in some species.

Clinometer – A device that is used to measure the slope between two points of land.

Deciduous trees – Trees that shed their leaves at the end of the growing season.

Desiccation – Loss of moisture causing plants to dry out. May result in damage or death.

Drip line – A line on the ground around a tree that follows the outermost edges of the tree's branches.

Evapotranspiration – The process of transferring moisture from the earth to the atmosphere by evaporation of water and the passage of water through plants (transpiration).

Exotic species – Non-native species found in a given area as a direct or indirect result of human activity.

Fragile land – Land that requires special management to avoid loss of productivity due to degradation processes such as erosion or compaction.

Hybridization – The process of breeding plants of different varieties or species with the goal of emphasizing certain traits such as yield or disease resistance.

Income in-kind – Measure of the value of agricultural commodities produced on farms and consumed by individuals living on these farms.

Intercropping – Growing trees or shrubs in a planned fashion in a field growing other crops such as corn.

Invasive species – Highly competitive non-native species whose introduction or spread threatens the environment, human health, and /or the economy.

Marginal land – Land of limited potential productivity, e.g., excessively stony soils.

Meristems – Plant tissue consisting of cells that actively divide to form new tissues resulting in plant growth.

Mottles – Rust-coloured spots in the soil profile that mark the depth of the seasonal water table.

Mycorrhizae – Symbiotic fungi that colonize roots of many crop species, effectively extending the root system and increasing the absorption of nutrients, especially phosphorus.

Offsite planting – Planting of trees or shrubs in locations that are unsuitable due to soil or site conditions.

Photosynthesis – The process by which green plants make carbohydrates from carbon dioxide and water in the presence of chlorophyll. Plants use energy captured from sunlight and release oxygen as a byproduct.

Pioneer species – A tree species that is usually first to grow on a disturbed or open site.

Plantation – Woodland crop established by artificial means, either by sowing or planting.

Porosity – The amount of air space in a cross-sectional view of a windbreak. This air space allows wind to move through the barrier.

Reforestation – Natural or artificial restocking (i.e., planting, seeding) of an area with forest trees following a forest fire or other natural or human disturbances. Under the Kyoto Agreement, reforestation occurs when an area that has not been open for more than 50 years is returned to a forested state.

Regime – A class of physical conditions that can be defined by some particular physical phenomenon, e.g., moisture levels in soil.

Rills – Narrow channels running parallel to the slope of the land caused by the erosion of soil by water.

Riparian zone – The transitional area between surface water and uplands.

Root-to-shoot ratio – The amount of root (below-ground) material of seedlings/transplants compared to the amount of shoot (above-ground) material.

Seasonal water table – The uppermost level of groundwater that can vary in depth from the surface of the ground depending on the weather conditions and season.

Sequestration – Uptake and storage, especially of carbon.

Shade-tolerant – Plant species that are able to thrive and mature under low light conditions.

Sheet flow – The flow of water over a wide area of ground surface, generally of uniform depth. Typically occurs on uniform, gradual slopes.

Shelterbelt – A vegetative barrier that reduces the flow of wind and the associated negative impacts. Has at least six rows of trees or shrubs in open field areas or upwind and adjacent to buildings.

Silviculture – The practice of controlling the establishment, growth, composition, health and quality of forests and woodlands.

Silvipasture – The practice of growing trees with pasturing livestock.

Silvics – Study of the life history and general characteristics of trees.

Soil texture – Percentage of sand, silt and clay found in a particular soil.

Succession – The natural and gradual replacement of one community of trees and plants by another.

Windbreak – A vegetative barrier that reduces the flow of wind and the associated negative impacts. Consists of one or more rows of trees or shrubs in open field areas or upwind and adjacent to buildings.

Windbreak density – A measure of the space occupied by trees. Density is controlled by tree species selection, and in-row and between-row spacing.

Windfirm – A term describing trees with characteristics that make them resistant to damage by wind.

Agencies and Offices

Christmas Tree Farmers of Ontario
Box 93, Wasaga Beach, ON L9Z 1A2
ph: 705-429-5328
web: http://www.christmastrees.on.ca

Conservation Ontario
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ph: 905-895-0716
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web: http://conservationontario.ca

Eastern Ontario Model Forest
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Kemptville, ON K0G 1J0
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Landowner Resource Centre
Box 599
3889 Rideau Valley Drive
Manotick, ON K4M 1A5
ph: 1-800-267-3504
e-mail: info@lrconline.com
web: http://www.lrconline.com

Ontario Ministry of Agriculture, Food and Rural Affairs
Agricultural Information Contact Centre
ph: 1-877-424-1300
e-mail: ag.info.omafra@ontario.ca
web: http://www.omafra.gov.on.ca

Ontario Ministry of Natural Resources
Natural Resources Information Centre
ph: 1-800-667-1940
web: http://www.mnr.gov.on.ca

Ontario Soil and Crop Improvement Association
1 Stone Road West
Guelph, ON N1G 4Y2
ph: 1-800-265-9751
web: http://www.ontariosoilcrop.org

Ontario Stewardship
Ontario Ministry of Natural Resources
300 Water Street, 4th floor, South Tower
Peterborough, ON K9J 8M5
ph: 705-755-3278
web: http://www.ontariostewardship.org

Ontario Woodlot Association
275 County Road 44, R.R. #4
Kemptville, ON K0G 1J0
ph: 1-888-791-1103
e-mail: info@ont-woodlot-assoc.org
web: http://www.ont-woodlot-assoc.org

Publications

BEST MANAGEMENT PRACTICES SERIES

Buffer Strips, 2004

Fish and Wildlife Habitat Management, 1996

Woodlot Management, 2007

EASTERN ONTARIO MODEL FOREST

A Guide to Improving and Maintaining Sugar Bush Health and Productivity, 2006

A True Picture: Taking Inventory of Your Woodlot, 1997

Choosing the Right Tree: A Landowner's Guide to Putting Down Roots, 2004

Design, Installation and Maintenance of Plastic Tubing Systems for Sap Collection in Sugar Bushes, 2006

Eastern Ontario Model Forest Code of Forestry Practice, 1996

ONTARIO MINISTRY OF NATURAL RESOURCES

Extension Notes Series (approximately 55 titles) – Landowner Resource Centre, Manotick, Ontario

Guide to Stewardship Planning for Natural Areas

Silvicultural Guide to Managing Southern Ontario Forests, Version 1.1, 2000, 648 pages

See http://www.mnr.gov.on.ca/en/Business/Forests and click on "Private Forest Stewardship"

MNR also has a series of guide books regarding forest practices to protect and improve wildlife habitat, watersheds, and other values. Please see the Publications section of their website.

ONTARIO SOIL AND CROP IMPROVEMENT ASSOCIATION

Ontario Environmental Farm Plan Workbook, 3rd ed., 2004

ONTARIO WOODLOT ASSOCIATION

A Landowner's Guide to Selling Standing Timber, 2001

DISCLAIMER

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