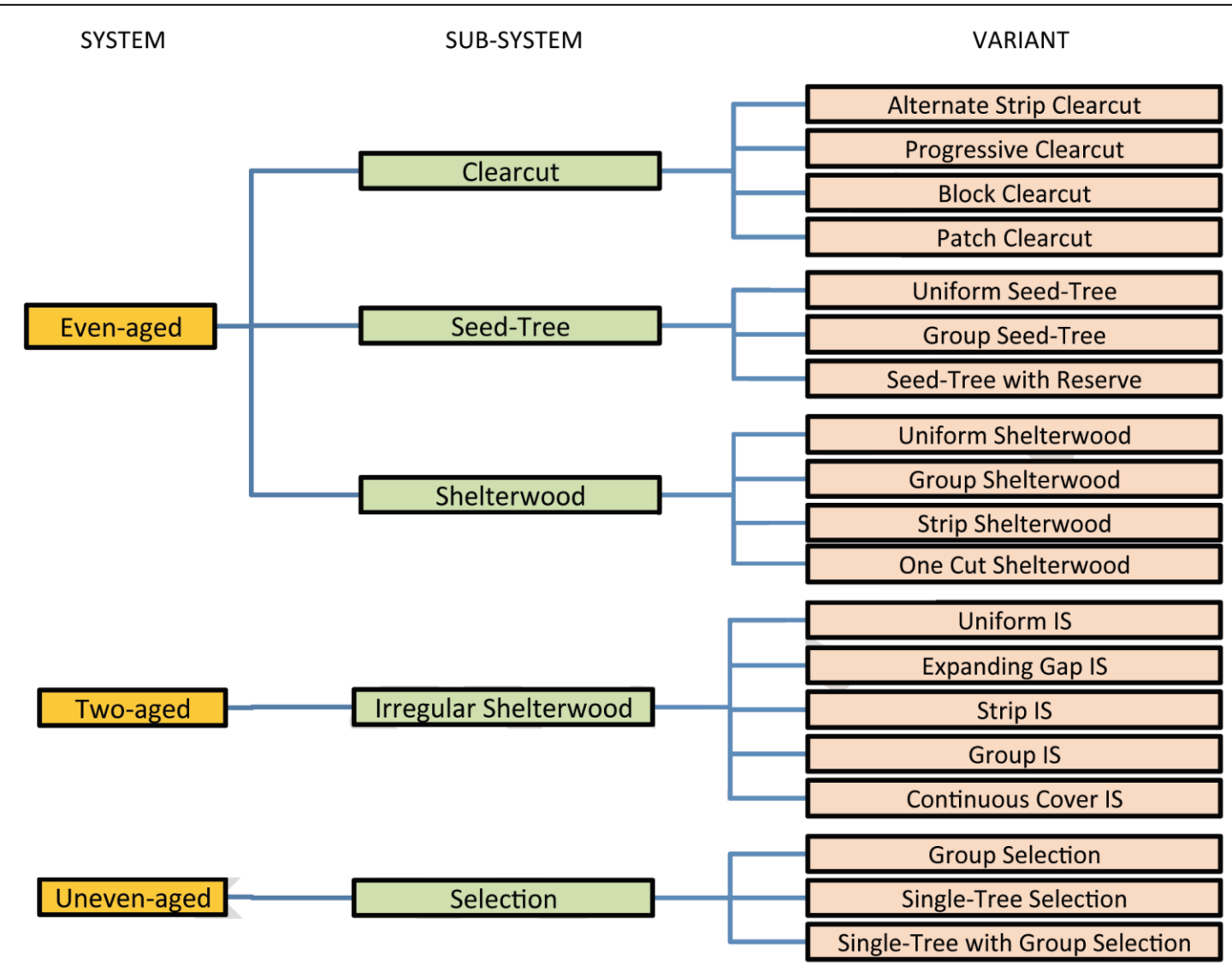
Institut de recherche sur les feuillus nordiques Inc.
Northern Hardwoods Research Institute Inc.

Description of NHRI Silviculture treatments

Hierarchical classification of silvicultural systems



Institut de recherche sur les feuillus nordiques
Northern Hardwoods Research Institute

Method/Treatment:

Alternate Strip Clearcut

System: **EVEN-AGED**

Sub-system: **Clearcut/seed tree**

ACC

Stand Eligibility

- **FUNA:** BETH, THIH, THMX
- **Structure:** all but M1 & M2 (except for BETH)
- Presence of trees of desired species and quality to provide seeds
- Species that do not require protection from exposure to regenerate successfully
- Mature to overmature development stage
- Poor quality stand or low stocking
- Even distribution of trees within stand
- Lack of pre-established regeneration
- Low probability of competition by aggressive interfering plants

Objectives of system

This process of regeneration brings together cuts that include harvesting all or almost all merchantable stems in a stand (90 to 100% of the merchantable volume) in 2 entries.

This sub-system removes most or all merchantable trees from the strips and subsequently regenerates an even-aged stand. The regeneration is obtained from natural seeding from adjacent stands, harvested trees, advance regeneration or artificial sources (planting or direct seeding). It is important to adjust the size of the areas cut based on the distance over which the seeds are disseminated

The general factors to consider before implementing clearcut are:

- High percentage of mature and unhealthy trees
- Presence of seed trees of desired species
- Seedling characteristics of desired species (i.e. do not need shelter for establishment and survival)
- Suitable seedbed and growing conditions
- Site preparation
- Existing and potential competition from undesired vegetation

Description

The stand is harvested in alternate strips at separate periods of time. The uncut strip serves as seed source to facilitate natural regeneration and protect the harvested strips. Hence, consideration must be given the strip width and orientation. . Depending on the width of the strips and the orientation and protective effect of the adjacent trees, this pattern can favor regeneration of intermediate shade-tolerant species like yellow birch, American elm and basswood (American linden) and better control invasion by competition. The alternate uncut strips are removed within a period of time not exceeding 20% of intended rotation (<20 years).

1. If possible, orient the strips northwest to southeast so that residual trees can protect regeneration from high light intensity but seed dispersion by wind is accentuated.
2. Cut strips should be perpendicular to the prevailing winds to promote even seed distribution.
3. Understand shade tolerance of the desired species (wider strips for less shade-tolerant species and vice versa).

.

Desired Outcomes

Immediate	Mid-term	Long-term
Creation of progressive strips in the stand.	Recruitement of new cohort of desired species	Full stocking of seedlings and saplings
Creation of germination beds	Low competition by interfering plants	Low competition High density to allow for quality development
Abundance of seeds for germination	Good seedling survival	Stand ready for intermediate silviculture
Adequate Soil exposure		

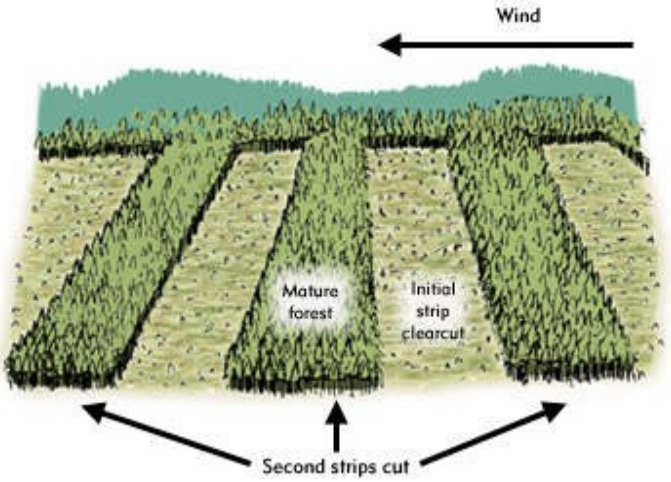
Key success factors

- Strip pattern adjusted to the species of interest
- Planned on good seed years
- Strips oriented to maximize seed dispersion

Implementing Alternate strip clear-cut treatments

Operational considerations

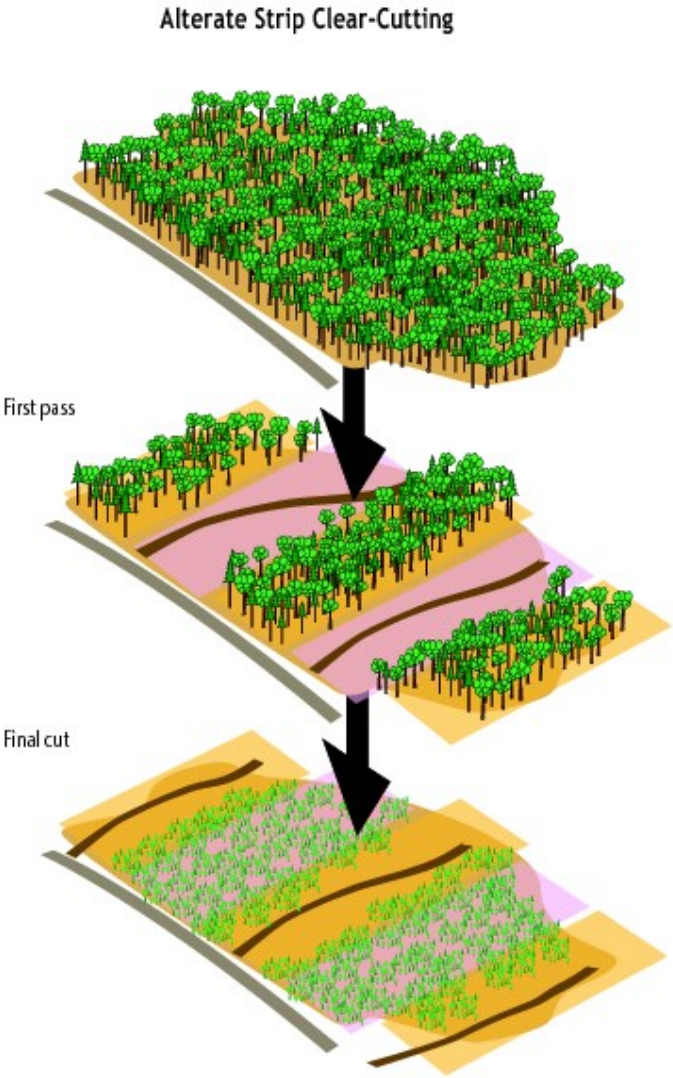
	Prefered	Tolerated	Avoid
Full tree system	X		
CTL system		X	
Leaves off		X	
Frozen ground		X	



https://www.for.gov.bc.ca/hfp/training/00014/varclear.htm#cl

Getting started:

- Plan treatments in a good seed year and in the proper season
- Determine the right strip width according to species (see table below) .
- When possible, orient strips so that they are mostly perpendicular to dominant winds but avoid prolonged direct light (NW or SE)
- Schedule the next re-entries so that the entire area is covered in less than 20 years. (i.e. years 1 and 15)



Source: CERFO

Recommended Strip Widths for Clear-Cutting, By Species and Type of Environment *(Lupien 2008)*

Species / environment	Strip Width (in metres or stem heights)
Poplars	20 m minimum
White birch	15-50 m
Yellow birch	15-30 m
Black cherry	1H
Red pine	1H
Dry sites	1H

*H=tree height

Institut de recherche sur les feuillus nordiques
Northern Hardwoods Research Institute

Method/Treatment:

Progressive strip Clearcut

System: **EVEN-AGED**

Sub-system: **Clearcut/seed tree**

PCC

Stand Eligibility

- **FUNA:** BETH, THIH, THMX
- **Structure:** all but M1 & M2 (except for BETH)
- Presence of trees of desired species and quality to provide seeds
- Species that require some protection from exposure to regenerate successfully
- Mature to overmature development stage
- Poor quality stand or low stocking
- Even distribution of trees within stand
- Lack of pre-established regeneration
- Low probability of competition by aggressive interfering plants

Objectives of system

This process of regeneration brings together cuts that include harvesting all or almost all merchantable stems in a stand (90 to 100% of the merchantable volume).

This sub-system removes most or all merchantable trees from the stand in three or more operations and subsequently regenerates an even-aged stand. The regeneration is obtained from natural seeding from adjacent stands, harvested trees, advance regeneration or artificial sources (planting or direct seeding). It is important to adjust the size of the areas cut based on the distance over which the seeds are disseminated

The general factors to consider before implementing clearcut are:

- High percentage of mature and unhealthy trees
- Presence of seed trees of desired species
- Seedling characteristics of desired species (i.e. need some shelter for establishment and survival)
- Suitable seedbed and growing conditions
- Site preparation
- Existing and potential competition from undesired vegetation

Description

The stand is removed using series of strips or patches harvested over three or more entries, usually covering an equal area on each occasion. This method may be chosen to reduce water fluctuations, windthrow. Erosion and offer some shelter.

Depending on the width of the strips and the orientation and protective effect of the adjacent trees, this pattern can favor regeneration of intermediate shade-tolerant species like yellow birch, American elm and basswood (American linden) and better control invasion by competition. The alternate uncut strips are removed within a period of time not exceeding 20% of intended rotation (<20 years).

1. If possible, orient the strips northwest to southeast so that residual trees can protect regeneration from high light intensity but seed dispersion by wind is accentuated.
2. Cut strips should be perpendicular to the prevailing winds to promote even seed distribution.
3. Understand shade tolerance of the desired species (wider strips for less shade-tolerant species and vice versa). .

Desired Outcomes

Immediate	Mid-term	Long-term
Creation of progressive strips in the stand.	Recruitement of new cohort of desired species	Full stocking of seedlings and saplings
Creation of germination beds	Low competition by interfering plants	Low competition High density to allow for quality development
Abundance of seeds for germination	Good seedling survival	Stand ready for intermediate silviculture
Adequate Soil exposure	Low tree mortality	
No site damage		
No valuable leave trees at risk		

Key success factors

- Strip pattern adjusted to the species of interest
- Planned on good seed years
- Strips oriented to maximize seed dispersion

Implementing Progressive clearcut treatments

Operational considerations

	Prefered	Tolerated	Avoid
Full tree system	X		
CTL system		X	
Leaves off		X	
Frozen ground		X	

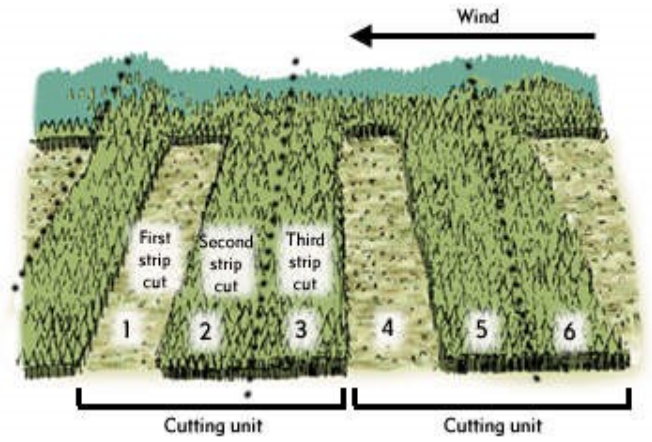
Getting started:

- Select the # of strips required (function of # entries desired)
- Plan treatments in a good seed year and in the proper season
- Determine the right strip width according to species (see table below) .
- When possible, orient strips so that they are mostly perpendicular to dominant winds but avoid prolonged direct light (NW or SE)
- Schedule the next re-entries so that the entire area is covered in less than 20 years (i.e. years 1, 10, 20)

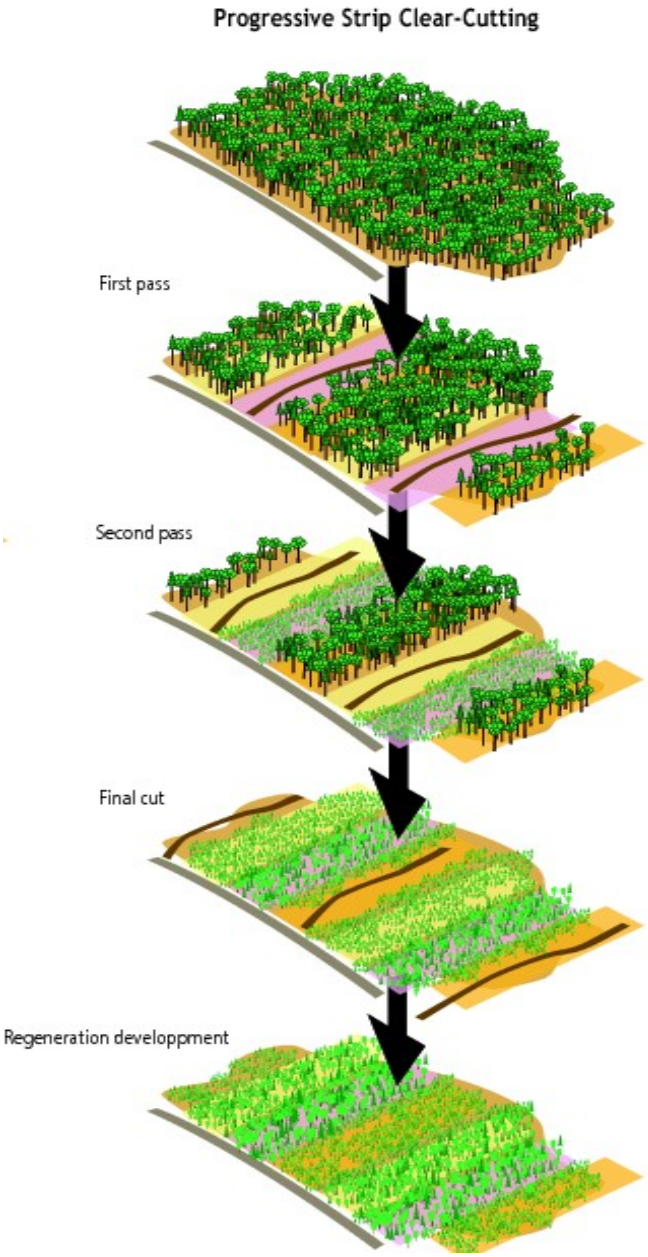
Recommended Strip Widths for Clear-Cutting, By Species and Type of Environment *(Lupien 2008)*

Species / environment	Strip Width (in metres or stem heights)
Poplars	20 m minimum
White birch	15-50 m
Yellow birch	15-30 m
Black cherry	1H
Red pine	1H
Dry sites	1H

*H=tree height



https://www.for.gov.bc.ca/hfp/training/00014/varclear.htm#clear



Source: CERFO

Institut de recherche sur les feuillus nordiques
Northern Hardwoods Research Institute

Method/Treatment:

Seed tree cut

System: **EVEN-AGED**

Sub-system: **Clearcut/seed tree**

STC

Stand Eligibility

- **FUNA:** BETH, THIH, TOHW, THMX
- **Structure:** all but M1 (except for BETH)
- Presence of trees of desired species and quality to provide seeds
- Species that do not require some protection from exposure to regenerate successfully
- Mature to overmature development stage
- Poor quality stand or low stocking
- Even distribution of trees within stand
- Lack of pre-established regeneration
- Low probability of competition by aggressive interfering plants

Objectives of system

In this process, a few well-distributed seed-trees establish regeneration when all the other trees have been cut. This process is used to optimize the distribution of seeds spread by the wind.

Spacing between seed-trees left on the cutover area varies based on the species and size of the trees (Table 2). If seed-trees are dispersed, the quantity of seed-trees to be preserved is determined by calculating the area that each tree can seed, adding a risk factor to cover any losses of seed-trees and converting the resulting area into density of trees by hectare.

Seed-trees can either be harvested a few years after the original cut when regeneration is established or be left for longer (reserve cutting or reserve seed-tree; réserve de semenciers) to produce timber of larger size. They can be harvested during the first thinnings of the regenerated stand or even during final cutting depending on the risk of causing damage to seedlings and saplings.

Description

This system leaves individual seed-trees or clusters of seed-producing trees in a clear-cut mainly to provide regeneration . The trees excluded from harvesting to supply seeds for the next crop should be of good quality and vigorous. They are generally too far apart to affect the microclimate or shelter the new regeneration. Seed-tree cutting involves up to two steps: a seed cut and a removal cut and has the following variants:

Uniform Seed-tree: Individual trees are excluded from harvesting and are generally distributed evenly throughout the harvested area. Seed trees are harvested in the future.

Group seed-tree: Clusters of seed trees are left in groups or strips throughout the harvested area. The distribution of the groups of trees excluded from harvesting could be uniform or irregular to maximize seed dispersal of the desired species. The seedf dessimination distance is an essential consideration for determining distances between patches or groups of seed trees. Clumps are later removed.

Seed-tree with reserve: Individual and patches of trees that are left to meet long-term objectives such as visual landscape management and special wildlife habitats rather than to regenerate the stand.

Desired Outcomes

Immediate	Mid-term	Long-term
Acceptable amount of quality seed trees throughout the block	Recruitement of new cohort of desired species	Full stocking of seedlings and saplings
Creation of germination beds	Low competition by interfering plants	Low competition
Abundance of seeds for germination	Good seedling survival	High density to allow for quality development
Adequate Soil exposure		Stand ready for intermediate silviculture
No site damage		

Key success factors

- Number and distribution of seed trees planned according to requirements of species of interest.
- Planned on good seed years
- Soil exposed to generate seed germination beds

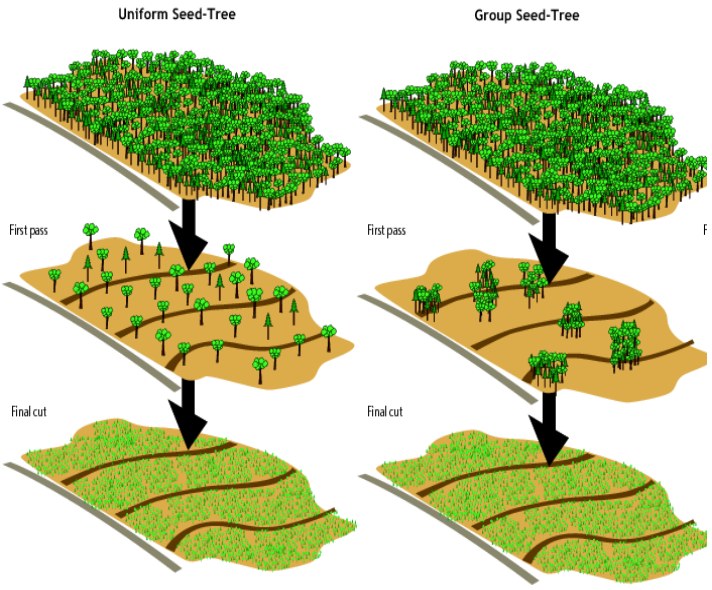
Implementing Seed tree cut treatments

Operational considerations

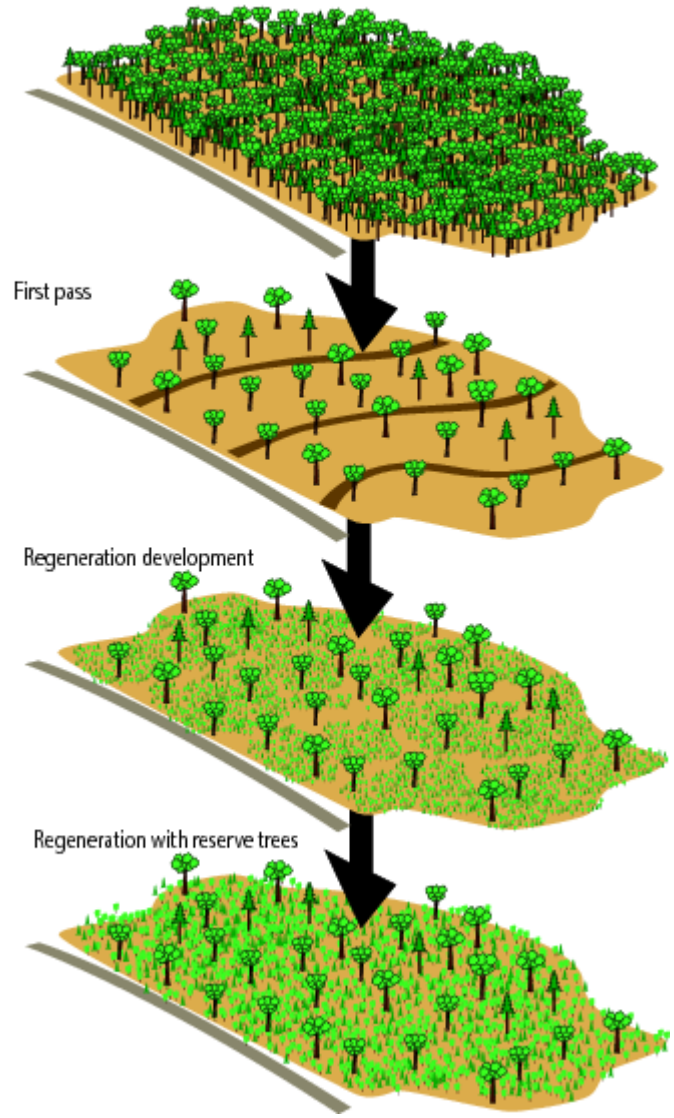
	Prefered	Tolerated	Avoid
Full tree system	X		
CTL system		X	
Leafs off		X	
Frozen ground		X	

Getting started:

- Select the amount and distribution of seed trees according to the requirements of species of interest)
- Decide on the variant to use
- Plan treatments in a good seed year and in the proper season
- Determine the right tree spacing according to species (see table below) .
- Schedule the next re-entries so that the removal of seed trees does not damage regeneration (i.e. < 2m)



Seed-Tree with Reserve



Source: CERFO

Average Distance of Dissemination of Seeds by Species (from guide sylvicole du Québec)

Distance of Dissemination (m)			
Hardwoods		**Softwoods**	
Trembling Aspen aspen	Several km	White pine	1H*
White birch	< 60	Jack pine	2H*
Yellow birch	> 100	Balsam fir	25-60
Red maple	> 100	Black spruce	50-80
White ash	140	Red spruce	< 100
American elm	< 450	White spruce	20-30
Basswood	< 150		

*H=tree height

Institut de recherche sur les feuillus nordiques
Northern Hardwoods Research Institute

Method/Treatment:

Group Shelterwood Cut

System: **EVEN-AGED**

Sub-system: **SHELTERWOOD**

GSH

Stand Eligibility

- **FUNA/Structure:** all except quality SMTH-M1 and YBTH-M1
- Presence of trees of desired species and quality to provide seeds
- Species that require some protection from exposure to regenerate successfully
- Mature to overmature development stage
- Poor quality stand or low stocking
- Uneven distribution of trees within stand or in patches
- Lack of pre-established regeneration
- Presence of aggressive interfering plants

Objectives of system

The shelterwood system removes the overstory in a series of harvest entries to regenerate the stand under the shelter . The number of residual trees vary from one area to another depending on tree species, tree structure (diameter, height, and crown width), slope, and aspect. .

This system is recommended for long-lived shade tolerant species and in poor quality stands made up of least 30% of long-lived and shade tolerance species.

The general considerations in the application of the shelterwood system are:

- Overstory condition (risk,form, structure and composition)
- Density of seed trees in the stand
- Site suitability to desired species
- Presence, abundance, and size of established regeneration of desired species
- Seedbed or site preparation
- Potential competition from undesirable vegetation.

Description

The stand is progressively opened in small gaps (one to two tree heights in diameter). The uncut overstory or adjacent standing trees provide shelter to the new regeneration. The harvesting is done in relatively quick succession within the intended rotation length (10-20 years) to create an even-aged stand.

This method is used when the stand is made up of patches, groups or clumps (frequent in mixed and heterogeneous stands). It produces small gaps or enlarges preexisting ones. During subsequent entries, they are gradually expanded. As a rule of thumb, the initial size of a gap should be about 0.75 H (tolerant species) or 1-2 H (intermediate shade-tolerant species), where H = average height of the dominant story as larger patches will encourage competition.

This pattern requires a carefully planned network of trails to extract timber in successive cuts around the periphery of the gaps without damaging established regeneration.

It is acceptable to reach outside of the patches and harvest tress as in a uniform shelterwood operation.

Desired Outcomes

Immediate	Mid-term	Long-term
Creation of openings in canopy	Recruitement of new cohort of desired species	Full regeneration and sapling stocking
Creation of germination beds	Sheltered seedlings by residual trees	Low competition by residual trees
Abundance of seeds for germination	Good seedling survival	High density to allow for quality development
Adequate Soil exposure	OSR planned before regeneration is too tall	
No site damage		

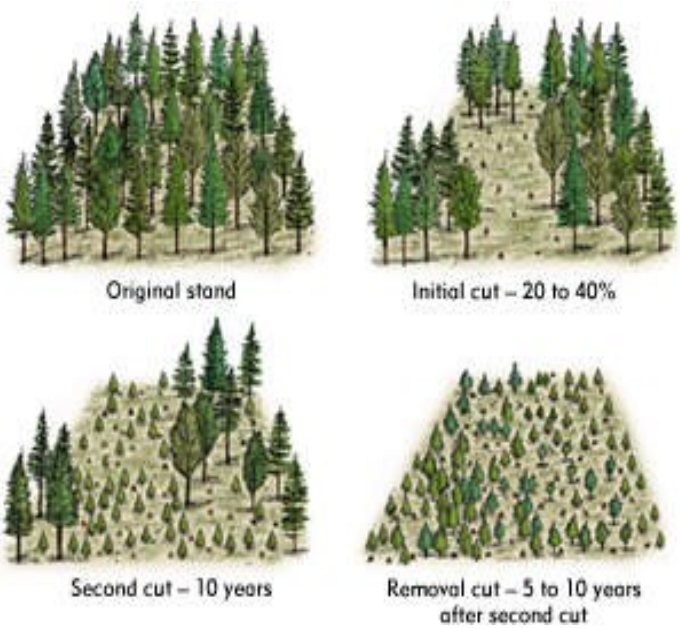
Key success factors

- Adequate mineral soil exposure
- Planned on good seed years
- Efficient trail pattern
- Carefull assessment of regeneration success in previous patches

Implementing Group shelterwood treatments

Operational considerations

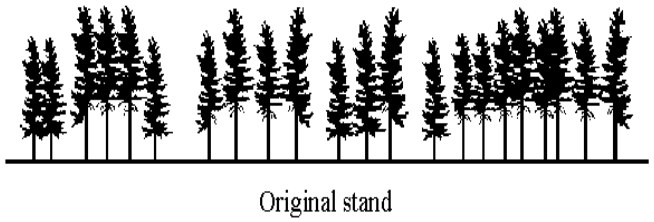
	Prefered	Tolerated	Avoid
Full tree system		X	
CTL system		X	
Leafs off	X		
Frozen ground			X
High trail footprint		X	



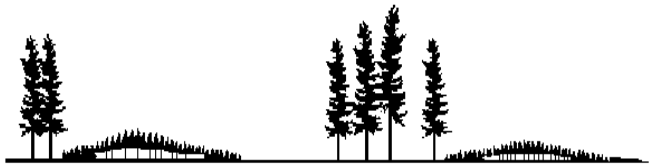
https://www.for.gov.bc.ca/hfp/training/00014/varshel.htm#strpshel

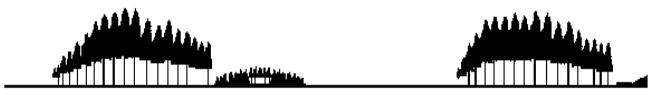
Getting started:

- Plan treatment in a good seed year and in the proper season
- Determine the proper patch size and removal sequence
- Design appropriate trail pattern to cover all entries
- Provide instructions for harvesting outside patches and clumps


Original stand


Removal of initial groups


Later removal of more groups


Final mature removal

https://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/system

Average seed dessimination distances ***(from guide sylvicole du Québec)***

Distance of Dissemination (m)			
Hardwoods		**Softwoods**	
Trembling Aspen aspen	Several km	White pine	1H*
White birch	< 60	Jack pine	2H*
Yellow birch	> 100	Balsam fir	25-60
Red maple	> 100	Black spruce	50-80
White ash	140	Red spruce	< 100
American elm	< 450	White spruce	20-30
Basswood	< 150		

*H=tree height

Institut de recherche sur les feuillus nordiques
Northern Hardwoods Research Institute

Method/Treatment:

Strip Shelterwood Cut

System: **EVEN-AGED**

Sub-system: **SHELTERWOOD**

SSH

Stand Eligibility

- **FUNA/Structure:** all except quality SMTH-M1 and YBTH-M1
- Presence of trees of desired species and quality to provide seeds
- Species that require some protection from exposure to regenerate successfully
- Mature to overmature development stage
- Poor quality stand or low stocking
- Even distribution of trees within stand
- Lack of pre-established regeneration
- Presence of aggressive interfering plants (beech, mtn maple)

Objectives of system

The shelterwood system removes the overstory in a series of harvest entries to regenerate the stand under the shelter . The number of residual trees vary from one area to another depending on tree species, tree structure (diameter, height, and crown width), slope, and aspect. .

This system is recommended for long-lived shade tolerant species and in poor quality stands made up of least 30% of long-lived and shade tolerance species.

The general considerations in the application of the shelterwood system are:

- Overstory condition (risk,form, structure and composition)
- Density of seed trees in the stand
- Site suitability to desired species
- Presence, abundance, and size of established regeneration of desired species
- Seedbed or site preparation
- Potential competition from undesirable vegetation.

Description

This method consists of cutting narrow strips progressively across the stand over a period of time (10 – 20 years). Subsequent strips are harvested beside the initial strips perpendicular to the direction of the wind-throughout the stand. Partial harvesting is allowed between the strips (in the leave strips).

Width of strips should be between 6m and 8m to maintain the shelterwood effect but in the case of yellow birch can be up to half a tree height. The trees in adjacent uncut strips provide shelter to new regeneration in the harvested strips. When laying out the strips, consideration must be given to the following:

1. Orient the strips northwest to southeast so that residual trees can protect regeneration from high light intensity.
2. Cut strips should be perpendicular to the prevailing winds to promote even seed distribution.
3. Accessibility and layout in relation to roads.
4. Shade tolerance of the desired species (wider strips for less shade-tolerant species and vice versa).

.

Desired Outcomes

Immediate	Mid-term	Long-term
Creation of progressive strips in the stand.	Recruitement of new cohort of desired species	Full regeneration and sapling stocking
Creation of germination beds	Sheltered seedlings by residual trees	Low competition by residual trees
Abundance of seeds for germination	Good seedling survival	Full stocking to allow for quality development
Adequate Soil exposure	I	

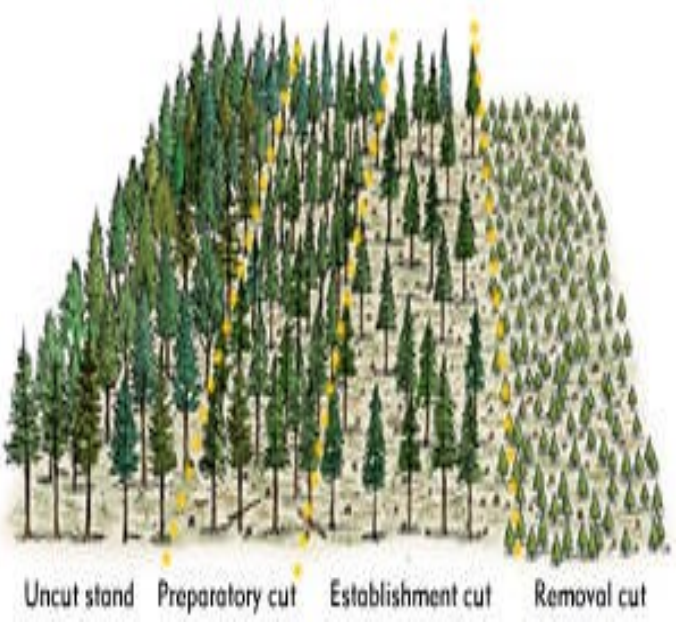
Key success factors

- Adequate mineral soil exposure
- Planned on good seed years
- Strip width according to species
- Strips oriented to maximize seed dispersion

Implementing Strip shelterwood treatments

Operational considerations

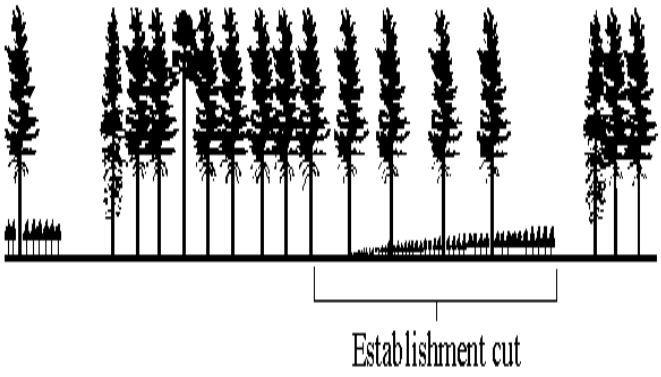
	Prefered	Tolerated	Avoid
Full tree system	X		
CTL system		X	
Leaves off	X		
Frozen ground			X

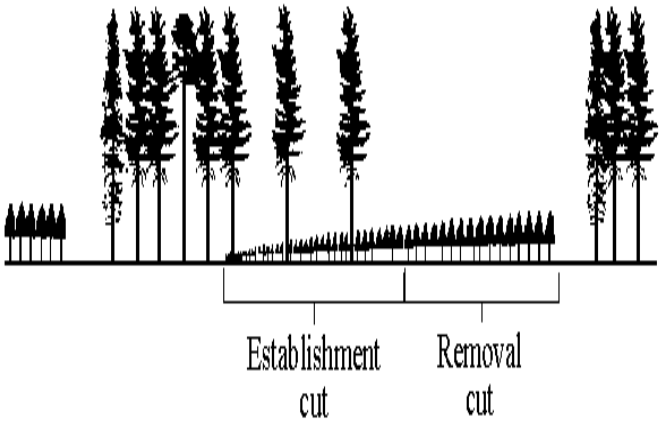


https://www.for.gov.bc.ca/hfp/training/00014/varshel.htm#strpshel

Getting started:

- Plan treatments in a good seed year and in the proper season
- Determine the right trail witdh and number according to species (see table below) but typically less than 0ne tree height.
- Decide if tree removal can occur outside of strips
- Schedule the next re-entries so that the entire area is covered in less than 20 years.





https://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/system/fig5.htm

Average seed dessimination distances ***(from guide sylvicole du Québec)***

Distance of Dissemination (m)			
Hardwoods		**Softwoods**	
Trembling Aspen aspen	Several km	White pine	1H*
White birch	< 60	Jack pine	2H*
Yellow birch	> 100	Balsam fir	25-60
Red maple	> 100	Black spruce	50-80
White ash	140	Red spruce	< 100
American elm	< 450	White spruce	20-30
Basswood	< 150		

*H=tree height

Institut de recherche sur les feuillus nordiques
Northern Hardwoods Research Institute

Method/Treatment:

Uniform Shelterwood Cut

System: **EVEN-AGED**

Sub-system: **SHELTERWOOD**

USH

Stand Eligibility

- **FUNA/Structure:** all except quality SMTH -M1 and YBTH-M1
- Presence of trees of desired species and quality to provide seeds
- Species that require some protection from exposure to regenerate successfully
- Mature to over-mature development stage
- Poor quality stand or low stocking
- Even distribution of trees within stand

Objectives of system

The shelterwood system removes the overstory in a series of harvest entries to regenerate the stand under the shelter . The number of residual trees vary from one area to another depending on tree species, tree structure (diameter, height, and crown width), slope, and aspect. .

This system is recommended for long-lived shade tolerant species and in poor quality stands made up of least 30% of long-lived and shade tolerance species.

The general considerations in the application of the shelterwood system are:

- Overstory condition (risk,form, structure and composition)
- Density of seed trees in the stand
- Site suitability to desired species
- Presence, abundance, and size of established regeneration of desired species
- Seedbed or site preparation
- Potential competition from undesirable vegetation.

Description

The system is implemented in 1 to 4 stages, each with specific objectives and characteristics:

1. preparatory cut is done to improve the vigor of prospective seed-bearing trees
2. a seed or regeneration cut is undertaken to remove 30-70% of the canopy, taking into consideration the species shade tolerance and site conditions
3. removal cuts may then be used to release well established regeneration from overstory shade
4. final cut (overstory removal) is done to remove most or all of the remaining canopy

All cuts must be undertaken within a 20 year cycle to ensure the establishment of a single cohort (<1/5 of a rotation). Intermediate silviculture treatments such as commercial thinning will normally be required.

Desired Outcomes

Immediate	Mid-term	Long-term
Creation of openings in canopy	Recruitement of new cohort of desired species	Full regeneration and sapling stocking
Creation of germination beds	Sheltered seedlings by residual trees	Low competition by residual trees
Abundance of seeds for germination	Good seedling survival	High density to allow for quality development
Adequate Soil exposure	OSR planned before regeneration is too tall	
No site damage		

Key success factors

Seed establishment cut

- Adequate mineral soil exposure
- Planned on a good seed year
- Even distribution of residual trees

Overstory removal (as above +)

- Timed when regeneration is established but < 2m tall
- Snow cover preferred

Implementing Uniform shelterwood treatments

Operational considerations

	Prefered	Tolerated	Avoid
Full tree system	X		
CTL system		X	
Leave off	X		
Frozen ground			X
High trail footprint (>20% ratio)		X	

Seedling establishment cut *(courtecy CERFO)*

Getting started:

- Plan treatment in a good seed year and in the proper season
- Determine the right residual Basal area taget for desi-red species as per the table below
- Decide if a preparatory cut is needed to make seed trees more vigourous
- Design appropriate trail pattern
- Establish a pecking order for removal
- Schedule the next re-entry

Regeneration established and ready for OSR

Percentage of Residual Cover after Preparatory Seedling establishment cuts

Percentage of Residual Cover (%)				
Hardwoods		Softwoods		
Species	After preparatory cut	Species	After preparatory cut	After seed estab. cut
Yellow birch	50-70	White pine	60-70	40-50
Red oak	50-70	Red spruce	60-70	40-50
Sugar maple	60-80	Eastern white cedar	60-70	40-50
White ash	50-80			
Black cherry	40-60			

From Lupien, 2008

Saplings approx. 20 yrs. After OSR ready for CT

Institut de recherche sur les feuillus nordiques
Northern Hardwoods Research Institute

Method/Treatment:

One-cut Shelterwood

System: **EVEN-AGED**

Sub-system: **SHELTERWOOD**

OSH

Stand Eligibility

- **FUNA/Structure:** all except quality SMTH -M1 and YBTH-M1
- Presence of trees of desired species and quality to provide seeds
- Mature to over-mature development stage or poor quality stand or low stocking
- **Already established regeneration that does not require shelter any longer**
- Regeneration is not so tall that it risks being damaged during harvesting

Overall objectives of the shelterwood sub-system

The shelterwood system removes the overstory in a series of harvest entries to regenerate the stand under the shelter . The number of residual trees vary from one area to another depending on tree species, tree structure (diameter, height, and crown width), slope, and aspect. .

This system is recommended for long-lived shade tolerant species and in poor quality stands made up of least 30% of long-lived and shade tolerance species.

The general considerations in the application of the shelterwood system are:

- Overstory condition (risk,form, structure and composition)
- Density of seed trees in the stand
- Site suitability to desired species
- Presence, abundance, and size of established regeneration of desired species
- Seedbed or site preparation
- Potential competition from undesirable vegetation.

Description of the one-cut treatment

The purpose of this overstory removal treatment is to liberate regeneration that has been established as a result of previous treatments (sometimes by accident) or through the process of stand dynamics notably in stratified mixture single cohort stands. It is typical of even -aged systems can also be part of two-aged systems.

It is conducted when seedlings no longer require protection or shelter by a partial canopy. Its timing is critical as to not damage regeneration while we make growth resources available to the new cohort.

The harvest is conducted with a priority on large trees of commercial size, unacceptable growing stock and trees at risk of loosing products and value. It is a good practice to keep and protect small trees with potential to grow quality products (AGS) but it is important to maintain a low residual basal area. In cases where there is a large proportion of small quality trees to maintain, a two-aged system may be more appropriate.

The subsequent treatment in a one-cut subsystem is likely to be a pre-commercial or a commercial thinning.

Desired Outcomes

Immediate

Release of established regeneration of desired species

Adequate stocking of healthy regeneration

No site damage

Maintenance of small quality trees

Mid-term

Good seedling survival

High stocking and low competition on saplings of desires species (>2000/ha)

High vigour and quality of regeneration

Free-to-grow saplings and small trees of desired species

Long-term

Full stocking (between A and B lines of stocking diagram) of commercial species

High AGS/UGS ratio

Key success factors

Overstory removal

- Timed when regeneration is established but < 2m tall to minimize harvesting damage
- Timed with snow cover if possible
- Carefull planning of trail pattern and choice of harvesting system to minimize damage to regeneration

Implementing One-cut shelterwood treatments

Operational considerations

	Prefered	Tolerated	Avoid
Full tree system	X		
CTL system		X	
Leaf off	X		
Frozen ground		X	
High trail footprint (>20% ratio)			X

Advanced regeneration in staratified mixture *(maybe too tall and likely sustain harvesting damage)*

Getting started:

- Chose a harvesting ssystem that will reduce the likely-hood of damage to regeneration and try to schedule harvest when there is snow to protect seedlings
- Design appropriate trail pattern to use (promote low trail foot prints)
- Decide the residual density of small trees of desired species to retain
- Prepare work instructions for machine operators with regards to target residual densities, trail pattern, peck-ing order and considerations to protect regeneration and release small trees (AGS)
- Determine quality standards to protect small trees, re-generation and soil
- Schedule the next re-entry

Regeneration established and ready for OSR

Desired mid-term outcomes

Saplings approx. 20 yrs. after OSR and ready for CT

Institut de recherche sur les feuillus nordiques
Northern Hardwoods Research Institute

Method/Treatment:

Continuous cover Ir.

System: **Irregular (2-aged)**

Sub-system: **Irregular shelterwood**

CIS

Stand Eligibility

- **FUNA:** all
- **Structure:** all
- Irregular stand structure
- Species that require some protection from exposure to regenerate successfully
- Mature to overmature development stage
- Poor quality stan
- Species of different lifespans
- Lack of pre-established regeneration
- Relatively even distribution of trees in stand

Objectives of system

The irregular high-forest system is characterized by a desire to regenerate the entire treated stand over a long period that is not continuous over time. It uses partial cuts of varying extents, allowing several vertical or horizontal stories of different age classes to be maintained: so forest cover is permanent but not necessarily dominated by mature trees throughout.

The main objective of this system is to generate stands with an irregular structure (two-story or uneven-aged structure including at least three age classes), preferably through natural seeding. This system is characterized therefore by the simultaneous presence of at least two cohorts of trees of different ages within the same stand. Because a wide spectrum of light conditions is created, this system allows species with different tolerances to shade and longevity to be grown together.

Description

This process creates favorable conditions for seedlings to establish themselves and survive while allowing for tending residual stems and harvesting mature trees of poor quality. It is also a way to extend harvesting long-lived species within a mix of species with varying lifespans.

It produces larger diameter stems and spreads revenues over a longer period but it requires thorough knowledge of species ecology and optimized harvesting operations.

This pattern differs from the others because it ***maintains a minimum 40% cover***. Harvesting pattern, frequency and intensity are guided by species autecology. The preferred way of creating gaps is by removal of dying or defective trees. They can also be designed so as to release groups of saplings or pockets of regeneration. As well, young quality trees should be released.

This process may be perceived as an extensive selection cutting, if the emphasis is on a balanced form of structure to ensure that cover is permanently renewed.

Desired Outcomes

Immediate	Mid-term	Long-term
Acceptable amount of quality residual trees throughout the block	Recruitement of new cohort of desired species	Full stocking of seedlings and saplings
Creation of germination beds	Low competition by interfering plants	Low competition
Abundance of seeds for germination	Good seedling survival of desired species	Healthy mature strata
Adequate Soil exposure	Moderate B.A. in vigourous residual trees	No loss of merchantable volume
No site damage	No residual trees at risk	
No residual trees at risk		

Key success factors

- Manage light in order to:
  - Control the establishment and growth of regeneration of desired species;
  - Optimize increase in the diameter of the stems kept by providing optimal space for their crowns to spread
- Planned on good seed years
- Expose soil to generate seed germination beds
- Maintain adequate cover to protect seedlings

Implementing Continuous cover irregular shelterwood treatments

Operational considerations

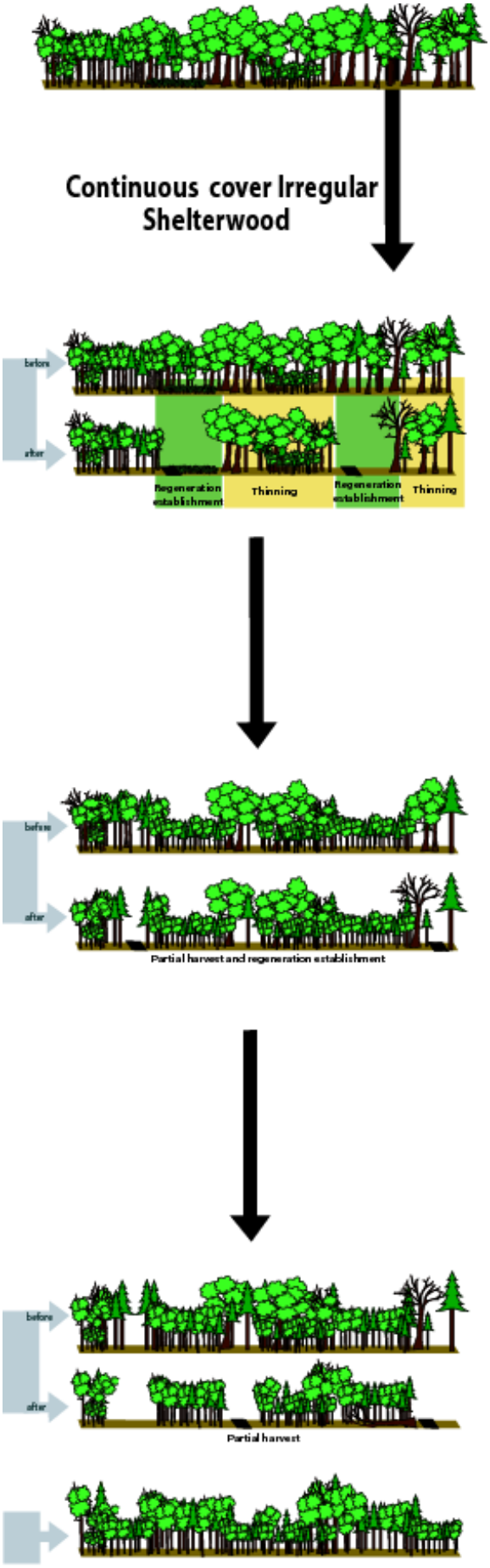
	Prefered	Tolerated	Avoid
Full tree system	X		
CTL system		X	
Leave off	X		
Frozen ground		X	
Outside sap season	X		

Getting started:

- Decide on the overall target residual basal area or crown cover
- Determine the ideal trail pattern to use (width and spacing)
- Plan treatments in a good seed year and in the proper season
- Provide operators with simple instructions for harvest by tree size category (i.e. 2/3 large trees, 1/2 medium trees, 1/4 small trees).
- Provide visual guidelines for assessing residual density (as per table below)
- Prepare tree selection criteria (pecking order)
- Decide the timing of the next re-entry

Example of residual spacing between trees (from Joanisse *et al.* 2013*)*

Target percentage of cover	Wide-crown hardwoods (YB, SM, WA, CHR)		Softwoods	
	DBH Classes	Distance between stems	DBH Classes	Distance between stems
50-60%	50 cm plus	11 to 14 m	50 cm plus	7 to 8 m
	40 to 48 cm	9 to 11 m	40 to 48 cm	6 to 7 m
	30 to 38 cm	7 to 9 m	30 to 38 cm	5 to 6 m
60-70%	24 to 28 cm	5 to 7 m	18 to 28 cm	4 to 5 m
	10 to 22 cm	4 to 5 m	8 to 16 cm	3 to 4 m



Source: CERFO

Institut de recherche sur les feuillus nordiques
Northern Hardwoods Research Institute

Method/Treatment:

Group Irregular shelterwood

System: **Irregular (2-aged)**

Sub-system: **Irregular shelterwood**

GIS

Stand Eligibility

- **FUNA:** all
- **Structure:** all
- Irregular stand structure
- Species that require some protection from exposure to regenerate successfully
- Mature to overmature development stage
- Poor quality stand
- Species of different lifespans
- Lack of pre-established regeneration
- Patchy distribution of trees in stand (groups)

Objectives of system

The irregular high-forest system is characterized by a desire to regenerate the entire treated stand over a long period that is not continuous over time. It uses partial cuts of varying extents, allowing several vertical or horizontal stories of different age classes to be maintained: so forest cover is permanent but not necessarily dominated by mature trees throughout.

The main objective of this system is to generate stands with an irregular structure (two-story or uneven-aged structure including at least three age classes), preferably through natural seeding. This system is characterized therefore by the simultaneous presence of at least two cohorts of trees of different ages within the same stand. Because a wide spectrum of light conditions is created, this system allows species with different tolerances to shade and longevity to be grown together.

Description

This pattern adapts to variations in stages of development often encountered in an irregular stand, and depends on recognizing groups of trees that require different treatments as follows:

Groups of pole-size trees: cover is partially harvested to maintain optimal growing space for enough crop trees (refer to stocking guides for residual targets).

Groups of regeneration or saplings: if there are patches of established regeneration (saplings), dominant cover is removed locally (forming a gap) to allow enough light to encourage growth in the regeneration.

Groups of mature trees: if a mature high-forest is ready for harvest but regeneration is deficient, partial harvesting takes place, maintaining enough residual cover in areas that need to regenerate for successful establishment. Generally, 50-60% of the residual cover allows enough light to ground level to stimulate regeneration of desired intermediate shade-tolerant and tolerant species, while preserving protective cover that limits invasion by competition. Uniform distribution of residual seed-trees and spacing between them that allows their crowns to spread out are also essential.

Desired Outcomes

Immediate	Mid-term	Long-term
Free-to –grow saplings	Recruitement of new cohort of desired species	Full stocking of seedlings and saplings
Released advanced regeneration	Low competition by interfering plants	Low competition
Treated mature patches to promote regeneration	Good seedling survival of desired species	Healthy mature strata
No site damage	Establishment of at least 2 cohorts	No loss of merchantable volume
No residual trees at risk	No residual trees at risk	

Key success factors

- Manage light in order to:
  - Control the establishment and growth of regeneration of desired species;
  - Optimize increase in the diameter of the stems kept by providing optimal space for their crowns to spread
- Planned on good seed years
- Expose soil to generate seed germination beds
- Maintain adequate cover to protect seedlings

Implementing Group irregular shelterwood treatments

Operational considerations

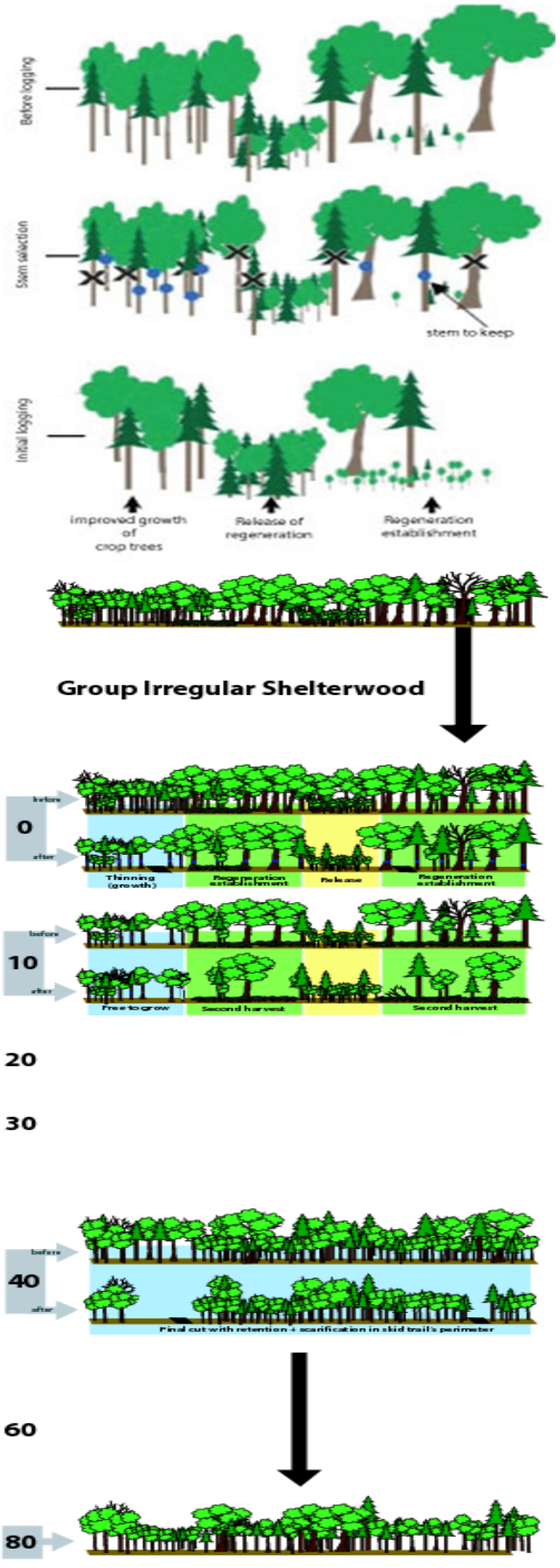
	Prefered	Tolerated	Avoid
Full tree system		X	
CTL system	X		
Leaves off	X		
Frozen ground		X	
Outside sap season	X		

Getting started:

- Determine the ideal trail pattern to use (width and spacing)
- Plan treatments in a good seed year and in the proper season
- Use stocking guides to set targets for residual density by size class
- Provide operators with simple instructions for harvest by tree size category (i.e. 2 out of 3 large trees, 1 out of 2 medium trees, 1 out of 4 small trees).
- Provide visual guidelines for assessing residual density (as per table below)
- Prepare tree selection criteria (pecking order)
- Decide the timing of the next re-entry

Example of residual spacing between trees (from Joanisse *et al.* 2013*)*

Target percentage of cover	Wide-crown hardwoods (YB, SM, WA, CHR)		Softwoods	
	DBH Classes	Distance between stems	DBH Classes	Distance between stems
50-60%	50 cm plus	11 to 14 m	50 cm plus	7 to 8 m
	40 to 48 cm	9 to 11 m	40 to 48 cm	6 to 7 m
	30 to 38 cm	7 to 9 m	30 to 38 cm	5 to 6 m
60-70%	24 to 28 cm	5 to 7 m	18 to 28 cm	4 to 5 m
	10 to 22 cm	4 to 5 m	8 to 16 cm	3 to 4 m



Source: CERFO

Institut de recherche sur les feuillus nordiques
Northern Hardwoods Research Institute

Method/Treatment:

Strip Irregular shelterwood

System: **Irregular (2-aged)**

Sub-system: **Irregular shelterwood**

SIS

Stand Eligibility

- **FUNA:** all
- **Structure:** all
- Irregular stand structure
- Species that require some protection from exposure to regenerate successfully
- Mature to overmature development stage
- Poor quality stand
- Species of different lifespans
- Lack of pre-established regeneration
- Even distribution of trees in stand (groups)

Objectives of system

The irregular high-forest system is characterized by a desire to regenerate the entire treated stand over a long period that is not continuous over time. It uses partial cuts of varying extents, allowing several vertical or horizontal stories of different age classes to be maintained: so forest cover is permanent but not necessarily dominated by mature trees throughout.

The main objective of this system is to generate stands with an irregular structure (two-story or uneven-aged structure including at least three age classes), preferably through natural seeding. This system is characterized therefore by the simultaneous presence of at least two cohorts of trees of different ages within the same stand. Because a wide spectrum of light conditions is created, this system allows species with different tolerances to shade and longevity to be grown together.

Description

This uniform pattern is used on narrow strips. The stages of partial cuts are offset from one strip to the next. The recommended strip width is about ½ H for yellow birch or white pine (H = average height of the dominant stage) for mechanized operations.

Partial removal is usually conducted on each side of the strips. This pattern was designed to minimize the risk of windfall.

Desired Outcomes

Immediate

Creation of progressive strips in the stand.

Creation of germination beds

Abundance of seeds for germination

Adequate Soil exposure

No site damage

No valuable leave trees at risk

Mid-term

Recruitement of new cohort of desired species

Low competition by interfering plants

Good seedling survival of desired species

Low tree mortality

Long-term

Full stocking of seedlings and saplings

Low competition High density to allow for quality development

Stand ready for intermediate silviculture

Key success factors

- Strip pattern adjusted to the species of interest
- Planned on good seed years
- Strips oriented to maximize seed dispersion

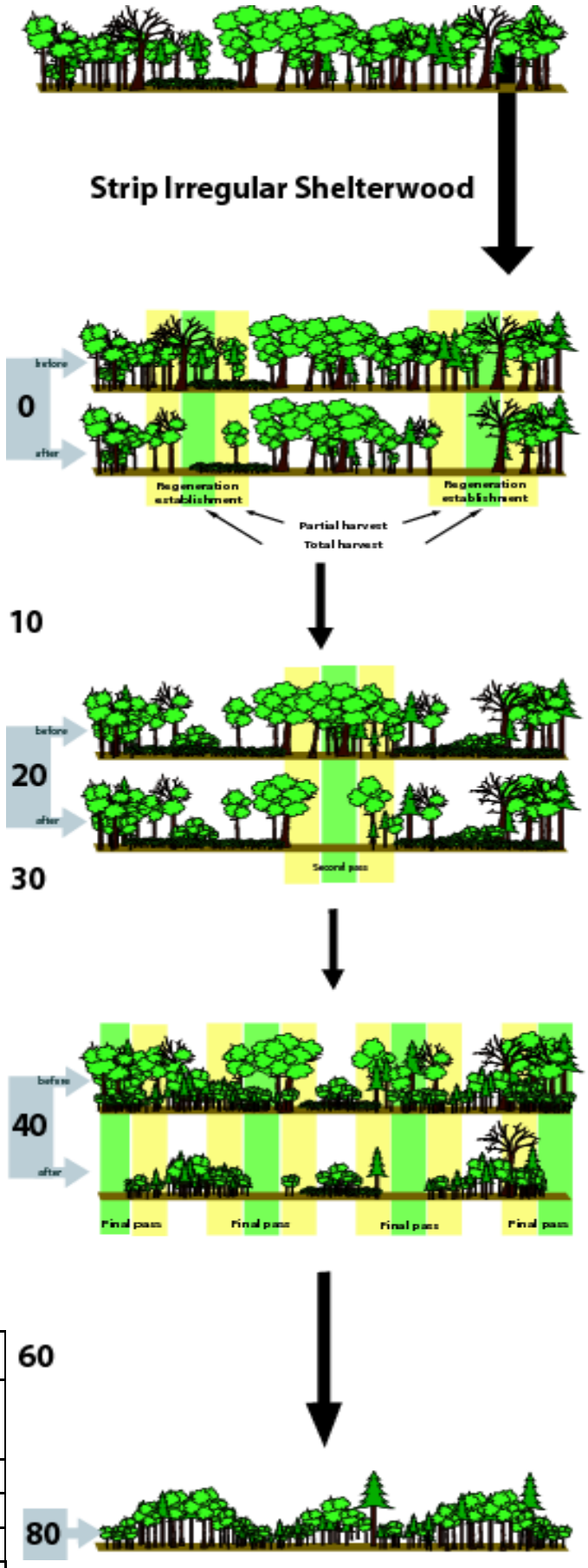
Implementing Strip irregular shelter-wood treatments

Operational considerations

	Prefered	Tolerated	Avoid
Full tree system	X		
CTL system		X	
Leaves off	X		
Frozen ground		X	
Outside sap season	X		

Getting started:

- Determine the strip pattern to use (based on 1/2 tree height rule of thumb)
- Decide on the number of strips and the timing for complete coverage
- Decide if removals outside strips will be allowed
- When possible, orient strips so that they are perpendicular to dominant winds



Source: CERFO

Example of residual spacing between trees (from Joanisse *et al.* 2013*)*

Target percentage of cover	Wide-crown hardwoods (YB, SM, WA, CHR)		Softwoods	
	DBH Classes	Distance between stems	DBH Classes	Distance between stems
50-60%	50 cm plus	11 to 14 m	50 cm plus	7 to 8 m
	40 to 48 cm	9 to 11 m	40 to 48 cm	6 to 7 m
	30 to 38 cm	7 to 9 m	30 to 38 cm	5 to 6 m
60-70%	24 to 28 cm	5 to 7 m	18 to 28 cm	4 to 5 m
	10 to 22 cm	4 to 5 m	8 to 16 cm	3 to 4 m

Institut de recherche sur les feuillus nordiques
Northern Hardwoods Research Institute

Method/Treatment:

Uniform Irregular shelterwood

System: **Irregular (2-aged)**

Sub-system: **Irregular shelterwood**

UIS

Stand Eligibility

- **FUNA:** all
- **Structure:** all
- Irregular stand structure
- Species that require some protection from exposure to regenerate successfully
- Mature to overmature development stage
- Poor quality stand
- Species of different lifespans
- Lack of pre-established regeneration
- Relatively even distribution of trees in stand

Objectives of system

The irregular high-forest system is characterized by a desire to regenerate the entire treated stand over a long period that is not continuous over time. It uses partial cuts of varying extents, allowing several vertical or horizontal stories of different age classes to be maintained: so forest cover is permanent but not necessarily dominated by mature trees throughout.

The main objective of this system is to generate stands with an irregular structure (two-story or uneven-aged structure including at least three age classes), preferably through natural seeding. This system is characterized therefore by the simultaneous presence of at least two cohorts of trees of different ages within the same stand. Because a wide spectrum of light conditions is created, this system allows species with different tolerances to shade and longevity to be grown together.

Description

This pattern is used when cover is uniform. Cover is opened progressively throughout the whole stand, targeting uniform distribution of residual stems and avoiding creating gaps that are too large.

The degree to which cover is opened up varies according to the tolerance of the species involved and the aggressiveness of the competition. Several harvests are conducted over an extended period (30-40 years) until two distinct cohorts of crop trees have been established. As in other types of irregular shelterwood variants, trees in all mature size classes receive treatment.

Regenerated sections may be harvested completely, open non-regenerated areas may have to be scarified and closed portions may undergo partial harvesting and any needed site preparation.

Partial removal usually involves harvesting a third of the stems according to simple rules (e.g.: for each group of three stems, harvest the largest, or the ugliest). The last cut corresponds to a final cut and occurs a few years later, when the sections that regenerated under cover are tall enough.

Desired Outcomes

Immediate	Mid-term	Long-term
Acceptable amount of quality residual trees throughout the block	Recruitement of new cohort of desired species	Full stocking of seedlings and saplings
Creation of germination beds	Low competition by interfering plants	Low competition
Abundance of seeds for germination	Good seedling survival of desired species	Two distinct cohorts of crop trees
Adequate Soil exposure	Moderate B.A. in vigourous residual trees	No loss of merchantable volume
No site damage	No residual trees at risk	
No residual trees at risk		

Key success factors

- Manage light in order to:
  - Control the establishment and growth of regeneration of desired species;
  - Optimize increase in the diameter of the stems kept by providing optimal space for their crowns to spread
- Planned on good seed years
- Expose soil to create seed germination beds
- Maintain adequate cover to protect seedlings

Implementing Uniform irregular shelterwood treatments

Operational considerations

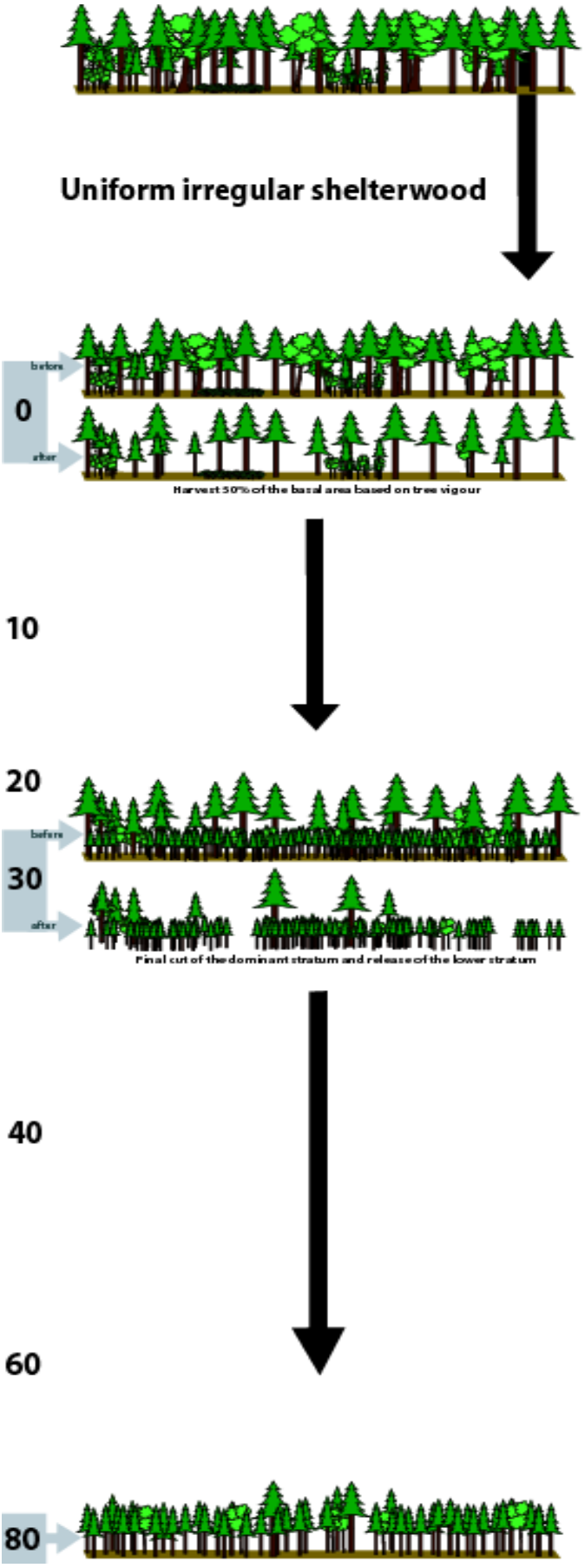
	Prefered	Tolerated	Avoid
Full tree system	X		
CTL system		X	
Leaves off	X		
Frozen ground		X	
Outside sap season	X		

Getting started:

- Decide on the target residual basal area or crown cover
- Determine the ideal trail pattern to use (width and spacing)
- Plan treatments in a good seed year and in the proper season
- Provide operators with simple instructions for harvest by tree size category (i.e. 2/3 large trees, 1/2 medium trees, 1/4 small trees).
- Provide visual guidelines for assessing residual density (as per table below)
- Prepare tree selection criteria (pecking order)
- Decide the timing of the next re-entry

Example of residual spacing between trees (from Joanisse *et al.* 2013*)*

Target percentage of cover	Wide-crown hardwoods (YB, SM, WA, CHR)		Softwoods	
	DBH Classes	Distance between stems	DBH Classes	Distance between stems
50-60%	50 cm plus	11 to 14 m	50 cm plus	7 to 8 m
	40 to 48 cm	9 to 11 m	40 to 48 cm	6 to 7 m
	30 to 38 cm	7 to 9 m	30 to 38 cm	5 to 6 m
60-70%	24 to 28 cm	5 to 7 m	18 to 28 cm	4 to 5 m
	10 to 22 cm	4 to 5 m	8 to 16 cm	3 to 4 m



Source: CERFO

Institut de recherche sur les feuillus nordiques
Northern Hardwoods Research Institute

Method/Treatment:

Expanding-gap Ir.

System: **Irregular (2-aged)**

Sub-system: **Irregular shelterwood**

EIS

Stand Eligibility

- **FUNA:** all
- **Structure:** all
- Irregular stand structure
- Species that require some protection from exposure to regenerate successfully
- Mature to overmature development stage
- Poor quality stand
- Species of different lifespans
- Lack of pre-established regeneration
- Patchy distribution of trees in stand

Objectives of system

The irregular high-forest system is characterized by a desire to regenerate the entire treated stand over a long period that is not continuous over time. It uses partial cuts of varying extents, allowing several vertical or horizontal stories of different age classes to be maintained: so forest cover is permanent but not necessarily dominated by mature trees throughout.

The main objective of this system is to generate stands with an irregular structure (two-story or uneven-aged structure including at least three age classes), preferably through natural seeding. This system is characterized therefore by the simultaneous presence of at least two cohorts of trees of different ages within the same stand. Because a wide spectrum of light conditions is created, this system allows species with different tolerances to shade and longevity to be grown together.

Description

The initial cut creates or opens up small natural gaps in the residual stand. The gaps are enlarged progressively by partial cuts along the edges until the initial stand is completely harvested. The scenario may call for enlarging the gaps at regular intervals throughout the whole rotation or only during part of the rotation, followed by a period of growth. Regeneration is started, or released if already under way, in gaps where the size is adjusted to create favorable conditions for the desired species. Patches of young trees are thinned and clumps of poles should be cleared out as needed to promote desired species in the cover.

This pattern is used when vertical structure is in the form of patches, groups or clumps (frequent in mixed stands) or when this type of horizontal structure is desired.

Expanding-gap shelterwood requires a carefully planned network of trails so that wood can be removed progressively from the edges of the gaps without damaging established regeneration.

Desired Outcomes

Immediate	Mid-term	Long-term
Acceptable amount of openings throughout the block	Recruitement of new cohort of desired species	Full stocking of seedlings and saplings
Creation of germination beds	Low competition by interfering plants	Low competition
Abundance of seeds for germination	Good seedling survival of desired species	Two distinct cohorts of crop trees
Adequate Soil exposure	Expansion of original gaps	No loss of merchantable volume
No site damage	No residual trees at risk	
No residual trees at risk		

Key success factors

- Manage light in order to:
  - Control the establishment and growth of regeneration of desired species;
  - Optimize increase in the diameter of the stems kept by providing optimal space for their crowns to spread
- Planned on good seed years
- Expose soil to generate seed germination beds
- Carefully planned network of trails and gaps

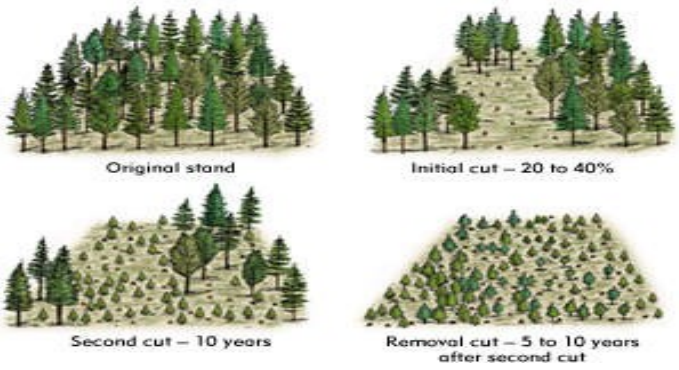
Expanding-Gap irregular shelter-wood treatments

Operational considerations

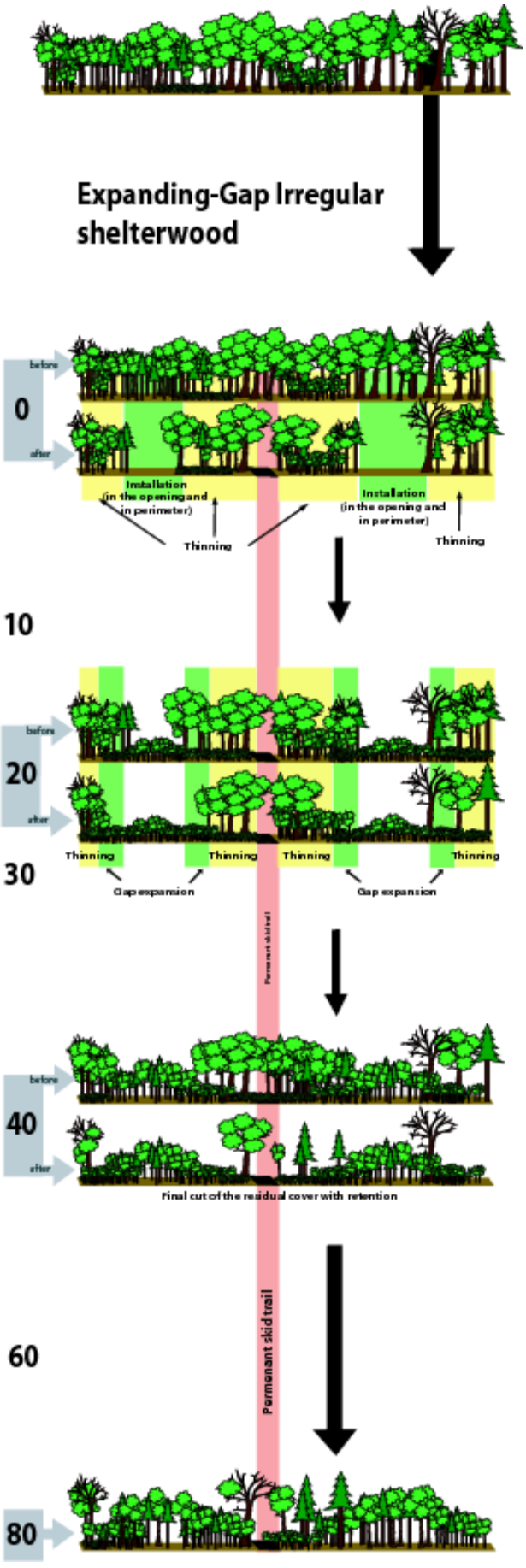
	Prefered	Tolerated	Avoid
Full tree system	X		
CTL system		X	
Leaves off	X		
Frozen ground		X	

Getting started:

- Design the trail network for the whole regime in the stand
- Decide on the size of the original gaps and the timing of subsequent entries
- Plan treatments in a good seed year and in the proper season
- Decide if harvesting outside the gaps is allowed



https://www.for.gov.bc.ca/hfp/training/00014/varshel.htm



Source: CERFO

Institut de recherche sur les feuillus nordiques
Northern Hardwoods Research Institute

Method/Treatment:

GROUP SELECTION CUT

System: **UNEVEN-AGED**

Sub-system: **SELECTION**

GSC

Stand Eligibility

- **FUNA:** SMTH, YBTH, TOHW, THMX, BETH, THIH
- **Structure:** multi-cohort
- The proportion of beech must be less than 30% and not prominent in the understory
- Ideally, there should be at least 25m^2 /ha of basal area and >60% crown cover to allow harvesting enough volume
- More than half the trees need to be of quality (AGS)
- Should have a high proportion of sugar maple and yellow birch
- Acceptable regeneration should be present
- Site should have high productivity

Objectives of system

Production of high-quality sawlogs is a management goal. Under this method the highest grade trees are selected and then "released" by removing lower grade trees which would otherwise compete with the selected tree for resources.

It continually creates or maintains an uneven-aged stand by removing single trees or small groups of trees from various age and size classes. The regeneration cut, tending operation and harvesting generally occur simultaneously, but may vary across the stand.

Specific objectives are:

- Create multiple cohort stand (at least 3 age classes)
- Perpetuate natural gap creation
- Regulate a balanced age-class distribution over the stand
- Promote conditions for good growth
- Control species composition and quality.
- Increase sawlog volume
- Enable the establishment of yellow birch and other intermediates

Description

Trees are harvested using the Arbogast method also known as the ***BDq* method**. Under this method, a harvest is specified by defining a maximum diameter to retain (***D***), a residual basal area (***B***), and a q-ratio (***q***). The q-ratio is the ratio of the number of trees in a diameter class to the number of trees in the next larger class.

Regular re-entries (approx. every 20 yrs) remove merchantable timber, reduce competition to crop trees and promote regeneration of desirable species. Treatments are done in all 3 age classes.

This involves the removal of group of trees to create gaps of different sizes and shapes. The trees are removed at regular intervals to create and or maintain an uneven-aged stand. The gaps created in this method may range from 0.1- 0.5 ha in sizes or more than two times the height of adjacent mature trees. Subsequent cuttings create new gaps instead of enlarging the previous gaps.

Group selection method modifies the understory conditions significantly so that regeneration of mid-tolerant and some intolerant species are promoted.

Desired Outcomes

Immediate	Mid-term	Long-term
BA>16m^2/ha	Recruitement of new cohort	High Basal Area
AGS>UGS	Healthy crowns	AGS>75%
<5% crop trees damaged	Diameter growth	R1, R2 trees >75%
Crop trees released on 2-3 sides	Reduction of risk trees	Sm, Yb >75%
No site damage		Balanced age/DBH strucure

Key success factors

- Small trail footprint with wide spacing and narrow trails
- Operate after sap season and with snow cover if possible
- Chose proper harvesting system
- Use trained and operators that are dedicated to special harvesting
- Implement quality system
- Stratify stands correctly
- Develop BDQ methodology/targets

Version 2016_12

Implementing group selection treatments

Operational considerations

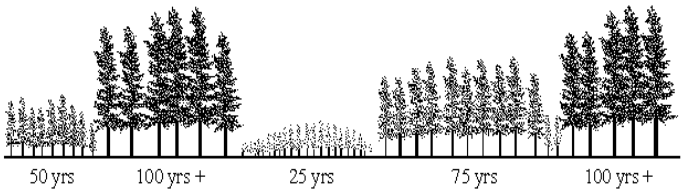
	Prefered	Tolerated	Avoid
Full tree system	X		
CTL system	X		
Sap-free season	X		
Frozen ground	X		
Leaves off	X		
High trail footprint (>20%)			X

Getting started:

- Choose a trail network that provides < 20% area in trails
- Determine maximum trail width and plan according to topography
- Select a residual basal area target for the leave strip by reducing the existing pre-treatment basal area by as much as 40% without dropping below 16m^2/ha
- Establish a pecking order for removal
- Decide if operator will be allowed to remove complete pockets of trees if dominated by unacceptable growing stock
- Establish thresholds for maximum patch size
- Prepare criteria for determination of acceptable growing stock (AGS)
- Select maximum tree size to retain

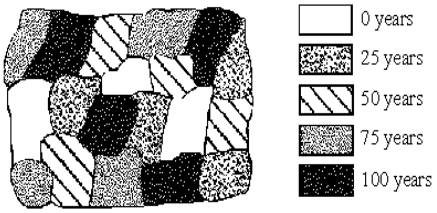
In the thinned strip:

- Try to release crop trees on at least 2 sides
- Create guidelines for tolerance for damage on crop trees
- Make sure the ratio of AGS to UGS is improved
- Try to maintain the basal area target but allow for within stand variability
- Protect established regeneration and saplings of commercial species

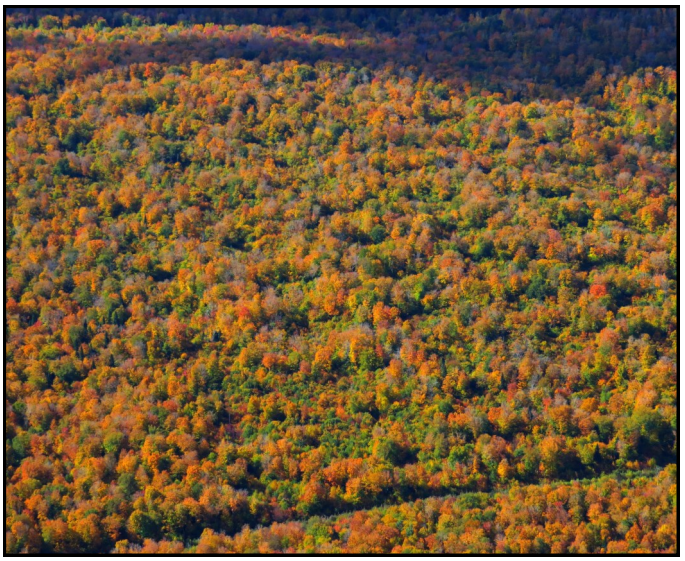


The ages indicate a 25–year cutting cycle (longer or shorter cycles may be appropriate).

Aerial view



https://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/system/fi



Institut de recherche sur les feuillus nordiques
Northern Hardwoods Research Institute

Method/Treatment:

SINGLE-TREE SELECTION

System: **UNEVEN-AGED**

Sub-system: **SELECTION**

SC

Stand Eligibility

- **FUNA:** SMTH, YBTH, TOHW, THMX
- **Structure:** Balanced multi-cohort
- The proportion of beech must be less than 30% and not prominent in the understory
- Ideally, there should be at least 25m^2 /ha of basal area and >60% crown cover to allow harvesting enough volume
- More than half the trees need to be of quality (AGS)
- Should have a high proportion of sugar maple and yellow birch
- Acceptable regeneration should be present
- Site should have high productivity

Objectives of system

Production of high-quality sawlogs is a management goal. Under this method the highest grade trees are selected and then "released" by removing lower grade trees which would otherwise compete with the selected tree for resources.

To continually create or maintain an uneven-aged stand by removing single trees or small groups of trees from various age and size classes. regeneration cut, tending operation and harvesting generally occur simultaneously, but may vary across the stand.

Specific objectives are:

- Create multiple cohort stand (at least 3 age classes)
- Perpetuate natural gap creation
- Regulate a balanced age-class distribution over the stand
- Promote conditions for good growth
- Control species composition and quality.
- Increase sawlog volume

Description

Individual trees are harvested using the Arbogast method also known as the ***BDq* method**. Under this method, a harvest is specified by defining a maximum diameter to retain (***D***), a residual basal area (***B***), and a q-ratio (***q***). The q-ratio is the ratio of the number of trees in a diameter class to the number of trees in the next larger class.

Regular re-entries (approx. every 20 yrs) remove merchantable timber, reduce competition to crop trees and promote regeneration of desirable species. Treatments are done in all 3 age classes.

Single mature trees or small groups of trees from a range of diameter classes are removed more or less uniformly across the cutover area.

Generally, the size of gap created in this method is equivalent to the crown spread of a single tree or clumps of mature trees.

Desired Outcomes

Immediate	**Mid-term**	**Long-term**
BA>16m^2/ha	Recruitement of new cohort	High Basal Area
AGS>UGS	Healthy crowns	AGS>75%
<5% crop trees damaged	Diameter growth	R1, R2 trees >75%
Crop trees released on 2-3 sides	Reduction of risk trees	Sm, Yb >75%
No site damage		Balanced age/DBH strucure

Key success factors

- Small trail footprint with wide spacing and narrow trails
- Operate after sap season and with snow cover if possible
- Chose proper harvesting system
- Use trained operators dedicated to special harvesting
- Implement quality system
- Stratify stands correctly
- Develop BDQ methodology/targets

Version 2016_12

Implementing single-tree selection treatments

Operational considerations

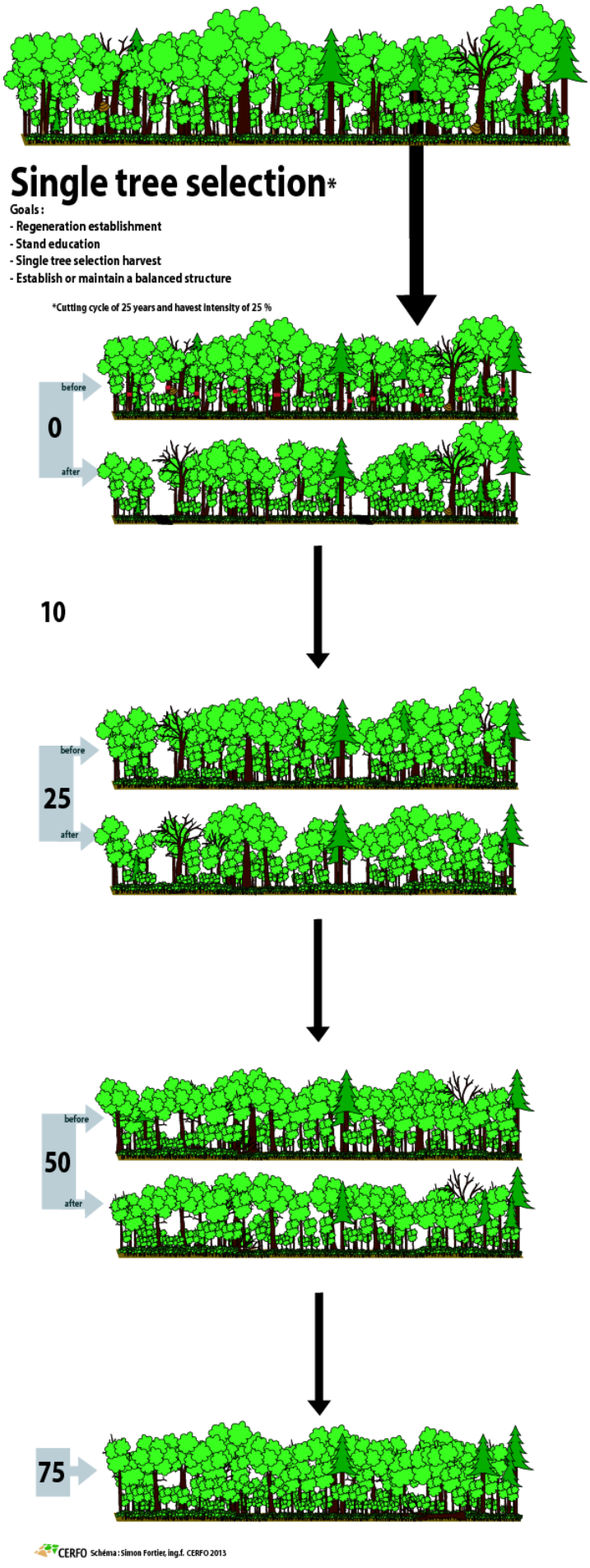
	Prefered	Tolerated	Avoid
Full tree system	X		
CTL system		X	
Sap-free season	X		
Frozen ground	X		
Leaves off	X		
High trail footprint			X

Getting started:

- Design a trail network that provides < 20% area in trails
- Determine maximum trail width and plan according to topography
- Select a residual basal area target for the leave strip by reducing the existing pre-treatment basal area by as much as 40% without dropping below 16m2/ha
- Establish a pecking order for removal
- Decide if operator will be allowed to remove complete pockets of trees if dominated by unacceptable growing stock
- Establish thresholds for maximum pocket size
- Prepare criteria for determination of acceptable growing stock (AGS)
- Select maximum tree size to retain

In the leave strip:

- Try to release crop trees on at least 2 sides
- Create guidelines for tolerance for damage on crop trees
- Make sure the ratio of AGS to UGS is improved
- Try to maintain the basal area target but allow for within stand variability
- Protect established regeneration and saplings of commercial species



Institut de recherche sur les feuillus nordiques
Northern Hardwoods Research Institute

Method/Treatment:

Commercial thinning

Sub-system: *N/A*

Intermediate treatment

CT

Stand Eligibility

- **FUNA:** SMTH, YBTH,
- **Structure:** E1, E2,
- Regular stand or patch structure
- AGS>UGS
- Young to immature development stage
- High stocking
- Productive site
- Even distribution of trees in stand
- QMD<20cm
- BA > 20m^2/ha

Objectives of system

The stands that were subjected to major disturbances generally develop as single cohort stand with one species or stratified mixture of more than two species (E1 and E2 stands). In this type of stands, trees grow without competition until the growing space is reoccupied.

When the growing space is fully occupied, trees will compete each other for light, moisture and nutrients. In this condition, thinning denser stands can redistribute the resources to the remaining trees and thus help producing large diameter trees in a shorter period compared to not-thinned stands.

To fulfill this objective, trees that are (1) of undesirable species, (2) poor-quality (damaged or defective) and (3) good quality but in strong competition can be removed. This can be implemented through intermediate treatments prior to the final harvest. An intermediate treatments are usually designed to modify the stand so that continued stand development will enhance the quality and growth of established trees. Hence, intermediate treatments aim to improve stand composition, structure, growth, quality, and health. Therefore, it is also known as a stand-tending phase of a silvicultural system.

Description

Commercial thinning is implemented to single cohort SMTH and YBTH fully stocked stands (BA>20 m2/ha), which have quadratic mean diameter less than 20 cm. Individual tree form and vigor are important considerations for CT. The objective of producing quality saw timber will only be met if the stand has larger proportion of trees with better form and vigor. Therefore, the proportion of AGS and UGS needs to be determined using risk and form class of the trees as mentioned in NHRI tree classification system.

The stand is recommended for CT only if the proportion of AGS>UGS. Branch free bole length is another consideration that helps to determine thinning intensity.

The treatment is regulated by use of stocking guides and stand density management diagrams. If more than 50% of the trees have branch free bole greater than 4 m then the stand can be thinned to B-line. If not, then the stand need to be thinned to quality line for promoting natural pruning . This will help to maintain desired length of branch free bole.

A crop-tree variant can be considered where less emphasis is put on stand but more on elite trees.

Desired Outcomes

Immediate

Well stocked stand of crop trees after treatment

Crop trees released on 3 sides

Low damage on residual trees

Increased proportion of desired species and AGS

No site damage

Reduced proportion of trees at risk

Mid-term

Increased growth on crop trees

Low competition by interfering plants

Good development of crowns on crop trees

Low tree mortality

Long-term

High proportion of sawtimber

Clear boles (5m) on elite trees

Stand ready for other intermediate treatment

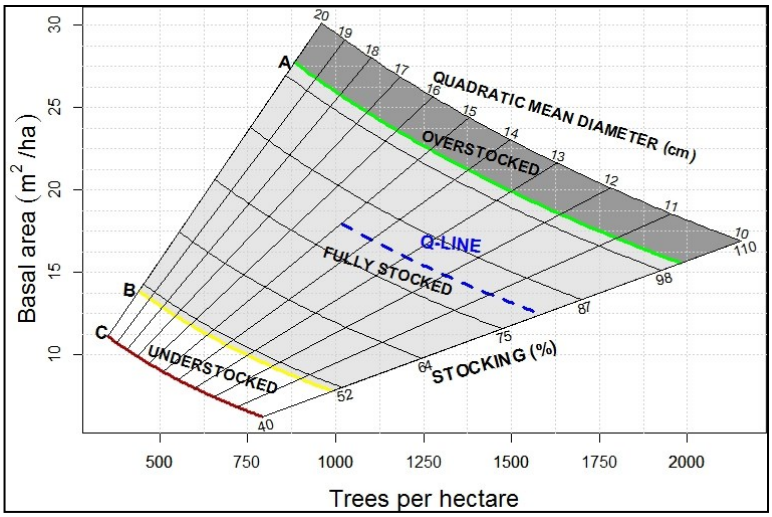
Key success factors

- Strip pattern adjusted to the species of interest
- Planned on good seed years
- Strips oriented to maximize seed dispersion

Implementing Commercial thinning treatments

Operational considerations

	Prefered	Tolerated	Avoid
Full tree system		X	
CTL system		X	
Leaves off	X		
Frozen ground	X		
Outside sap season	X		



Northern hardwood stocking guide (The figure is a calibrated version of Gingrich Stocking Diagram for Northwest New Brunswick). 'A', 'B' and 'C lines are the stocking levels. The `A' line represents the normal condition of maximum stocking for undisturbed stands of average structure. The 'B' line is the lower limit of stocking needed for full occupancy of the site. Stands at 'C'-level stocking are expected to reach the 'B' level within 10 years (Gingrich 1967).

Types of thinnings for hardwoods

Low Thinning (Thinning From Below):

The removal of trees from the lower crown classes to favor those in the upper crown classes. Least desirable competitors (high risk, low vigor, poor quality) are generally removed. The removal of some co-dominants may create canopy openings and releases the crowns of crop trees to stimulate their growth. This thinning type puts equal emphasis on the production of volume and quality.

Crown Thinning (High Thinning, Thinning From Above):

The removal of trees from the dominant and co-dominant crown classes in order to favor the best trees of those same crown classes. As the trees removed are relatively large, it is often conducted as commercial operations. In this method, best dominant and co-dominant crop trees are ideally selected, favoured and carried through the entire rotation. The number of crop trees to leave is usually between 100 and 400 per hectare.

Free Thinning:

Trees are removed to control stand density and favor desired crop trees using a combination of low and crown thinning despite of the crown position. This type of thinning is used to develop and manage quality hardwood stands for the production of high value sawtimber and veneer logs.

Pre-planning

- Conduct a pre-treatment inventory to determine elligibility
- Decide on the thinning type based on management objectives
- Use stocking guide to determine removal intensity and residual levels.
- Set targets for regulating thinnings (i.e. B.A., distance between trees etc.)

Implement treatment

- Determine length of clear bole (BLC) on crop trees
- Using the stocking guide:

  If BLC<4m, thin to quality line

  If BLC>4m, thin to B line
- Prepare quality standards and pecking order

Institut de recherche sur les feuillus nordiques
Northern Hardwoods Research Institute

Method/Treatment:

Overstory removal

Sub-system: *N/A*

General treatment

OSR

Stand Eligibility

- All except M1 SMTH and YBTH
- Stands where regeneration is well established and ready to be released
- Stands that did not receive recent treatment on purpose but where regeneration is ready
- Regeneration cohort < 2m in height

Objectives of system

The overstory removal treatment is associated mostly with shelterwood, some irregular shelterwood and seed-tree cut sub-systems. The purpose is to liberate regeneration that has been established as a result of previous treatments. It is typical of even-aged systems as well as being locally conducted in two-aged systems.

It is conducted when seedlings no longer require protection or shelter by a partial canopy. Indeed, its timing is critical as to not damage regeneration but to make resources available to the new cohort.

Description

Harvesting the topmost cover up to a diameter limit releases the saplings and small merchantable stems.

Particularly when the merchantable diameter is increased (e.g.: 18 cm plus), the residual stand has an irregular structure and this treatment can be categorized as part of the irregular high-forest system. The treatment may also be similar to a selective commercial thinning if the exploitable diameter is smaller.

Desired Outcomes

Immediate	Mid-term	Long-term
Well stocked regeneration of desired species	Vigorous growth of desired species regeneration	High proportion of sawtimber
Released established regeneration	Good stems development of desired species	Clear boles (5m) on elite trees
Low damage to advanced regeneration	Low mortality of regeneration	
No site damage	Low competition from interfering plants	

Key success factors

- Ideal timing as to liberate advanced regeneration, reduce risk of invasion by interfering plants
- A well planned trail network to minmize damage to regeneration and soil
- Conducted before saplings reach 2m in height
- Conducted under snow cover when possible

Implementing Overstory removal treatments

Operational considerations

	Prefered	Tolerated	Avoid
Full tree system		X	
CTL system		X	
Leaves off	X		
Frozen ground	X		
Outside sap season	X		

Pre-planning

Implement treatment