

# 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.**

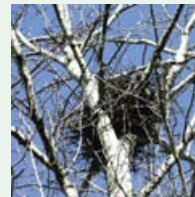
##### ATMOSPHERE

- 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](http://geogratis.cgdi.gc.ca/CLI/index_agriculture.html).

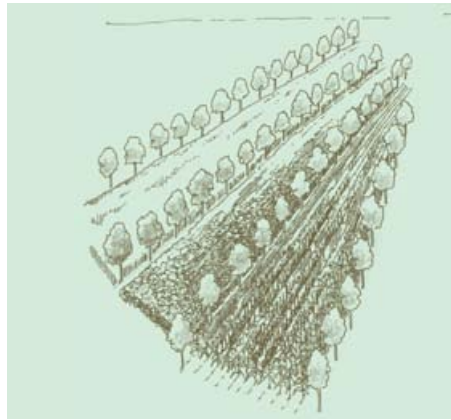
For agriculture, the CLI has seven classes, where Class 1 has no significant restrictions to production and Class 7 is not suitable for any agriculture.

INTERCROPPING SYSTEM	CLI CLASS 1-2	CLI CLASS 3-4	CLI CLASS 5
HIGH-VALUE HARDWOODS	<ul style="list-style-type: none"> <li>tree rows widely spaced</li> <li>crop production continues for many years</li> </ul>	<ul style="list-style-type: none"> <li>tree rows closely spaced</li> <li>crop production changes to shade-tolerant crops or ends</li> </ul>	<ul style="list-style-type: none"> <li>not recommended</li> </ul>
ENERGY PLANTATION	<ul style="list-style-type: none"> <li>not recommended</li> </ul>	<ul style="list-style-type: none"> <li>tree rows widely spaced</li> <li>crop production continues for many years</li> </ul>	<ul style="list-style-type: none"> <li>tree rows closely spaced</li> <li>crop production changes to shade-tolerant crops, cool-season grasses or ceases</li> </ul>
NUT/FRUIT/MAPLE ORCHARD	<ul style="list-style-type: none"> <li>tree rows wide or closely spaced</li> <li>crop production ends as tree canopy matures</li> <li>possibility of growing shade-tolerant crops where pesticide use does not conflict</li> </ul>	<ul style="list-style-type: none"> <li>tree rows closely spaced</li> <li>crop production ends as tree canopy matures</li> <li>possibility of growing shade-tolerant crops where pesticide use does not conflict</li> </ul>	<ul style="list-style-type: none"> <li>suitable for Maple orchard only – provided the reason the site is Class 5 is due to topography and surface stoniness</li> <li>not recommended for fruit and nut production</li> <li>tree rows closely spaced</li> </ul>
AFFORESTATION	<ul style="list-style-type: none"> <li>not recommended</li> </ul>	<ul style="list-style-type: none"> <li>recommended for fragile soils</li> <li>trees closely spaced</li> <li>crop production ends as tree canopy matures</li> </ul>	<ul style="list-style-type: none"> <li>recommended for degraded or fragile soils</li> <li>tree rows closely spaced</li> <li>crop production ends as tree canopy matures or permanent cover crop is established with trees</li> </ul>
INTEGRATED NURSERY PRODUCTION	<ul style="list-style-type: none"> <li>possible on all soil types</li> </ul>	<ul style="list-style-type: none"> <li>possible on sites with adequate drainage, rooting depth and few stones</li> </ul>	<ul style="list-style-type: none"> <li>not recommended</li> </ul>
SPECIALTY CROP PRODUCTION (e.g., ginseng, golden seal)	<ul style="list-style-type: none"> <li>possible on all soil types</li> <li>crop must be carefully selected to match site</li> </ul>	<ul style="list-style-type: none"> <li>possible on all soil types</li> <li>crop must be carefully selected to match site</li> </ul>	<ul style="list-style-type: none"> <li>not recommended</li> </ul>

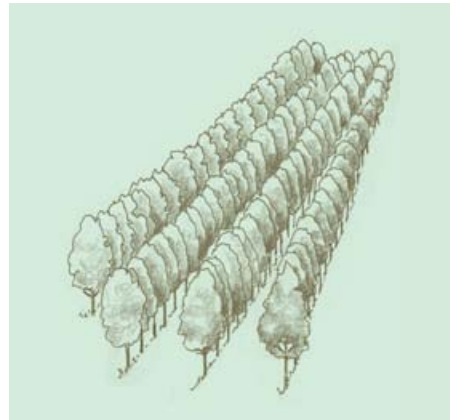




Intercropping with high-value hardwoods on Class 1–3 lands.



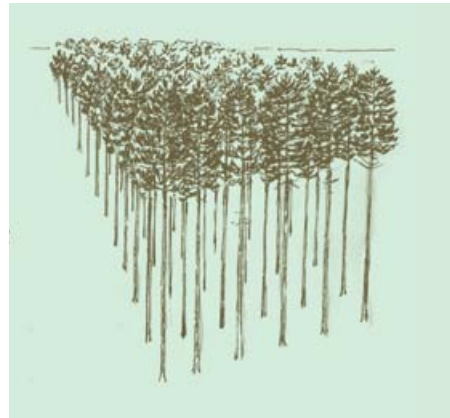
High-value hardwoods



Energy plantation



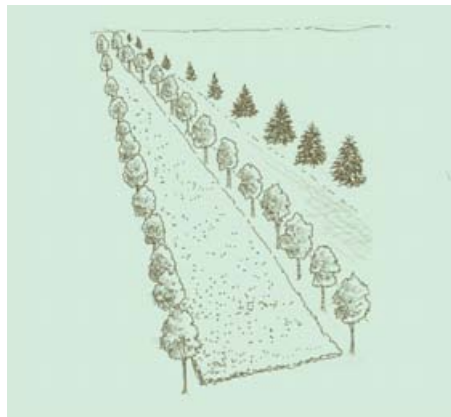
Nut/Fruit/Maple orchard



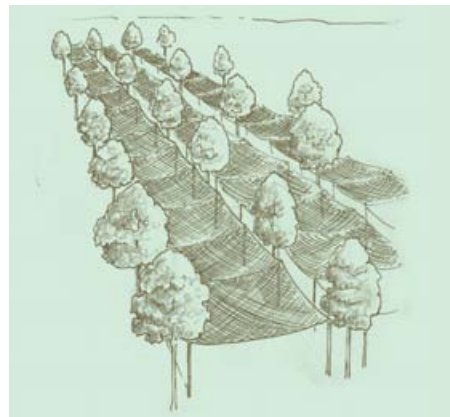
Afforestation



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



Integrated 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
<b>energy plantation</b> <ul style="list-style-type: none"> <li>• 3–5-year rotation, typically using fast-growing Poplar or Willow</li> </ul>	<b>specialty crops</b> (ginseng, golden seal, mushroom) <ul style="list-style-type: none"> <li>• in narrow alleys, typically associated with hardwoods</li> </ul>	<b>afforestation with conifers</b> (land retired from farm production) <ul style="list-style-type: none"> <li>• revenue depends on future value of standing tree crop</li> </ul>	<b>high-value hardwood plantation</b> <ul style="list-style-type: none"> <li>• intercropped with annual cash crops</li> </ul>
<b>fibre production</b> <ul style="list-style-type: none"> <li>• 5–10-year rotation, typically using fast-growing Poplar for OSB* and other building materials</li> </ul>	<b>nursery production</b> <ul style="list-style-type: none"> <li>• a variety of crops may be grown unless pesticides that are incompatible with food crops are required</li> </ul>	<b>afforestation with valuable hardwoods</b> <ul style="list-style-type: none"> <li>• revenue depends on future value of standing tree crop</li> </ul>	<b>orchard production</b> (nut/fruit/maple) <ul style="list-style-type: none"> <li>• intercropped with cash crops until the tree crop becomes profitable</li> </ul>

\*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

Consulting services are optional, but may be needed.

1. Create a detailed map of your planned operation

2. Determine the orientation of your tree rows

3. Determine the appropriate row width

4. Determine the spacing of trees within your rows

5. Select a species that suits your operation

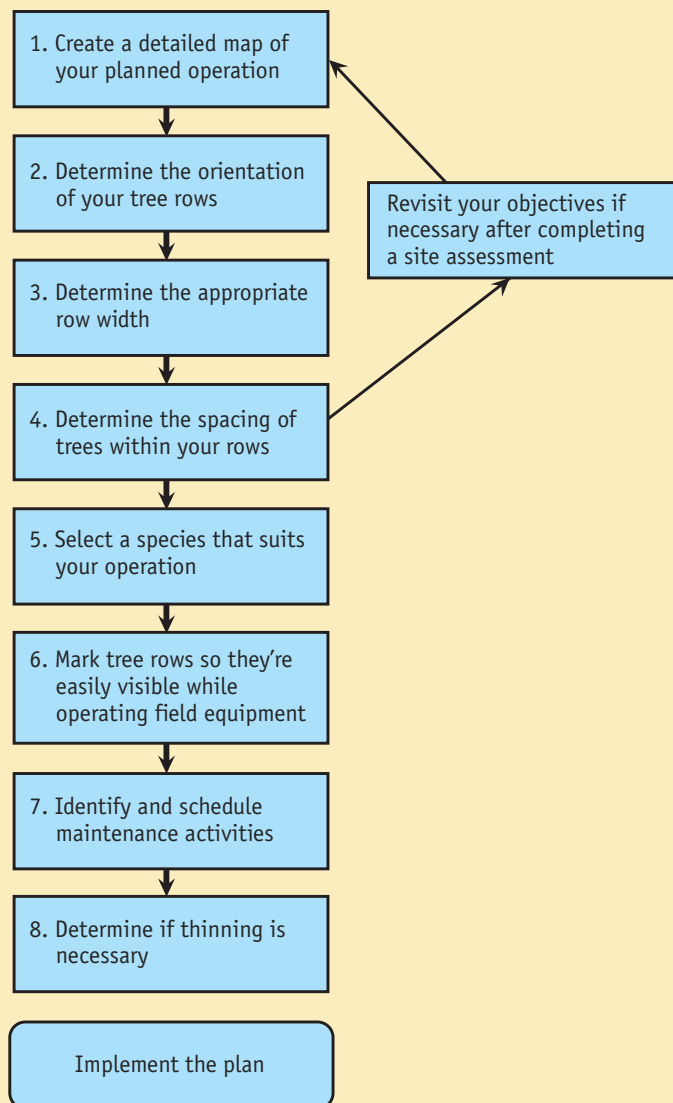
6. Mark tree rows so they're easily visible while operating field equipment

7. Identify and schedule maintenance activities

8. Determine if thinning is necessary

Implement the plan

Revisit your objectives if necessary after completing a site assessment



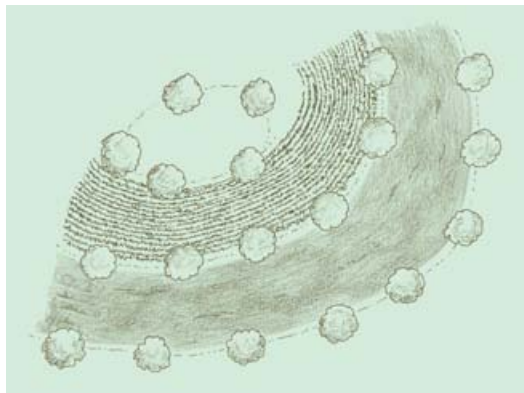


**PLANNING FOR INTERCROPPING:**

- 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

**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.

**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

**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

**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

**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
<ul style="list-style-type: none"> <li>improved soil physical characteristics – such as lower bulk density, increased infiltration, better tilth</li> </ul>	<ul style="list-style-type: none"> <li>increased competition for resources, especially light</li> </ul>
<ul style="list-style-type: none"> <li>improved nutrient characteristics</li> </ul>	<ul style="list-style-type: none"> <li>improved habitat for herbivores</li> </ul>
<ul style="list-style-type: none"> <li>greater biological activity and improved habitat for birds and other insectivores</li> </ul>	<ul style="list-style-type: none"> <li>increased weed and pest pressures</li> </ul>

## 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.

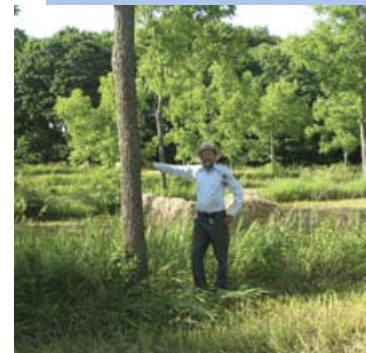
Forage crops may out-compete young trees for water and nutrients.

### 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.

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.



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

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



## 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.



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.

**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.**



**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.**

