Acadian Forest Ecosystem Research Program (AFERP) Silvicultural System: expanding gap group shelterwood ("Acadian Femelschlag") or group selection with reserves

Robert S. Seymour
NE Silviculture Institute - June 23, 2017

Two expanding-gap silviculture regeneration methods were designed to emulate the 1% annual disturbance intensity and disturbance pattern common to the Acadian ecoregion (Table 1). Gaps are created and then systematically expanded in all directions after the previous gap area has been regenerated. Both systems are applied using a 10-year cutting cycle.

Irregular Group Shelterwood with Reserves treatment – Harvests 20% of the area using 0.2 ha expanding gaps and with a 10-year regeneration period between expansions. This system is designed to encourage natural regeneration of tree species of intermediate shade tolerance and to maintain stands of mid-successional status.

Group Selection with Reserves treatment – This system is spatially and temporally a "half-speed" version of the group shelterwood treatment (above). This system harvests 10% of the area using 0.1 ha expanding gaps with a 20-year regeneration period between gap expansions. The 10:20 system is designed to encourage shade-tolerant species and accelerate development of late-successional stands.

Unharvested control **–** No harvesting will be used in the control, thus providing a background comparison for natural disturbance patterns.

Table 1 – Details of the AFERP treatments.

Treatment	Area Treated During Cutting Cycle	Gap Regeneration Period	Disturbance Frequency (yr^{-1})	Compositional Goal	Research Area #
Group Shelterwood	20%	10 yr	1% (2% for 1st 50 yrs, then rest for 50 yrs)	Mid-successional	1, 6, 9
Group Selection	10%	20 yr	1%	Late successional	2, 5, 7
Control	0%	Natural	Natural only	Natural succession	3, 4, 8

AFERP Prescription Details

Initial Entry: (1995-97)

1. Locate patches of established advance regeneration (in the understory reinitiation stage), distributed regularly throughout the stand if possible (Type A Gaps).
2. Remove most of the overstory; retain 10% (about 15 sq ft BA) of original stand in reserve trees.
3. Where necessary, locate additional gaps of the target size (approximately 0.1 or 0.2 ha) in areas of stem exclusion dispersed regularly in the stand, such that the total gap area = the 10% or 20% target (Type B gaps).
4. Because Type B gaps are presumably not well regenerated, leave the 10% in reserve trees (as above) plus 20% more (total = 45 sq ft BA) as a shelterwood overwood to promote regeneration and inhibit invasion of intolerants.

All Re-entries in the group shelterwood treatment: (2005—2007, 10 year intervals)

1. Expand existing gaps non-symmetrically over an additional 20% of the stand area, leaving 10% in reserve trees as above.
2. Remove non-reserve shelterwood overwood trees left in the Type B gaps during the first entry.
3. Repeat on a 10 year cycle until entire stand is regenerated in year 40 (the 5th entry).

Re-entry 1 in the group selection treatment:

1. Repeat initial entry as described above, making new Type A or B gaps over an additional 10% of the stand area, well distributed.

Re-entry 2 in the group selection treatment:

1. Expand gaps made during the initial entry non-symmetrically over an additional 10% of the stand area, leaving 10% in reserve trees as above.
2. Remove non-reserve shelterwood overwood left in the Type B gaps during the first entry.

Re-entry 3 in the group selection treatment:

1. Expand gaps made during the second entry non-symmetrically over an additional 10% of the stand area, leaving 10% in reserve trees as above.
2. Continue this pattern of gap expansion on a 10-year cycle, alternating between the initial and second-entry gaps.

Reserve Trees -- Criteria

1. Any medium-large dbh tree with obvious wildlife use (cavity, etc)
2. Large trees of poor timber quality (limby white pine, forked or cull trees, etc)
3. Any large tree of long-lived late successional species (hemlock, white pine, white-cedar)
4. Rare species (red oak, sugar maple)

Stand Tending (ds[;omh regeneration in gaps): Completed 2017 in RA1 only. See details below.

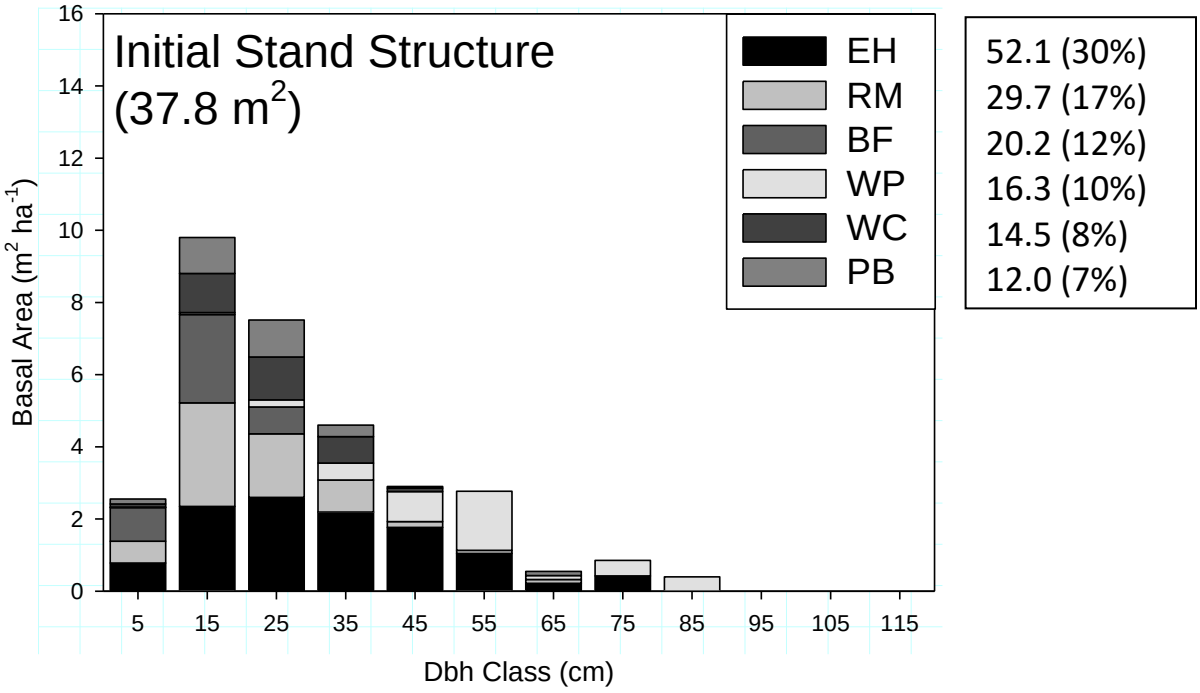
Advantages of area- based stand structures (ecological):

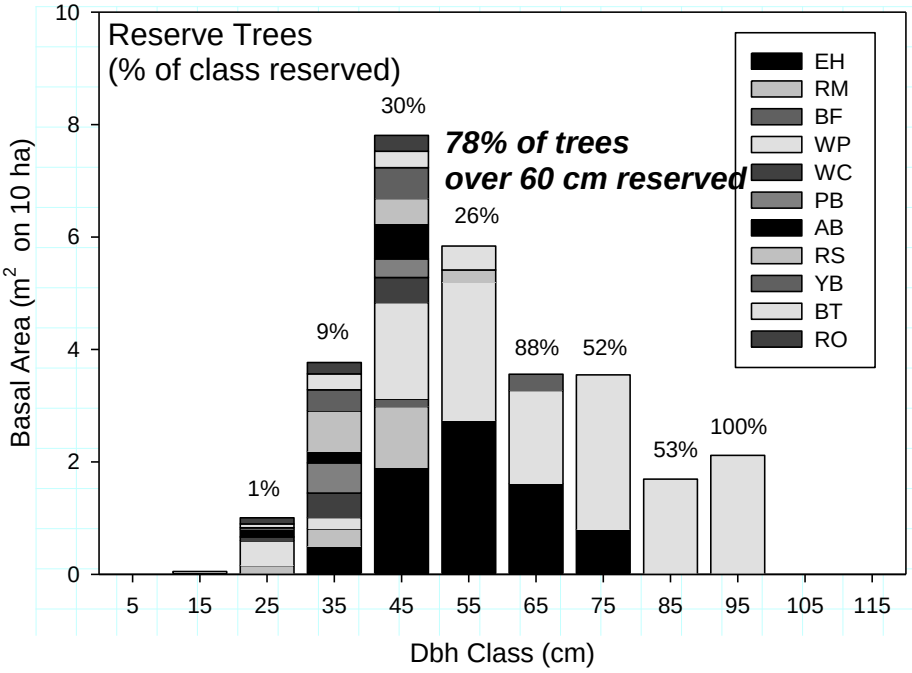
1. **Manages regeneration deliberately, not by assumption (of future ingrowth)**
   -- Gap size, overall regeneration rate
1. **Ecological sustainability guaranteed (if cutting cycle is comparable to natural disturbance rates)**
2. **No need to assume a problematic linkage between age and size**
3. **Manages regeneration deliberately, not by assumption (of future ingrowth)**

Advantages of area- based stand structures (operational):

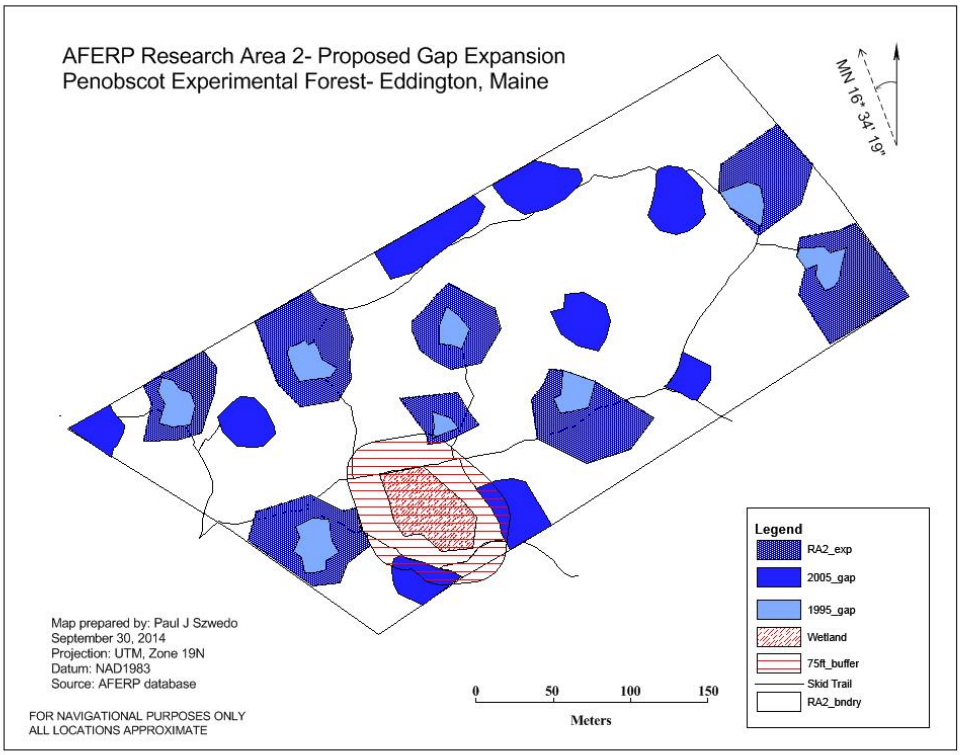
4. **Pre-harvest layout, logging, early tending are all concentrated on 10-20% of stand**
   -- No need to work throughout entire stand (after first entry)
4. **No need for pre-harvest dbh distribution information, or overall marking tally**
5. **Yields are more straightforward to predict**
6. **Light harvests (<25%) are feasible (really = “mini clearcuts”)**

Average of Research Areas 1, 2 and 3

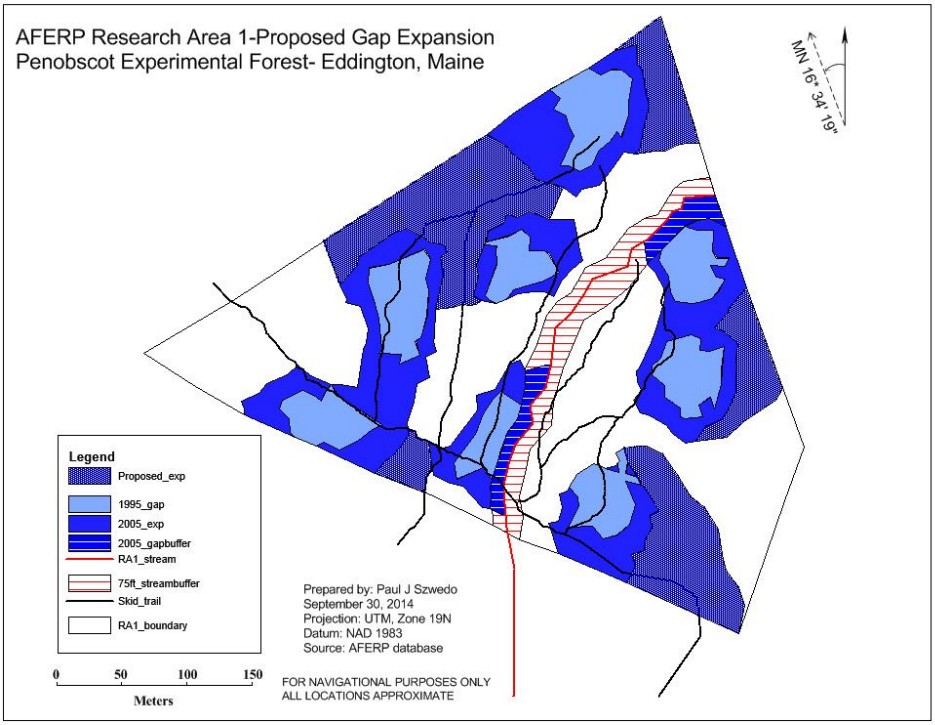




Group Selection with Reserves (RA 2)



Irregular Group Shelterwood with Reserves (RA 1)



	Retained Trees		No. of trees that died during the study				
Tree Species	No.	%Survival	Brash	Died Standing	Trunk Broken	Uprooted	Wind-caused deaths%
Abies balsamea	4	100.0	0	0	0	0	0
Acer rubrum	119	96.6	2	0	2	0	50
Acer saccharum	33	97.0	0	0	0	1	100
Amelanchier canadensis	1	0.0	0	1	0	0	0
Betula alleghaniensis	12	91.7	0	1	0	0	0
Betula papyrifera	24	83.3	3	1	0	0	0
Fagus grandifolia	17	88.2	1	0	1	0	50
Fraxinus americana	22	100.0	0	0	0	0	0
Fraxinus nigra	1	100.0	0	0	0	0	0
Ostrya virginiana	2	100.0	0	0	0	0	0
Pinus resinosa	12	91.7	0	0	0	1	100
Picea rubens	153	88.9	4	1	6	6	70.6
Pinus strobus	112	91.1	3	2	4	1	50
Populus grandidentata	9	100.0	0	0	0	0	0
Populus tremuloides	18	66.7	1	2	3	0	50
Quercus rubra	18	100.0	0	0	0	0	0
Thuja occidentalis	84	81.0	1	2	6	7	81.3
Tsuga canadensis	146	97.9	0	2	0	1	33.3
Total	787	91.6	15	12	22	17	59.1

20-year fate of Reserve Trees by species.

[Carter, D.R., R. S. Seymour, S. Fraver, and A. Weiskittel. 2017. Reserve tree mortality in two expanding-gap silvicultural systems 20 years after establishment in the Acadian Forest of Maine, USA. Forest Ecology and Management 389:149-157]

AFERP Harvest Prescription – Research Areas 1 and 2 off the Chemo Pond Road (Third Entry, replicate 1)

Feb. 12, 2015

Bob Seymour, Paul Szwedo

Background: This is the third entry into these stands; previous cuts were in 1995 and 2005. The general purpose of this entry is to expand gaps made in previous entries. In RA 1, 20% of the stand (5 acres) is designated to be cut; in RA 2, 10% (2.5 acres) is targeted, including only the gaps that were cut 20 years ago. The prescription is primarily an overstory removal, retaining 10-20% of the basal area in reserve and growing stock trees.

Prescription Details:

1. Gap boundaries and previous skid trails are contained in ARC GIS shape files. Boundaries of these gaps are flagged with **yellow ribbon**.
2. All merchantable-size trees designated for cutting are marked in **yellow paint** as high as possible, on at least two sides of the tree.
3. Every 50 meters there are older parallel yellow-painted grid lines we use to locate plots. In some cases these intersect the harvest gaps which are also marked to cut in yellow. If you see such a yellow-blazed tree with pink ribbon, this is meant to KEEP, not cut.
4. All residual trees over about 10 inches dbh that are designated to stay are **flagged in pink**. Some smaller trees of certain species (red spruce, white pine, sugar maple, hemlock) were also flagged to keep in order to help the operator in avoiding damage to these smaller stems.
5. Try to avoid felling and delimbing trees into the established regeneration in previous gaps. This means using the INNER yellow flagged line (defining the previous cut) as the first trail location, so that trees generally can fall into the unregenerated part of the stand.
6. Some gaps (mostly RA 1) will require multiple trails to complete the cut. Here we rely on operator discretion to minimize the overall trail impact while still completing the designated harvest.
7. When moving from gap to gap, try to use the old trail network as much as possible. These should be fairly obvious on the ground, and are also clearly marked in the shape file.
8. There are a few large white pines in RA 1 marked to cut that are probably too big for the processor to handle. This is Robin Avery's call on how to handle these.

The simple version:

- **CUT THE YELLOW PAINT-MARKED TREES.**
- **LEAVE THE PINK FLAGGED STEMS.**
- **START ON THE INNER FLAGGED TRAILS.**

Outcome:

Ponsse Ergo (Dangle-head CTL) Cut 300 cords in 4.5 days, with excellent results (7.7 cords per hour). Operations on deep snow in February. Stumpage income = $7,653 on 7.5 acres of gap harvested (50 total stand acres).

Treat immature growing stock as "tall regeneration" and NOT a part of the 10% gap retention target. See RA 1 SE corner.

Precommercial Thinning (Group Shelterwood Treatment) using multivariate cluster analysis

3.3 Cluster Descriptions

The following section details the clusters created in the final partitioning analysis. Among the patterns discovered, relative fir and pine compositions, having negative correlations with each other, seemed to represent pre-harvest conditions. Namely, where pine occurs in relatively high compositions, it is hypothesized that this condition is reflective of regeneration establishment following harvest. Conversely, where fir occurs in relatively high compositions, it is hypothesized that this condition is reflective of advance regeneration release at time of harvest. It is hypothesized that clusters with low relative percent compositions of both species contain variables such as high percent composition in overstory sized trees and high hardwood compositions.

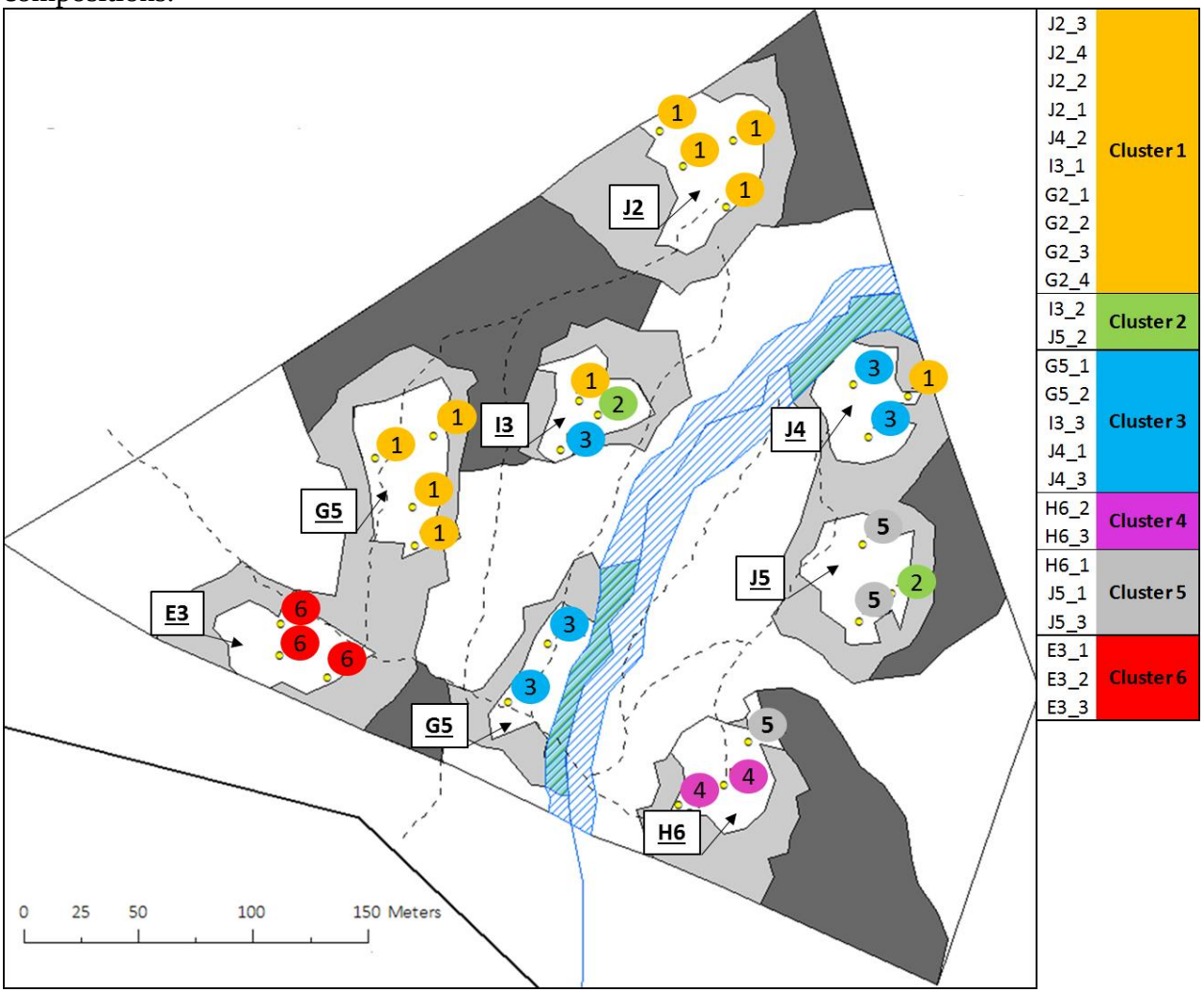


Fig. 9: Plot locations by cluster

Prescription: Cluster 1 "Sapling Thickets"

Management is intended to reduce overall densities within the sapling size class through targeted removal of fir and hemlock, allocate growing space to pine, spruce, and aspen, shift species composition away from fir, and reduce the impact of harvesting by treating the red maple stump sprouts via PCT. Furthermore, a future commercial thinning of fir will serve as a continuation of fir management in this cluster.

Through PCT, a trainer matrix will be created for pine in order to shade lower branches and reduce defect of form from white pine weevil. This roughly translates to retaining 1 fir and 1 hemlock per pine. Density reduction should still be carried out in the same manner in the absence of pine. Both fir and hemlock occur at very high densities and heavy reductions of their respective stockings are at the heart of this prescription. For modeling purposes, no potential crop tree (pine, spruce, or aspen) was removed from the tree list. It is likely that in the field, pine will have to be thinned, whether because of weevil damage or proximity to a better formed crop tree. However, intermediate or overtopped pine should be chosen as a trainer tree before either fir or hemlock.

A commercial thinning of the merchantable fir studwood component ≥ 12.7 cm (5 inches) is scheduled for 2065. It is therefore imperative that the majority of the fir retained in PCT treatment be of best possible quality, even for trainers.

Cluster 1 PCT Protocol

1. Fir and hemlock density reduction:
    1a. **Retain 1 out of every 12 fir between 4 - 10 cm (~1.5 – 4.0 inches) d.b.h.**
        - Translates to an approximately 92% reduction within this size-class
    1b. **Retain** 1 **out of every 50 fir between < 4.0 cm (1.5 inches) d.b.h.**
        - Translates to an approximately 98% reduction within this size-class
    1c. **Retain 2 out of every 5 hemlock < 10 cm (4.0 inches) d.b.h.**
        - Alternate between size of hemlock left (1 smaller one than 1 larger one)
    1d. Where pine occurs, **leave 1 fir and 1 hemlock of lesser size per pine crop tree**
        - Trainers can be shared among multiple pines
        - This should be carried out within the reduction protocol described above

2. Red maple stump sprout treatment
    2a. **Remove all stems from every 4 out of 5 red maple clumps**
        - Target clumps with visible stump decay and poorly formed stems for removal
    2b. Retain the **best formed stem of lowest origin on 1 out of every 5 clumps**
        - Space away from crop trees, such as pine and aspen

3. Reduction of the paper birch component
    3a. **Retain 1 out of every 4 paper birch**
        - ~ 75% of birch component
        - Space away from crop trees

4. Remove as many sub-sapling sized (< 1.37 m (4.5 ft)) tall **red maple and fir** as possible

5. Release any **spruce** with a relatively large "cone"

6. Treat any pine, aspen, and rare hardwoods as *invisible*

Prescription: Cluster 2 "Hemlock Residual"

Management is intended to shift species composition to more mid- to late-successional conditions. The prescription focuses on treating maple stump sprouts and cleaning of the fir component to limit effects of the harvest as well as attempt to accelerate late successional conditions. Red maple is retained on every third clump regardless of overall density of clumps to integrate red maple into an otherwise hemlock dominated condition. Hemlock is retained.

Cluster 2 PCT Protocol

1. Reduction of the fir component
    1a. **Retain 1 out of every 20 fir**
        - Translates to an approximately 95% reduction within this component

2. Red maple stump sprout treatment
    2a. **Remove all stems from on 2 out of every 3 red maple clumps**
        - Target clumps with visible stump decay and poorly formed stems for removal

    2b. **Retain the best formed stem of lowest origin on 1 out of every 3 clumps**
        - This should be carried out regardless of overall red maple clump density

3. Red maple of seed origin treatment
    3a. **Retain 1 out of every 4 red maple stems of seed origin**

4. Remove as many sub-sapling sized (< 1.37 m (4.5 ft)) tall **red maple and fir** as possible

5. Treat any **pine, spruce,** and **hemlock as invisible**

Prescription: Cluster 3 "Intolerant and Generalist Hardwood Dominated"

Management is intended to shift species compositions towards more conifer-dominated conditions. Due to the variety of densities that occur within this cluster, fir is primarily targeted for removal to achieve desired densities. This will also increase the proportion of pine to fir. This treatment can be seen as a gentle liberation of the white pine component from the overtopping hardwood component. Pine is currently too small for full release.

Cluster 3 PCT Protocol

1. Reduction of the fir component
    1a. **Retain 1 out of every 6 fir stems**
        - Translates to an approximately 85% reduction within the fir component
        - Preferably, space fir of lesser height to an adjacent pine

2. Red maple stump sprout treatment
    2a. **Retain the best formed stem on 1 out of every 3 clumps**
        - Preferably, these treated clumps should be spaced as evenly as possible
    2b. **Completely remove all stems on 2 of every 3 clumps**

3. Reduction of the paper birch component
    3a. **Retain 1 out of every 6 birch stems**
        - Space evenly, preferably providing only partial shade to surrounding pine component

4. Remove any **striped maple** encountered (minimal component observed)

5. Treat all **hemlock**, **pine**, aspen, and **rare hardwoods** (white ash, yellow birch, and red oak) as invisible

6. Remove as many sub-sapling sized (< 1.37 m (4.5 ft)) tall **red maple, paper birch, and fir** as possible

7. Release any **spruce** with a relatively large "cone"

Prescription: Cluster 4 "White Pine Regeneration Establishment"

Management is focused on a cleaning of the hardwood component and a reduction of the fir component in order to prepare the residual pine component for future pre-commercial thinning. Fir is to serve as future trainers, due to the potential heavy mortality of the intermediate to overtopped pines. Currently, the pine is too small for release due to risk of weevil damage. Very few pine were observed exhibiting severe weevil damage, potentially due to no one individual having long and thin enough leaders to cause complete mortality of the meristem. Secondly, damage to crowns from ice build-up was observed in this condition. It is not confirmed that thinning will either help or exacerbate this problem. The prescription therefore refrains from currently thinning the pine component. Furthermore, other conditions may be suitable for pine thinning in the future as well.

Cluster 4 PCT Protocol

1. Reduction of the fir component
    1a. **Retain 1 out of every 4 fir stems**
        - Translates to an approximately 75% reduction in the fir component
        - Residual fir should be left in close proximity to future pine stems in order to serve as trainers

2. Cleaning of the hardwood component

2a. **Completely remove red maple and paper birch stems <u>< 8 cm (~ 3inches)</u>**

3. Remove as many sub-sapling sized (< 1.37 m (4.5 ft)) tall **red maple, paper birch, and fir** as possible

4. Treat all **pine, hemlock** and **spruce** as *invisible*

<u>Prescription: Cluster 5 "Over-topped White Pine Establishment"</u>

Management is focused on reducing the stocking of overtopping hardwoods and hemlock impeding with the development of the pine sapling component. However, the pine has not reached adequate size to justify complete release. Removal of hemlock within the 6 – 12 cm classes and treatment of red maple clumps will serve to reduce the amount of low shade restricting pine growth without risking weevil damage to the pine. Furthermore, retention of hemlock < 5 cm and 10% retention of fir in the 2 cm class may motivate stratification of these species beneath pine, aid in in the shedding of the lower branches and reduce the risk of white pine blister rust infection. In the future, areas in this condition should be monitored. If pine has developed to proper sizes and forms, thinning of the pine component and a heavier liberation from overtopping hardwoods can occur. This treatment, in all, is an effort to gently liberate the pine component and assist in its development and survival.

<u>Cluster 5 PCT Protocol</u>

1. Reduction of the fir component

1a. **Retain 1 out of every fir stems**

- Preferably, leave fir 50-75% the height of an adjacent pine to serve as trainer

2. Red maple stump sprout treatment

2a. **Retain the best formed stem on 1 out of every 3 clumps**

- Preferably, these treated clumps should be spaced as to not completely overtop much of the surrounding pine component while not creating high light conditions (30-40% crown closure)

2b. **Completely remove the stem on 2 of every 3 clumps**

3. Hemlock treatment

3a. **Completely remove hemlock between <u>4 - 12 cm (~1.5 – 4.5 inches)</u>**

4. Remove as many sub-sapling sized (< 1.37 m (4.5 ft)) tall **red maple, paper birch, and fir** as possible

4. Treat all **hemlock < 5cm (2 inches), red oak, white ash, beech, pine** and **spruce** as *invisible*

Prescription: Cluster 6 "Advanced Development in Natural Gap"

Management is focused on using density reductions and fir removals to prepare areas in this condition for future commercial thinning of the fir component. Species composition shifts focus on moving from a fir to hemlock and hardwood dominated condition. Red maple stems are retained on every clump in an effort to diversify species composition. Light conditions are not conducive to pine survival. Removal of fir from the smaller size-classes along with a future commercial harvest is intended limit the extent to which fir will dominate these conditions in the future.

A commercial thinning of the merchantable fir component ≥ 12.7 cm (5 inches) is scheduled for 2055. It is therefore imperative that the majority of the fir retained in PCT treatment be of best possible quality.

Cluster 6 PCT Protocol

1. Reduction of the fir component
    1a. **Complete removal of fir < 4.0 cm (~ 1.5 inches)**
        - Intended to allocate growing space to hemlock of similar size
    1b. **Retain 1 out of every 4 fir between 5 – 12 cm (~ 2 -4.5 inches)**
        - Intended to allocate more growing space to sub-merchantable fir
        - Fir retained should be chosen on spatial distribution as well as form and health, in order to improve the chance its survival to commercial thinning
        - Translates to a **75% reduction** within this size-class

2. Red maple stump sprout treatment
    2a. **Retain the best formed stem on EVERY clump**
        - Red maple occurs sparingly within this condition; a stem should be left on every clump, regardless of spatial orientation
        - Where a larger maple may interfere with a future fir crop tree, chose a smaller stem with decent form and stump attachment

3. Remove as many sub-sapling sized (< 1.37 m (4.5 ft)) tall **fir** as possible

4. Treat all **hemlock, pine, and birch** as *invisible*

	C1	C2	C3	C4	C5	C6
B. fir	Retain **1 out of every 12** between 4-12 cm Retain **1 out of every 50** < 4cm > 12 cm: **Invisible** If pine crop tree is present, space residual fir of lesser size as trainer	Retain **1 out of every 20** across all size classes	Retain **1 out of every 6** across all size classes Any residual should serve as pine trainer if possible	Retain **1 out of every 4** across all size classes Any residual should serve as pine trainer if possible	Retain **1 out of every 10** across all size classes Any residual should serve as pine trainer if possible	Retain **1 out of every 4** between 5-12 cm **Complete** removal of < 4cm ≥ 12 cm: **Invisible**
W. pine	**Invisible**	**Invisible**	**Invisible**	**Invisible**	**Invisible**	**Invisible**
E. hemlock	Retain **2 out of every 5** < 10cm	**Invisible**	**Invisible**	**Invisible**	**Complete** removal of 4-12 cm < 4cm: Invisible	**Invisible**
R. maple	Retain best formed stem on **1 out of every 5** clumps (completely remove all stems on other 4)	Retain best formed stem on **1 out of every 3** clumps (completely remove all stems on the other 2) Retain **1 out of every 4** of seed origin	Retain best formed stem on **1 out of every 3** clumps (completely remove all stems on the other 2)	**Complete removal of all clumps**; increase in r. maple clumps indicates shift in cluster	Retain best formed stem on **1 out of every 3** clumps (completely remove all stems on the other 2)	**Retain** best formed stem on **EVERY** clump
P. birch	Retain **1 out of every 4** across all size classes	**Invisible**	Retain **1 out of every 6** across all size classes	**Complete removal**	**Invisible**	**Invisible**
R. spruce	**Cone release**	**Invisible**	**Cone release**	**Invisible**	**Invisible**	**Invisible**
Seedlings	Remove all red maple and fir	Remove all red maple and fir	Remove all red maple, fir, and p. birch	Remove all red maple, fir, and p. birch	Remove all red maple, fir, and p. birch	Remove all fir