Description of NORTHERN MINNESOTA & ONTARIO PEATLANDS Subsection Forest Resource Management Plan (SFRMP) modeling

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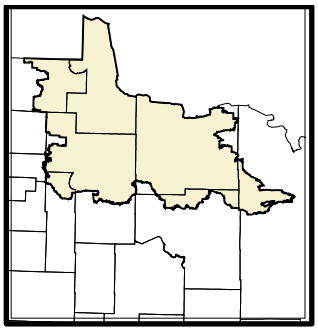
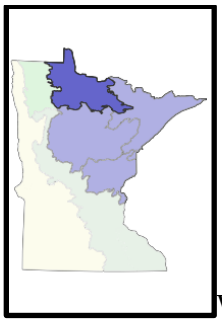
The Minnesota Department of Natural Resources has begun preparing the Northern Minnesota & Ontario Peatlands Section Forest Resource Management Plan (NMOP SFRMP). This Plan will identify forest vegetation management for two ecological subsections: Agassiz Lowlands and the Littlefork-Vermilion Uplands.



The Northern Minnesota & Ontario Peatlands ecological Section consists of a total land area of approximately 5.3 million acres. The majority of the land cover in the NMOP is identified as lowland conifer deciduous, upland deciduous forest and aquatic environments (swamp, wetlands). The majority of the land is in public ownership. There is a little over 2.9 million acres (55%) of land in public ownership (federal, county, state). State ownership accounts for approximately 2.3 million acres. From these acres this planning process will identify Forestry and Wildlife administered lands that will be site visited and possibly assigned a treatment prescription over the next ten years (10-year stand exam list).

As part of the SFRMP, landscape modeling was conducted. For this purpose, a software package called the Remsoft Spatial Planning System (RSPS) was used. Woodstock is a component of RSPS that allows users to examine how various land uses, management alternatives, and social policies will impact timber supply at a strategic-level, given the existing forest types and stand inventories. Strategic means at a large-scale, and ignores the spatial relationships between/among individual stands.



Within DNR's strategic-level plans, the planning horizon is 150 years but only the initial 50 years are analyzed by the NMOP planning team. For this analysis, the objective function in Woodstock is to maximize discounted revenues. Since Woodstock uses linear programming to find an optimal solution when trying to maximize discounted revenues, which is merely a mathematical operation, if no constraints are included most stands will be harvested at year 150. Of course linear programming has no concept of the future beyond the 150 year planning period. Hence, the additional 100 years helps to provide a more realistic depiction of how stands will be managed near the end of the initial 50 year period.

It is felt this is advantageous to placing binding constraints (or constraints that must be met) to avoid illogical behavior 45 and 50 years into the future. Even-flows also help to avoid projected harvesting spikes at the end of the 150 year planning period. For the part of the planning horizon that is analyzed, 10 five-year planning periods were used.

In general, individual stands are not projected throughout a planning horizon when using Woodstock. Rather, stands are grouped into categories and then acres within a category (where the acres are a conglomeration of many stands) receive treatments and are projected throughout the planning horizon. For example, all stands classified as a Balsam Fir cover type (within FIM/CSA coded as 62), could be grouped into site qualities using an interval of 5 feet (e.g. site quality class 50 could encompass all Balsam Fir cover type stands with site qualities ranging from 50 to 54 feet) and then these Balsam Fir cover type stands grouped by site quality class would receive treatments within Woodstock and projected forward as a group. In this case, when treatments are assigned to a category, there is no way to tell what specific stands should be treated within a particular planning period.

As opposed to other optimization techniques, linear programming allows proportions of a landbase to receive treatments. For example, it could be that only 34% of Aspen cover type, site index 65 stands receive a clearcut operation in a particular planning period. For other optimization techniques, such as integer programming, activities either occur or don't (either 1 or 0) in a particular planning period.

Harvest scheduling does not optimize management objectives of the target forest. Rather, it is about developing an optimal activity schedule for the transition of the existing forest to the desired future forest. For many stands, individual stand management may be less than optimal so that section/subsection objectives as a whole can be met.

NMOP GIS ARCMAP SHAPEFILE

To conduct a landscape level harvest scheduling analysis, the landbase must be quantified as to the amount of cover type acres by age and site productivity and potential management restrictions/actions that can occur on those acres. The most recent DNR FIM shapefile database (05/15/2014) for the NMOP was queried. Cover type is determined based on internal DNR algorithms, site index is calculated based on measurement of dominant trees within the field and appropriate equations, and age is based on field measurements.

Within Woodstock, after excluding old growth stands and other stands designated as not allowing timber harvest, there is a total of 66,785 polygons totaling an acreage of 2,168,223 acres – the smallest stand acreage is 0.1 acres and the largest stand acreage is 7,461 acres. For the commonly managed timber types, this landbase only includes harvestable stands, and is referred to as "timberlands" (hence excludes old growth and other non-harvestable stands). Prior to conducting the analysis within Woodstock, this original dataset was manipulated to prepare it for the modeling exercise. For instance, new cover types were created (e.g. red pine plantations are coded as 521 rather than 52 to allow for different management treatments relative to natural red pine stands which remain coded as 52).

Number of acres by cover type are shown in Table 1. Table 2 shows modifications of the MN_CTYPE field for modeling purposes.

Table 1. MANAGEABLE (excludes old growth and other non-harvestable acres) cover type acreages within the NMOP SFRMP dataset.

MN_CTYPE	Cover Type Name	Number of Stands	Acres
1	Ash	2,845	50,484
9	Lowland Hardwoods	252	5,968
12	Aspen	16,568	338,332
13	Birch	368	5,868
14	Balm of Gilead	1,500	23,242
20	Northern Hardwoods	131	1,927
30	Oak	26	396
301	Oak - High Slope	-	-
51	White Pine	99	997
52	Red Pine Natural	265	3,042
521	Red Pine Plantation	1,068	15,864
53	Jack Pine	2,984	44,399
61	White Spruce	251	3,107
611	White Spruce Plantation	639	10,856
62	Balsam Fir	1,385	23,070
71	Black Spruce – High	2,435	53,170

710	BS – Low	2,686	83,638
711	BS - Medium	5,521	165,430
72	Tamarack – High	2,960	98,594
721	Tamarack - Low	2,892	139,420
74	Upland Black Spruce	126	1,768
Total		45,001	1,069,572
Non-merchantable Acreage			
6	Willow	2	11
15	Cottonwood	2	8
73	NWC	3,630	93,014
Low Productivity			
75	Stagnant Spruce	3,132	257,432
76	Stagnant Tamarack	815	107,452
77	Stagnant Cedar	2,173	98,537
78	Offsite Aspen	115	2,847
79	Offsite Oak	3	31
82	Cutover Area	3	22
83	Lowland Grass	1,083	35,225
84	Upland Grass	1,203	8,316
85	Lowland Brush	6,161	330,864
86	Upland Brush	162	1,989
87	Duff	1	9
88	Moss	3	84
90	Other	49	2,149
91	Agriculture	117	2,044
92	Industrial Development	360	5,545
93	Recreational Development	3	33
94	Roads	290	2,598
95	Rock Outcrop	18	87
96	Permanent Water	176	4,689
97	Non-permanent Water	992	33,075
98	Marsh	726	43,766
99	Muskeg	565	68,824
Grand Total		66,785	2,168,223

OLD GROWTH (OG)

At the current time lowland conifer old growth acres have not been officially designated. Hence, these acres do not exist within the current GIS shapefile and do not exist on the current DNR

land base and were not excluded from timber harvest consideration. Thus, within the model during the first planning period, Woodstock assigned an old growth status to acres and this status was permanently maintained on these acres. These acres are tracked within Woodstock for a cover type separately from non-old growth (or harvestable) status using an OG designation.

For upland cover types, old growth designation has actually occurred and thus these acres were deleted from the GIS shapefile and from representation within the Woodstock modeling land base.

Table 2. For the purposes of modeling, several cover types above have been split and in some cases new cover types have been created. Creating these treatment *regimes* provides more realistic model outcome.

MN_CTYPE	Cover Type Name	Creation	Reasoning
101	Regulated Ash	Created during model	-
109	Regulated Lowland Hardwoods	Created during model	-
120	Regulated Northern Hardwoods	Created during model	-
301	Oak – High Slope	Existing, TOPO = 3	High slope Oak sites
130	Regulated Oak	Created during model	-
151	Regulated White Pine	Created during model	-
152	Once Thinned Red Pine Natural Stand	Created during model	
252	Twice Thinned Red Pine Natural Stand	Created during model	
352	Three Thinned Red Pine Natural Stand	Created during model	To ensure stands can only be thinned
452	Four Thinned Red Pine Natural Stand	Created during model	**UP TO** 6 times prior to age 100
552	Five Thinned Red Pine Natural Stand	Created during model	
652	Six Thinned Red Pine Natural Stand	Created during model	
521	Red Pine Plantation	Existing, ORIGIN = 2 or 3	-
522	Once Thinned Red Pine Plantation	Created during model	
523	Twice Thinned Red Pine Plantation	Created during model	
524	Three Thinned Red Pine Plantation	Created during model	To ensure stands can only be thinned
525	Four Thinned Red Pine Plantation	Created during model	**UP TO** 6 times prior to age 100
526	Five Thinned Red Pine Plantation	Created during model	
527	Six Thinned Red Pine Plantation	Created during model	
1151	Once Thinned White Pine Stand	Created during model	
251	Twice Thinned White Pine Stand	Created during model	
351	Three Thinned White Pine Stand	Created during model	To ensure stands can only be thinned
451	Four Thinned White Pine Stand	Created during model	**UP TO** 6 times prior to age 100
551	Five Thinned White Pine Stand	Created during model	
651	Six Thinned White Pine Stand	Created during model	

71	Black Spruce – High	Existing, SI >=40	Allows for three different rotation ages for conventional runs of Woodstock
710	Black Spruce – Low	Existing, SI 23 to 29	
711	Black Spruce – Medium	Existing, SI 30 to 39	
72	Tamarack – High	Existing, SI >=40	Allows for two different rotation ages for conventional runs of Woodstock
721	Tamarack – Low	Existing, SI < 40	
161	Regulated White Spruce	Created during model	-
611	White Spruce Plantation	Existing, ORIGIN = 2 or 3	-
612	Once Thinned White Spruce Plantation	Created during model	To ensure stands can only be thinned **UP TO** 2 times prior to clearcut
613	Twice Thinned White Spruce Plantation	Created during model	

DESCRIPTION OF YIELD TABLES

For this analysis, cover type volumes are initially estimated using cover type specific yield tables, then average cover type species compositions (calculated using FIA/FIM data) are used to determine the amount of individual species volume harvested.

Basal area, mean stand diameter, and total cordwood volume were estimated for each planning period. All equations require cover type, site index, and age. All clearcut even-aged systems were modeled using Walters and Ek forms (1993, Whole Stand Yield and Density Equations for Fourteen Forest Types in Minnesota, Northern Journal of Applied Forestry, 10:75-85) – these are values basically using only FIM data from within the NMOP section. Yield tables were created for the section as a whole rather than by subsection.

All red pine, white pine, and white spruce thinnings were assumed to generate 10 cords per acre, regardless of cover type or age. For uneven-aged types (partial cutting harvests) a reduced portion of the predicted yields were assumed to represent partial cuttings. For the Ash, Lowland Hardwood, Northern Hardwoods, and Oak cover types, it was assumed each partial cutting generates 50% of the predicted clearcut yields. For the uneven-aged White Spruce and White Pine cover types, it was assumed each partial cutting generates 33% of the predicted clearcut yields.

For all clearcut harvests, only 95% of the expected volume (yield table estimate) was available at final harvest to reflect the current DNR practice of leaving 5% of the harvest area intact to address non-timber concerns.

DESIRED FUTURE FOREST CONDITIONS (DFFCs) AND CONSTRAINTS

The following values were utilized during this particular analysis (Tables 3 to 5).

Table 3. Normal rotation age (NRA) by cover type. AL refers to Agassiz Lowlands, and LFV refers to Littlefork-Vermilion Uplands.

Cover Type	Subsection	Site Type	Age
Aspen/BG	All	All	45
Birch	All	All	50
Jack Pine	All	All	50
Upland Black Spruce	AL	All	70
Upland Black Spruce	LFV	All	50
BSL Low 23-29	All	All	120
BSL Medium 30-39	All	All	100
BSL High 40+	All	All	80
Tamarack Low <40	AL	All	100
Tamarack Low <40	LFV	All	90
Tamarack High 40+	AL	All	80

Tamarack High 40+	LFV	All	60
White Spruce <65	AL	Planted	70
White Spruce 65+	AL	Planted	60
White Spruce	LFV	Planted	70
Balsam Fir	AL	All	45
Balsam Fir	LFV	All	50
Red Pine	All	Natural	100
Red Pine 65+	All	Planted	60
Red Pine 55-64	All	Planted	65
Red Pine <55	All	Planted	70

Table 4. "Older" forest age by cover type.

Cover Type	Site Index	Age
Aspen/BG	All	55
Birch	All	55
Jack Pine	All	65
BSL Low 23-29	All	125
BSL Medium 30-39	All	105
BSL High 40+	All	85
Tamarack Low <40	All	105
Tamarack High 40+	All	85
White Spruce	Planted	75
Balsam Fir	All	55
Red Pine	All	105
NWC	All	140

Table 5. "Younger" forest age by cover type.

Cover Type	Site Index	Age
Aspen/BG	All	30
Birch	All	35
Jack Pine	All	30
BSL Low 23-29	All	70
BSL Medium 30-39	All	60
BSL High 40+	All	40
Tamarack Low <40	All	50
Tamarack High 40+	All	30
White Spruce	Planted	25
Balsam Fir	All	30
Red Pine	All	25

UNDER DEVELOPMENT STANDS

At the time of the shapefile creation, many stands were scheduled to receive some type of treatment (based on past plans), these stands are specified as "Under Development" within FIM. Unfortunately the exact treatment is not specified within FIM. To account for changes to the landbase from these treatments, stand ages were specified based on revised ages provided within the GIS shapefile.

POTENTIAL MANAGEMENT ACTIONS

Given the current amount of acres by cover type, site quality, and age, and desired future forest conditions and management objectives, and potential management actions that can occur, Woodstock will find the optimal management scheme of all stands to move the existing forest to the desired future forest. For any acre, there are many potential management actions that could occur and the timing of those actions can vary. It is important that potential management actions within Woodstock reflect possible operational management options and the conditions that could impact choosing one alternative over another.

For instance, operationally, ABg stands are generally clearcut, and these clearcut operations do not occur until a stand reaches age 45. There are many options for a particular stand, for instance it could be harvested at age 45 or it could be harvested at age 55. The timing of a specific operation depends on the projected yields and the desired future forest conditions. It could be that for a particular ABg stand, based on its site index, volume is maximized at age 46. However, because of age-class distribution constraints at the landscape level, the optimal time to harvest this stand is at age 54. Thus, in order to optimize landscape level management objectives, some stand-level harvested volume would be sacrificed.

Table 6. Potential clearcut operations by cover type.

Cover Type	Cover Type Code	Site Index (base age 50)	Ages
Aspen	12	All site qualities	> = 45
Balm of Gilead	14	All site qualities	> = 45
Birch	13	All site qualities	> = 50
Red Pine (both natural and plantation)	52, 521	All site qualities	See Table 3
Jack Pine/Upland Black Spruce	53	All site qualities	See Table 3
White Spruce Plantation	611	All site qualities	See Table 3
Balsam Fir	62	All site qualities	See Table 3
Black Spruce – Low	710	<= 29 ft	> = 120
Black Spruce – Medium	711	>= 30 ft and <= 39 ft	> = 100
Black Spruce – High	71	>= 40 ft	> = 80
Tamarack – Low	721	<= 39 ft	See Table 3
Tamarack – High	72	>= 40 ft	See Table 3

For red pine, white pine, and white spruce thinnings, at least 10, 10, and 15 years must pass before another thinning can occur, respectively. For red pine and white pine, up to 6 thinnings can occur beginning at age 30 up to age 100, and for white spruce up to 2 thinnings can occur beginning at age 40 before the final harvest.

Table 7. Potential thinning operations by cover type.

Cover Type	Cover Type Code	Site Index (base age 50)	Ages
Red Pine (both natural and plantation)	52, 521	>= 45	>= 30 years and <= 100 years
White Spruce Plantation	611	All site qualities	>= 40 years
White Pine	51	>= 45	>= 30 years and <= 100 years

For any partial cutting (whether GROUP or REGULATED), at least 20 years must pass before another cutting can occur.

Table 8a. Potential uneven-aged (partial cutting) GROUP harvesting operations by cover type.

Cover Type	Cover Type Code	Site Index (base age 50)	Ages	Basal Area Per Acre	Cords Per Acre
Ash	1	>= 45	All	>= 90	>= 15
Lowland Hardwoods	9	>= 45	All	>= 90	>= 21
Northern Hardwoods – Young	20	All site qualities	>= 26 years and <= 55 years	>= 100	-
Northern Hardwoods – Old	20	All site qualities	>= 56 years	>= 100	-
Oak	30	All site qualities	>= 60 years	-	-
White Pine	51	All site qualities	>= 125 years	-	-
White Spruce	61	All site qualities	>= 80 years	-	-

Table 8b. Potential uneven-aged (partial cutting) REGULATED harvesting operations by cover type.

Cover Type	Cover Type Code	Site Index (base age 50)	Ages
Ash	101	All site qualities	All
Lowland Hardwoods	109	All site qualities	All
Northern Hardwoods	120	All site qualities	All
Oak	130	All site qualities	All
White Pine	151	All site qualities	All
White Spruce	161	All site qualities	All

Because of ecological concerns, we assumed no harvesting of northern white cedar stands. Due to low acreages, there are no management actions in Willow and Cottonwood cover type stands. Due to low productivity and therefore relatively high logging costs per unit harvested, stagnant spruce, stagnant tamarack, stagnant cedar, offsite aspen, and offsite oak have no management actions.

AVERAGE PERCENT SPECIES COMPOSITIONS

To estimate individual species volumes, average percent species compositions were obtained by cover type. A combination of USDA Forest Service Forest Inventory and Analysis (FIA) and FIM data were used. Merchantable volume (as opposed to say total volume or basal area) was used to determine percent species compositions.

LOWLAND CONIFER DESIGNATION

For scenarios requiring a certain amount of forest be specified as "old growth," acres were permanently assigned during the first period. Hence, these acres were removed from the harvest pool.

CONVERSION ACTIONS

There were two different sets of cover type conversion goals achieved through forest management. One set considered the implications of climate change on cover type management goals while the other set specified conversion goals without consideration of climate change to support other forest management directions such as conversions for wildlife habitat. The implications of climate change on cover type management as a response to climate change is a newly introduced management action into the SFRMP process, whereas conversion to support wildlife habitat has been a management action found in past SFRMPs.

Tables 9 through 13 identify the factors and percentages used in modeling the conversion actions.

Table 9 identifies the modeled change in cover type acres based on past SFRMPs but modified for potential climate change. These reflect realistic percentages given the actual historic conversions proposed in past plans.

Table 9. Percent change in cover type acres achieved through clearcutting over the next 50 years FOR THE CLIMATE CHANGE SCENARIO. Percentages are cumulative.

Cover Type	Site Index	10-Year	20-Year	30-Year	40-Year	50-Year
Aspen	All	-1.4%	-2.8%	-4.2%	-5.6%	-7.0%
Balm	All	-1.4%	-2.8%	-4.2%	-5.6%	-7.0%
Birch	All	-1.4%	-2.8%	-4.2%	-5.6%	-7.0%

Table 10 identifies the percent change in cover types acres which may be pursued to accommodate other conversion goals such as for wildlife habitat. These percentages are viewed as aggressive, not particularly achievable but are intended to show how changes in conversions compare among the scenarios.

Table 10. Percent change in cover type acres achieved through clearcutting over the next 50 years FOR THE SCENARIOS NOT CONSIDERING CLIMATE CHANGE. Percentages are cumulative.

Cover Type	Site Index	10-Year	20-Year	30-Year	40-Year	50-Year
Aspen	All	-5.0%	-10.0%	-15.0%	-20.0%	-22.0%
Balm	All	-5.0%	-10.0%	-15.0%	-20.0%	-22.0%
Birch	All	-5.0%	-10.0%	-15.0%	-20.0%	-22.0%

When considering potential climate change impacts (refer to Table 9), the following transitions of cover types are assumed:

Table 11. Cover type transitions by decade.

Cover Type	Site Index	10-Year	20-Year	30-Year	40-Year	50-Year
Jack Pine	All	15.0%	15.0%	15.0%	15.0%	15.0%
Red Pine Planted	All	25.0%	25.0%	25.0%	25.0%	25.0%
White Pine	All	15.0%	15.0%	15.0%	15.0%	15.0%
N Hardwood	All	35.0%	35.0%	35.0%	35.0%	35.0%
L Hardwood	All	3.0%	3.0%	3.0%	3.0%	3.0%
White Spruce Natural	All	7.0%	7.0%	7.0%	7.0%	7.0%

For the conversion goals not accounting for climate change (refer to Table 10), percent of acres transitioning to other cover types differs whether a conversion is obtained through a clearcut operation or not. For conversions obtained through operations other than clearcutting **(Soft Conversion)**, the following percent transitions are assumed:

Table 12. Soft conversion transition percentages

Cover Type	Site Index	10-Year
Balsam Fir	All	25.0%
White Spruce Natural	All	25.0%
White Pine	All	50.0%

For conversions obtained through clearcutting **(Hard Conversion)**, the following percent transitions are assumed:

Table 13. Hard conversion transition percentages

Cover Type	Site Index	10-Year	20-Year	30-Year	40-Year	50-Year
Jack Pine	All	33.0%	33.0%	33.0%	33.0%	33.0%
White Spruce Natural	All	11.0%	11.0%	11.0%	11.0%	11.0%
Balsam Fir	All	11.0%	11.0%	11.0%	11.0%	11.0%
Red Pine Planted	All	17.0%	17.0%	17.0%	17.0%	17.0%
White Pine	All	17.0%	17.0%	17.0%	17.0%	17.0%
NWC-Upland	All	11.0%	11.0%	11.0%	11.0%	11.0%

STUMPAGE PRICES PER SPECIES

Revenues per cord of harvested wood are presented below. For several species a blended pulpwood/bolt/sawtimber price was used. This was obtained by multiplying the per cord stumpage revenues associated with pulpwood exclusively, bolts/pulpwood, and sawtimber times their reported cords to produce a weighted-average cord revenue. Examples are provided for aspen, red pine, and birch. A 3% interest rate was used when discounting stumpage revenues.

Table 14. Prices per cord of harvested wood. Applies to all scenarios. Prices are from the 2013 Public Stumpage Price Review for DNR Forestry http://files.dnr.state.mn.us/forestry/timber_sales/stumpage/stumpageReviewReport2013.pdf . The exceptions being Red Oak, White Oak, and NWC which were provided by Don Deckard, DOF Forest Economist.

Species	Stumpage Price Per Cord of Pulpwood	Blended Stumpage Price Per Cord of Bolts/Pulpwood/Sawtimber	Real Price Adjustment (1)
Trembling Aspen	$24.97	-	-
Largetooth Aspen	$24.97	-	-
Balm	$20.66	-	-
Paper Birch	-	$10.19	-
Basswood	-	$13.67	-
Red Oak (2)	-	$40.00	Y
White Oak (3)	-	$30.00	Y
Maple (4)	-	$13.13	-
Ash (5)	-	$6.47	-
Elm (6)	-	$18.39	-

Balsam Fir	-	$11.04	-
Black Spruce	$17.62	-	-
Jack Pine	-	$27.70	Y
Red Pine on non-RP cover types (7)	-	$41.84	Y
Tamarack	$4.66	-	-
White Pine	-	$44.12	Y
White Spruce	-	$19.46	Y
White-cedar (8)	$5.00	-	-

Table Notes:

(1) For planning purposes, designated species increase in real terms at 0.5% per year.

(2) Includes black oak.

(3) Includes bur oak.

(4) Sugar and red maple.

(5) Black, green, and white ash.

(6) Includes American elm, red elm, black cherry, butternut, pin oak, hackberry, hickory, silver maple, cottonwood, willow, and misc.

(7) For red pine cover type, use red pine price table by age and silvicultural treatment.

(8) Includes northern white and eastern red cedar.

$$\text{Aspen}_{\text{Blend}} = \frac{\$0 \text{ per Sawtimber cord} * 0 \text{ cords} + \$0 \text{ per Pulp and Bolt cord} * 0 \text{ cords} + \$24.97 \text{ per pulpwood cord} * 400{,}759.1 \text{ cords}}{0.0 \text{ cords} + 0.0 \text{ cords} + 400{,}759.1 \text{ cords}} = \$24.97 \text{ per cord}$$

$$\text{Red Pine}_{\text{Blend}} = \frac{\$110.66 \text{ per Sawtimber cord} * 1{,}496.2 \text{ cords} + \$41.54 \text{ per Pulp and Bolt cord} * 52{,}880.8 \text{ cords} + \$13.50 \text{ per pulpwood cord} * 3{,}080.2 \text{ cords}}{1{,}496.2 \text{ cords} + 52{,}880.8 \text{ cords} + 3{,}080.2 \text{ cords}} = \$41.84 \text{ per}$$

$$\text{Birch}_{\text{Blend}} = \frac{\$0 \text{ per Sawtimber cord} * 0 \text{ cords} + \$16.98 \text{ per Pulp and Bolt cord} * 8246.8 \text{ cords} + \$7.45 \text{ per pulpwood cord} * 20{,}446.4 \text{ cords}}{0.0 \text{ cords} + 8246.8 \text{ cords} + 20{,}446.4 \text{ cords}} = \$10.19 \text{ per cord}$$

Table 15. Prices per cord of red pine harvested wood ON RED PINE COVER TYPES. Applies to all scenarios.

Age	Stumpage Price Per Cord	
	Thinning	Clearcut
30	$16.00	-
40	$26.00	-
50	$32.00	$50.00
60	$40.00	$65.00
70	$45.00	$70.00
80	$50.00	$75.00
90	$50.00	$75.00
100	$50.00	$75.00
110	-	$75.00
120	-	$75.00
130	-	$75.00
140	-	$75.00
150	-	$75.00

These prices reflect that a thinning at age 30 will generally only contain pulpwood, but with age the percent bolts (or small sawlogs) will likely increase and at older ages thinnings may even remove smaller sawlogs. For clearcuts, as age increases, the percent bolts and sawlogs will increase, but at some point a percentage of the tree diameters will become too large for current mill specifications, thereby eliminating the potential to sell that timber.

EVEN-FLOWS

Even-flows by cover type provide a target relative range of harvested volume over the next 150 years and represents the stability of harvested volumes. Quantifying the average amount of harvested volume and the likely variations from that average over the next 150 years provides industry some idea of the amount of fiber available for the production of primary wood products (e.g. pulpwood for oriented strand board and paper/pulp production and sawlogs for lumber, pallet, and veneer production) and even the production of secondary wood products.

Factors such as the rotation ages and yield tables (predicted volumes) all play an important part in estimating even-flows and their variation around the long-term average harvested volume. A greater percent even-flow allows for more flexibility as to the timing of harvests across the landscape and will likely result in slightly greater average harvested volumes. However, the greater average harvested volumes across time may result in periods of excessive supply and demand that could negatively impact the forest industry.

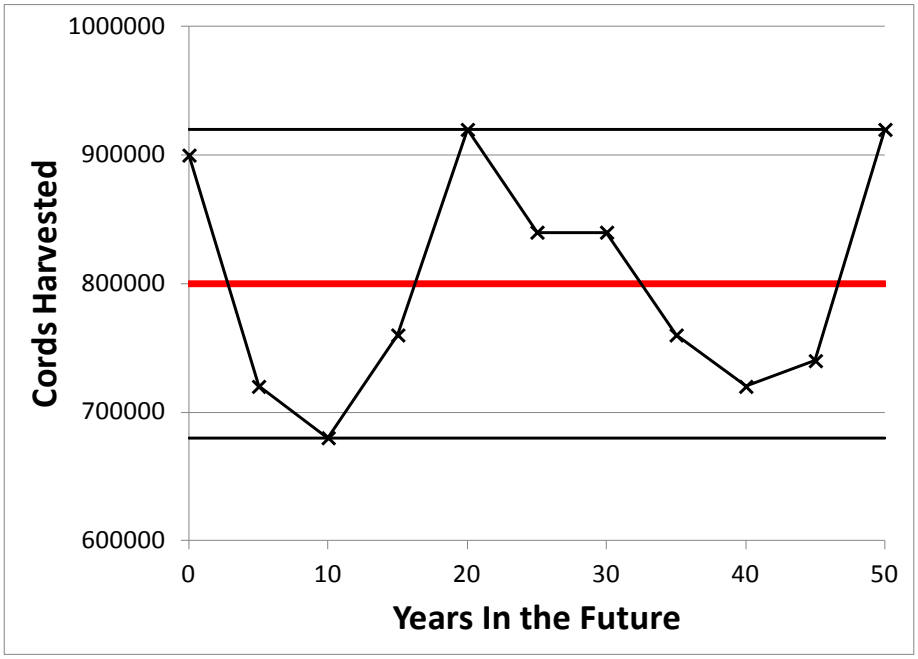


Figure 1. Depiction of an even-flow constraint on harvested volume.

In the figure above, the average amount of cords harvested over the next 50 years is 800,000 cords. An even-flow constraint of 15% was utilized. Hence, in any one year, the amount of harvested volume could deviate +/- 15% from the average harvest of 800,000 cords.

Greater percent even-flows allow for more flexibility in choosing stands to harvest across time to meet Desired Future Forest Conditions (DFFCs), this will generally result in a greater average harvested volume. However, greater percent even-flows result in more variation in the amount of harvested volumes from year to year which could negatively impact the forest industry.

SCENARIO MODELING

To address the variety of interests related to MNDNR land management, four different scenarios were developed. These four scenarios use the same rotation ages, stand density management, and revenues but differ in their Desired Future Forest Conditions (DFFC) for Lowland Conifer Old Growth (LCOG), even-flows of harvested volume, conversion goals (see Tables 9-13), and differ in their older forest goals. If a section planning team identified that existing forests could not provide enough older forest in the future ACROSS ALL OWNERSHIPS WITHIN THE BOUNDARIES OF THAT SECTION then the team could designate that purposeful management should be conducted on DNR LANDS to produce sufficient older forest in the future. The older forest analysis across all ownerships suggested that adequate older forest exists on the landscape today. However due to data uncertainties the NMOP section team added additional older forest constraints to the scenario modeling. This will the Team to continue to consider the amount of older forest as the SFRMP plan direction is determined.

The reader must be cautioned that the value of these modeling scenarios is not in determining final numbers, volumes, dollars or to produce absolute numbers that will be used as targets in future management. Rather the intended value of this modeling exercise is in comparing how the mix of parameters in one Scenario results in outputs that are relatively compared to outputs of other Scenarios.

Table 16. Percent Lowland Conifer Old Growth (LCOG) percentages.

Cover Type	Cover Type Code	Site index (base age 50)	A	B	C	D
Black Spruce – Low	710	<= 29 ft	10%	5%	10%	1.5%
Black Spruce – Medium	711	>= 30 ft and <= 39 ft	10%	5%	10%	1.5%
Black Spruce – High	71	>= 40 ft	10%	5%	10%	1.5%
Tamarack – Low	721	<= 39 ft	10%	5%	10%	1.5%
Tamarack – High	72	>= 40 ft	10%	5%	10%	1.5%
Northern White Cedar	73	All	10%	5%	10%	1.5%

Table 17. Even-flow of harvested volume across all cover types and species, and also by individual cover type.

Cover Type	Cover Type Code	Site index (base age 50)	A	B	C	D
All cover types	-	-	5%	20%	40%	40%
ABg	12, 14	All	5%	20%	40%	40%
Birch	13	All	5%	20%	40%	40%
Jack Pine/Upland Black Spruce	53, 74	All	5%	20%	40%	40%
Black Spruce – Low	710	All	5%	20%	40%	40%
Black Spruce – Medium	711	All	5%	20%	40%	40%

Black Spruce – High	71	All	5%	20%	40%	40%
Tamarack – Low	721	All	5%	20%	40%	40%
Tamarack – High	72	All	5%	20%	40%	40%
White Spruce Plantation	611	All	5%	20%	40%	40%
Balsam Fir	62	All	5%	20%	40%	40%
Red Pine (Natural)	52	All	5%	20%	40%	40%
Red Pine (Plantation)	521	All	5%	20%	40%	40%

Table 18. Percent older forest percentages applied to Scenarios across Agassiz Lowlands and Littlefork-Vermilion Uplands.

Cover Type	Cover Type Code	Scenario			
Upland Conifer		A	B	C	D
Red Pine - Planted	521				
Red Pine - Natural	52				
White Spruce - Planted	611	8%	4%	8%	0%
Jack Pine	53				
Balsam Fir	62				

Cover Type	Cover Type Code	Scenario			
Upland Hardwood		A	B	C	D
Aspen	12				
balm of Gilead	14	8%	4%	8%	0%
Birch	13				

Table 19. Summary of Desired Future Forest Conditions (DFFCs) for the four Scenario models. Where CC Response refers to the use of conversion goals taking into consideration climate change and Original SFRMP does not consider climate change when specifying conversion goals.

SFRMP Modeling Scenarios

Parameter	Scenario A	Scenario B	Scenario C	Scenario D
Even Flow	Tight 5%	Moderate 20%	Relaxed 40%	Relaxed 40%
LCOG Designation	High 10%	Moderate 5%	High 10%	Low 1.5%
Cover Type Change	Climate Change Response	Original SFRMP	Original SFRMP	No Change

Older Forest (if needed for certain Cover Types or groupings of types)	More	Some	More	None

OUTPUTS

Figure 1. Estimated harvested cords by scenario and five-year projection period across all cover types and species.

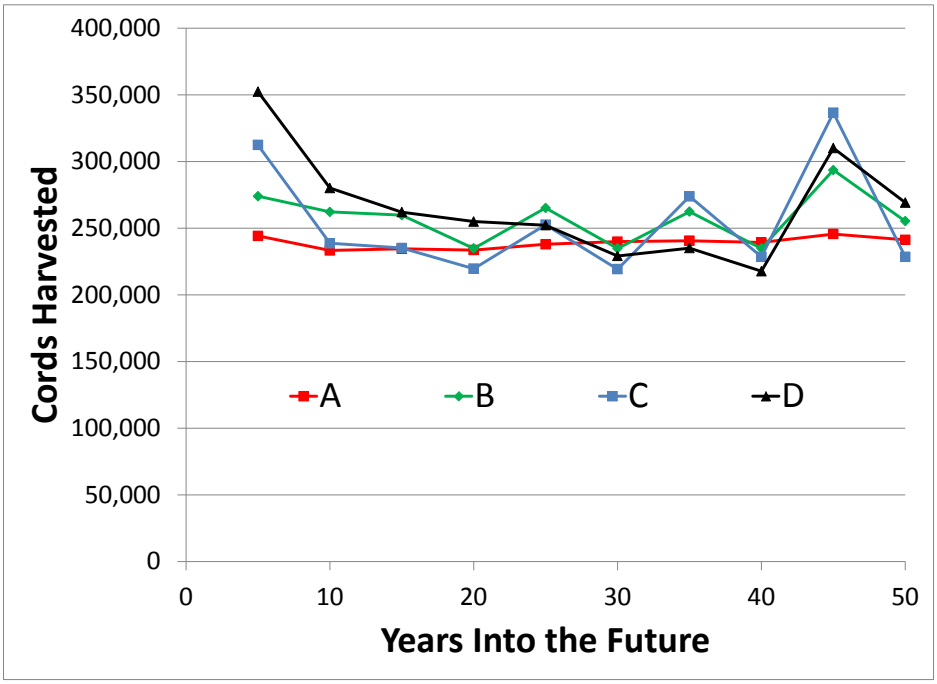


Figure 2. Estimated ASPEN and BALM SPECIES harvested cords by scenario and five-year projection period across all cover types.

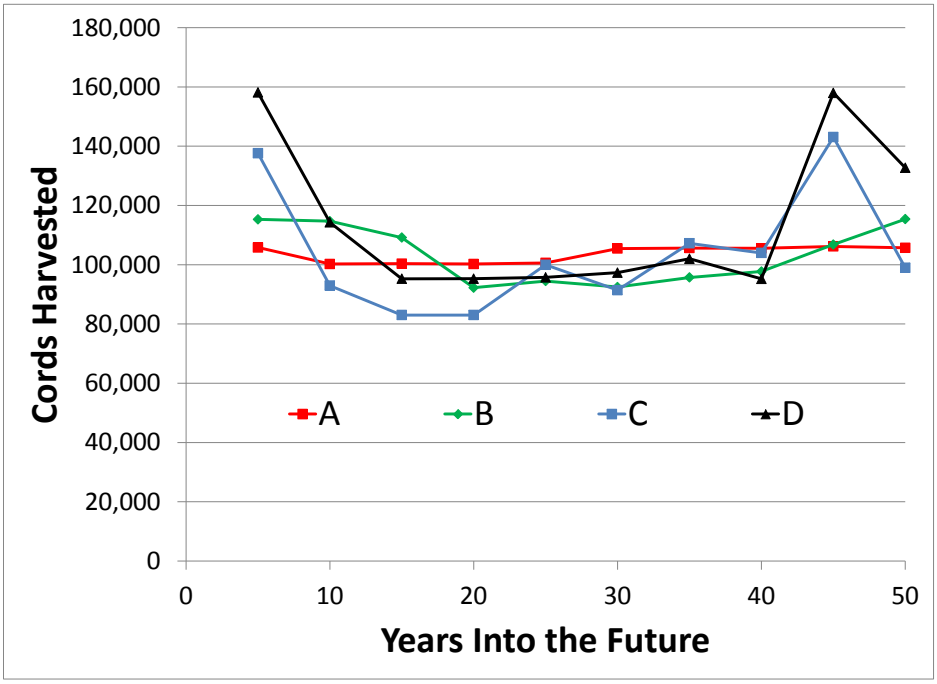


Figure 3. Estimated BIRCH SPECIES harvested cords by scenario and five-year projection period across all cover types.

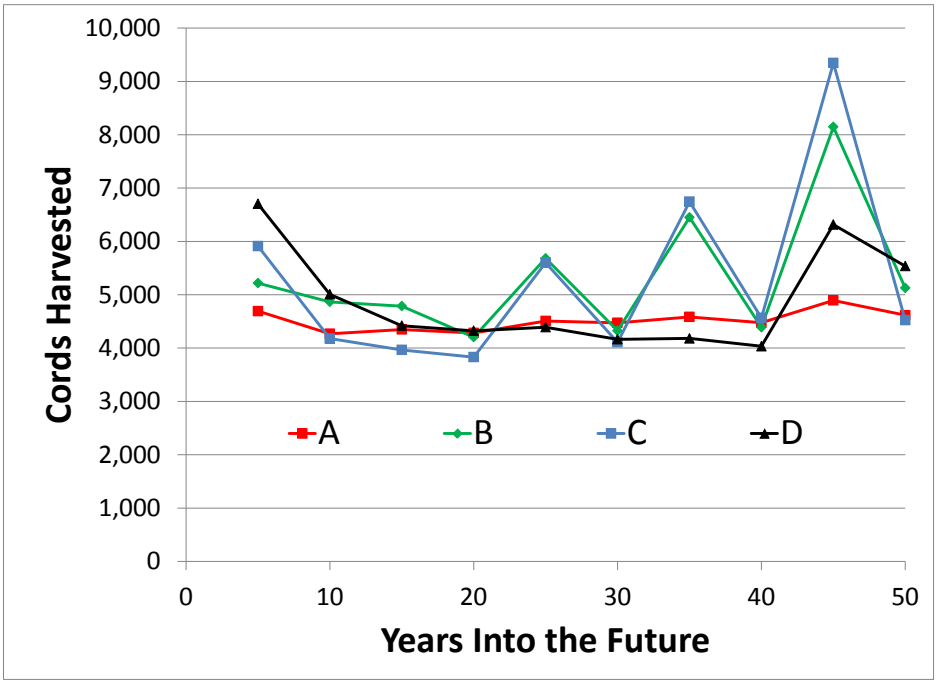


Figure 4. Estimated JACK PINE SPECIES harvested cords by scenario and five-year projection period across all cover types.

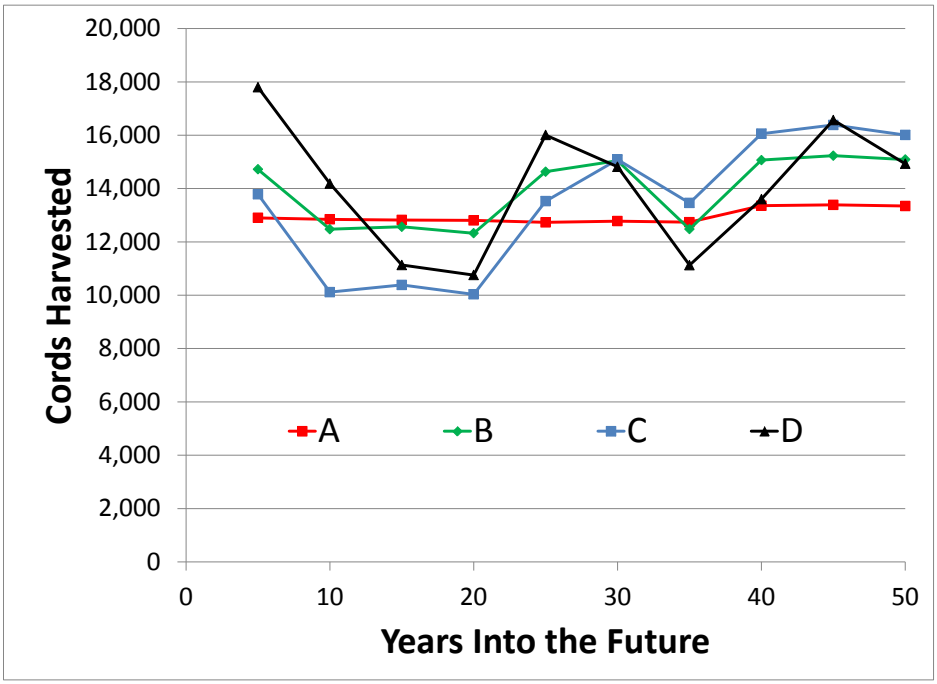


Figure 5. Estimated RED PINE SPECIES harvested cords by scenario and five-year projection period across all cover types.

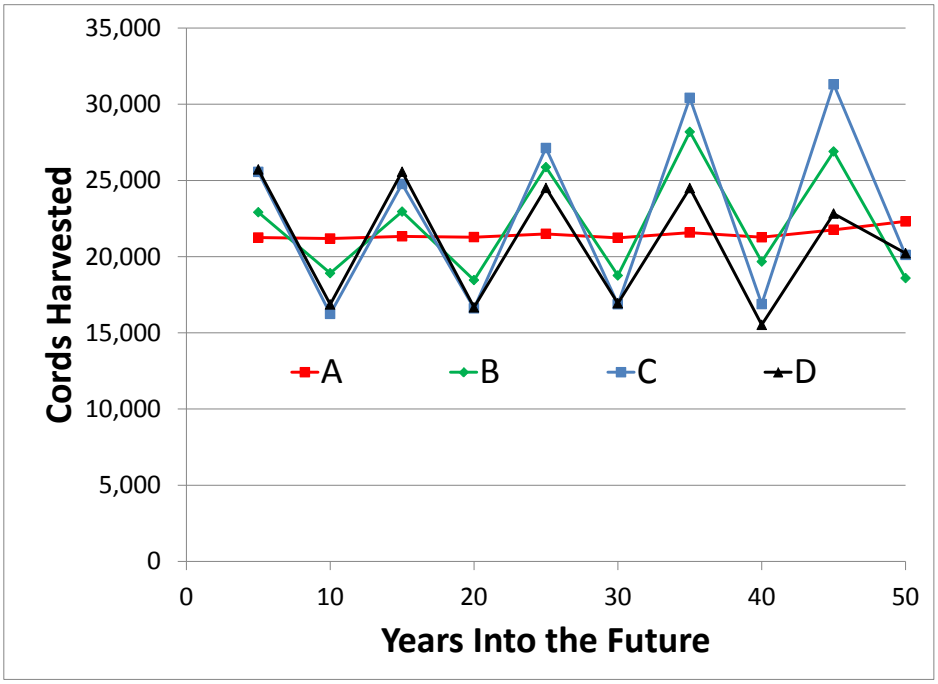


Figure 6. Estimated BLACK SPRUCE SPECIES harvested cords by scenario and five-year projection period across all cover types.

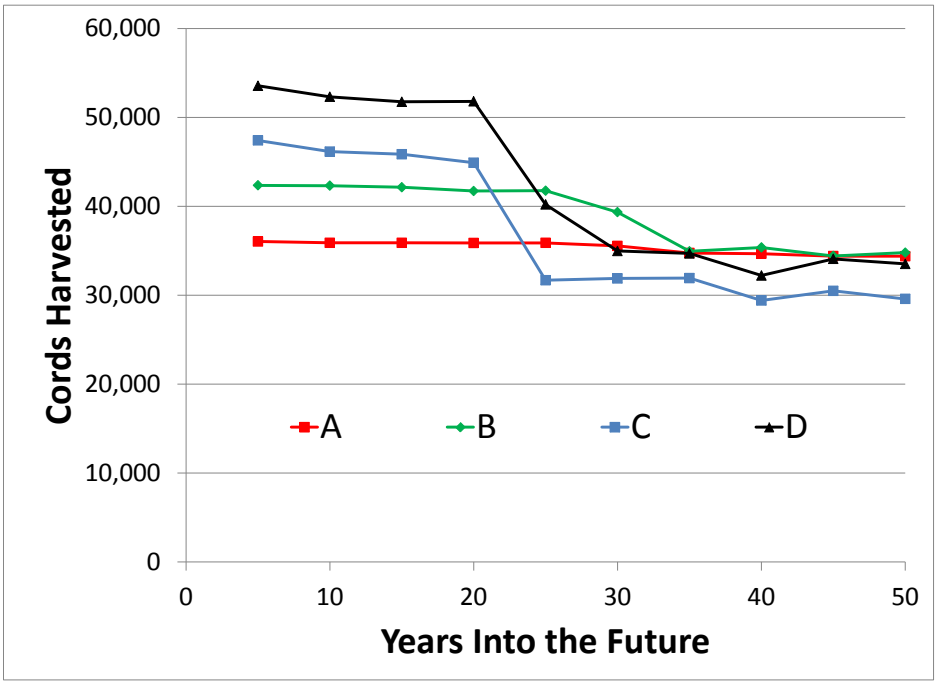


Figure 7. Estimated DISCOUNTED ANNUAL REVENUES over the next 10 (gray) and 50 years generated from harvested cords by scenario. A 3% interest rate was used.

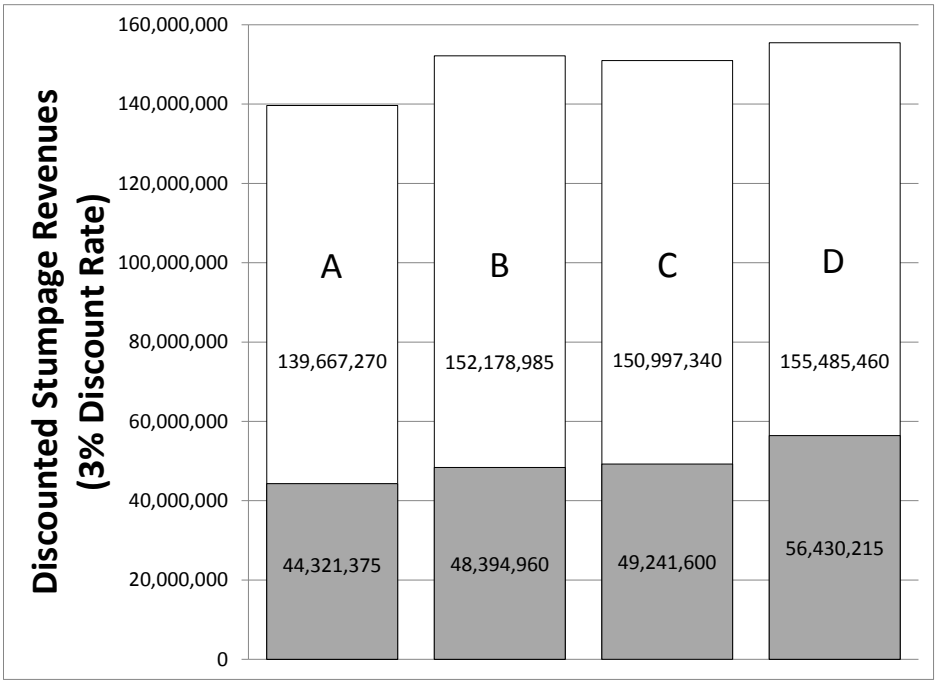


Figure 8. Percent older forest of lowland conifers (includes Tamarack, Black Spruce, and NWC cover types) by scenario. (See Table 4, page 9, for definition of "Older" forest age by cover type).

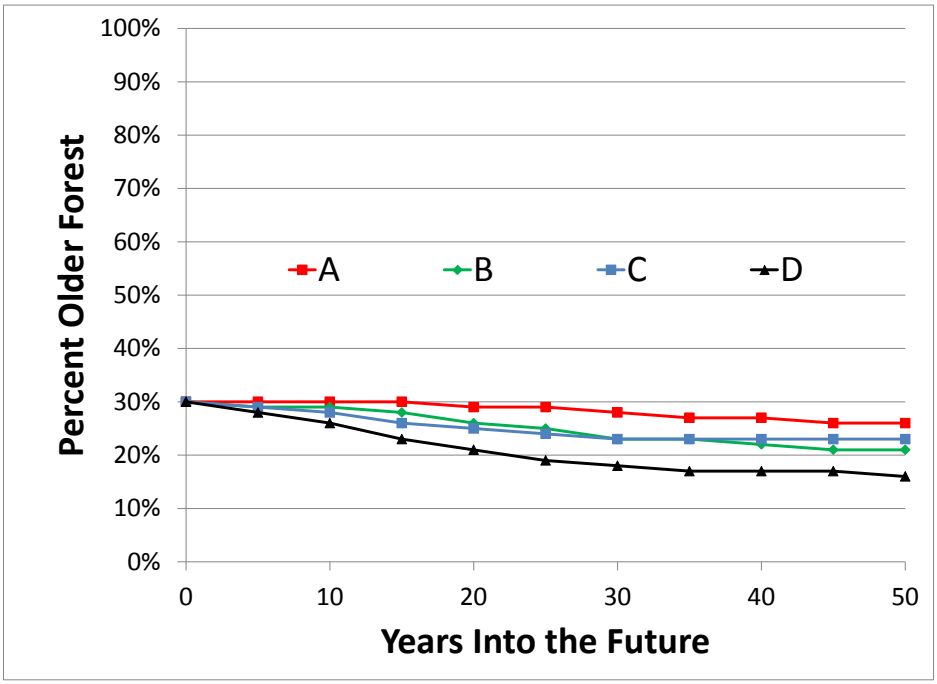


Figure 9. Percent older forest of upland conifers (includes Red Pine Natural, Red Pine Plantation, Jack Pine, White Spruce Plantation, and even-aged Balsam Fir cover types) by scenario. (See Table 4, page 9, for definition of "Older" forest age by cover type).

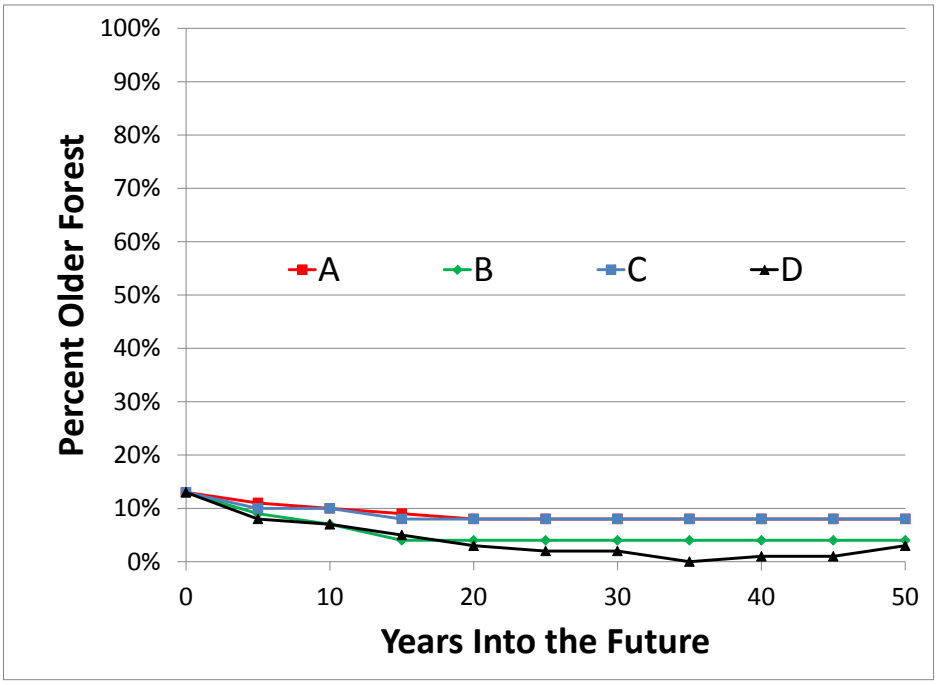


Figure 10. Percent older forest of upland hardwoods (includes Aspen, Balm, and Birch cover types) by scenario. (See Table 4, page 9, for definition of "Older" forest age by cover type).

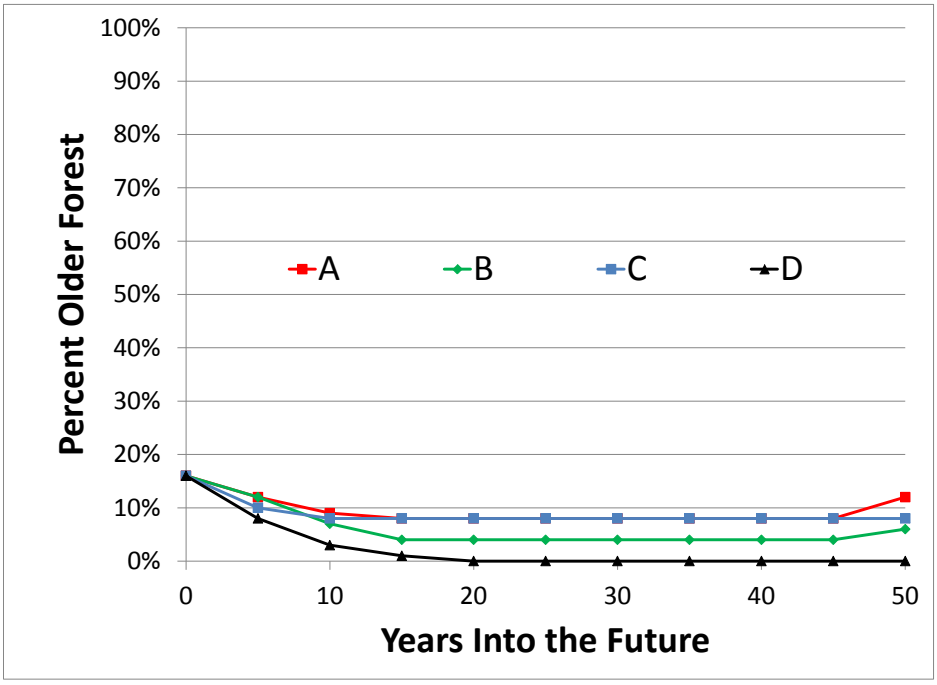


Figure 11. Percent younger forest of lowland conifers (includes Tamarack and Black Spruce cover types) by scenario. Due to the lack of final harvest NWC younger forest was not included. (See Table 5, page 9, for definition of "Younger" forest age by cover type).

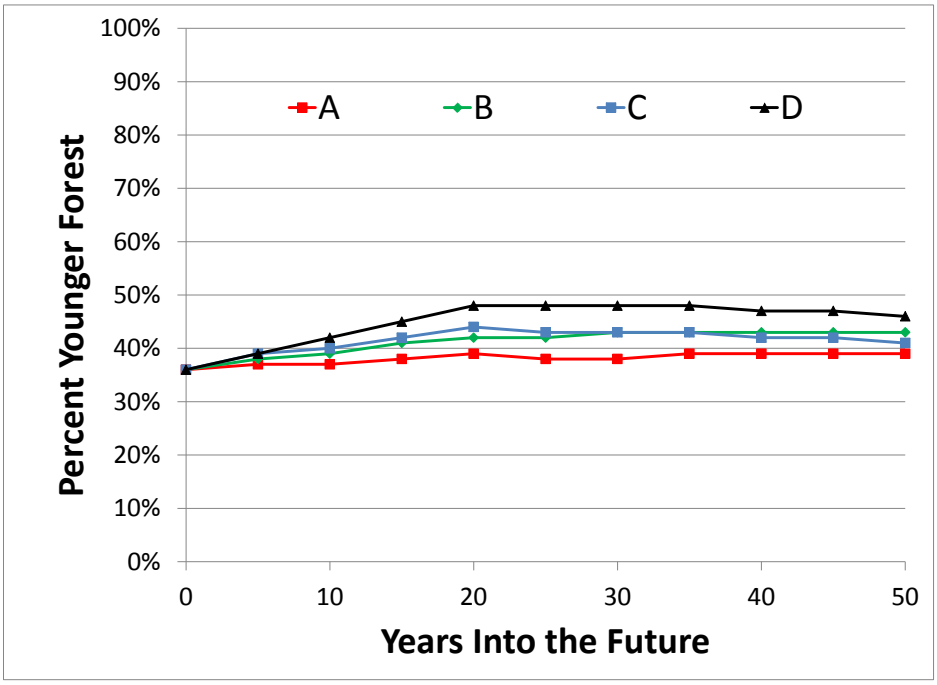


Figure 12. Percent younger forest of upland conifers (includes Red Pine Natural, Red Pine Plantation, Jack Pine, White Spruce Plantation, and even-aged Balsam Fir cover types) by scenario. (See Table 5, page 9, for definition of "Younger" forest age by cover type).

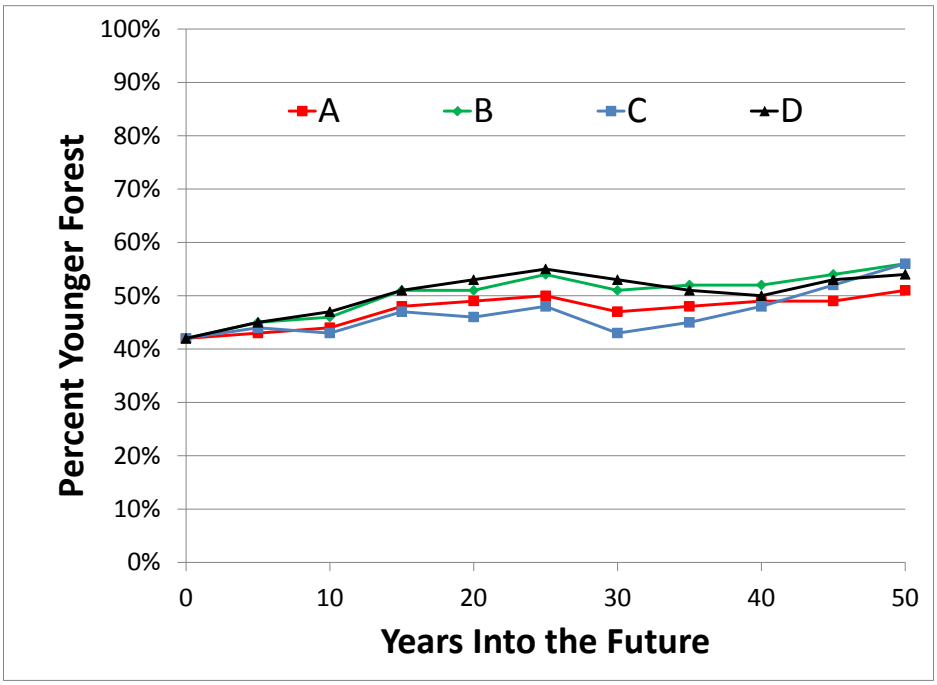


Figure 13. Percent younger forest of upland hardwoods (includes Aspen, Balm, and Birch cover types) by scenario. (See Table 5, page 9, for definition of "Younger" forest age by cover type).

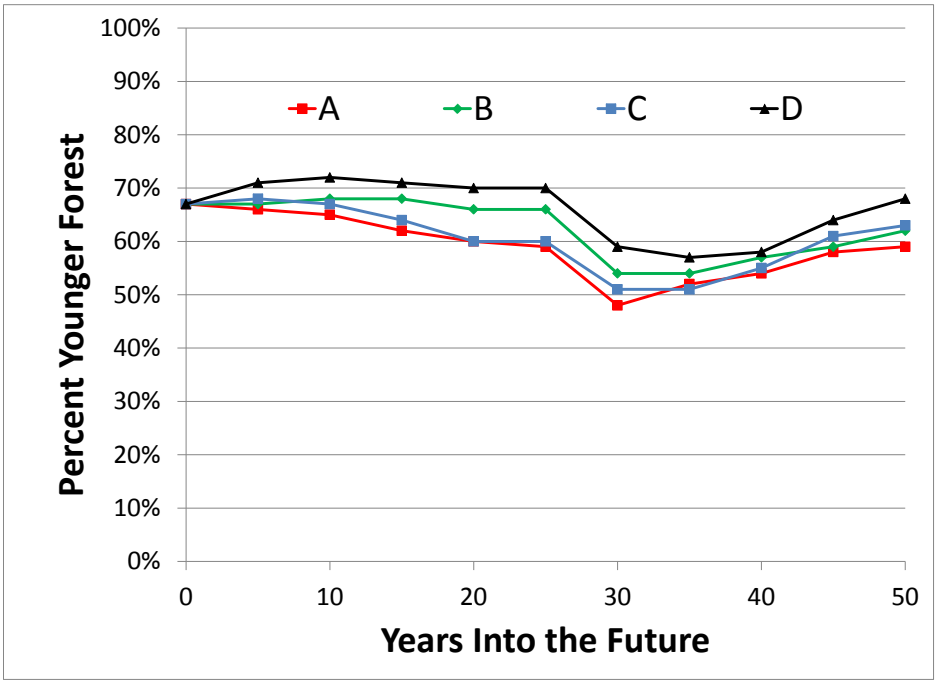


Table 19. Percent older forest by scenario and cover type and cover type grouping. Lowland conifers includes Tamarack, Black Spruce, and NWC cover types, Upland conifers includes Red Pine Natural, Red Pine Plantation, Jack Pine, White Spruce Plantation, and even-aged Balsam Fir cover types, and Upland hardwoods includes Aspen, Balm, and Birch cover types. (See Table 4, page 9, for definition of "Older" forest age by cover type).

	Years Into the Future																							
	Current				10				20				30				40				50			
Cover Type	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
Abg	16%	16%	16%	16%	8%	6%	7%	2%	8%	4%	8%	0%	8%	4%	8%	0%	8%	4%	8%	0%	12%	6%	8%	0%
Birch	36%	36%	36%	36%	46%	43%	39%	38%	34%	29%	22%	21%	19%	15%	13%	13%	6%	3%	3%	3%	13%	15%	14%	6%
Jack Pine	10%	10%	10%	10%	1%	0%	3%	0%	0%	2%	5%	0%	3%	1%	5%	0%	6%	1%	8%	0%	3%	0%	0%	0%
WS Plantation	0%	0%	0%	0%	1%	1%	2%	0%	11%	11%	11%	0%	27%	26%	28%	6%	51%	36%	44%	7%	48%	32%	39%	11%
Balsam Fir	35%	35%	35%	35%	37%	24%	32%	28%	27%	6%	14%	11%	15%	2%	8%	3%	0%	0%	1%	0%	9%	3%	11%	6%
BS High	24%	24%	24%	24%	23%	21%	20%	18%	22%	18%	15%	12%	17%	12%	12%	6%	16%	11%	11%	5%	15%	10%	11%	4%
BS Medium	28%	28%	28%	28%	26%	24%	23%	21%	23%	20%	18%	13%	20%	15%	16%	10%	16%	10%	13%	6%	12%	7%	11%	3%
BS Low	31%	31%	31%	31%	31%	30%	29%	27%	33%	30%	28%	25%	29%	25%	22%	17%	26%	20%	18%	13%	23%	17%	16%	10%
Tamarack High	24%	24%	24%	24%	19%	16%	16%	13%	13%	9%	10%	2%	16%	9%	10%	3%	20%	15%	15%	9%	18%	12%	14%	7%
Tamarack Low	30%	30%	30%	30%	31%	29%	28%	26%	27%	22%	20%	16%	19%	13%	14%	6%	14%	8%	10%	2%	13%	7%	10%	2%
Red Pine (all)	3%	3%	3%	3%	2%	2%	1%	0%	3%	3%	3%	0%	2%	2%	3%	0%	1%	0%	1%	0%	0%	0%	0%	0%
Lowland Conifer	30%	30%	30%	30%	30%	29%	28%	26%	29%	26%	25%	21%	28%	23%	23%	18%	27%	22%	23%	17%	26%	21%	23%	16%
Upland Conifer	13%	13%	13%	13%	10%	7%	10%	7%	8%	4%	8%	3%	8%	4%	8%	2%	8%	4%	8%	1%	8%	4%	8%	3%
Upland HW	16%	16%	16%	16%	9%	7%	8%	3%	8%	4%	8%	0%	8%	4%	8%	0%	8%	4%	8%	0%	12%	6%	8%	0%

Table 20. Percent younger forest by scenario and cover type and cover type grouping. Lowland conifers includes Tamarack and Black Spruce cover types, Upland conifers includes Red Pine Natural, Red Pine Plantation, Jack Pine, White Spruce Plantation, and even-aged Balsam Fir cover types, and Upland hardwoods includes Aspen, Balm, and Birch cover types. (See Table 5, page 9, for definition of "Younger" forest age by cover type).

	Years Into the Future																							
	Current				10				20				30				40				50			
Cover Type	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
Abg	67%	67%	67%	67%	65%	69%	67%	72%	60%	66%	60%	70%	48%	54%	50%	59%	54%	57%	55%	58%	59%	62%	64%	69%
Birch	31%	31%	31%	31%	45%	49%	53%	53%	61%	67%	73%	74%	75%	79%	80%	82%	60%	57%	59%	59%	58%	55%	50%	55%
Jack Pine	64%	64%	64%	64%	57%	58%	55%	61%	56%	56%	49%	58%	52%	55%	46%	59%	55%	59%	53%	56%	56%	67%	65%	65%
WS Plantation	18%	18%	18%	18%	10%	10%	10%	13%	2%	3%	1%	15%	2%	4%	2%	23%	14%	27%	19%	50%	39%	54%	48%	57%
Balsam Fir	30%	30%	30%	30%	49%	56%	51%	58%	65%	74%	69%	81%	60%	68%	56%	71%	58%	57%	53%	49%	53%	51%	55%	41%
BS High	45%	45%	45%	45%	46%	48%	48%	50%	46%	50%	53%	56%	47%	52%	52%	58%	39%	44%	44%	50%	39%	42%	41%	45%
BS Medium	52%	52%	52%	52%	56%	57%	58%	60%	55%	59%	60%	65%	55%	60%	58%	64%	55%	60%	58%	65%	54%	59%	56%	63%
BS Low	41%	41%	41%	41%	44%	45%	46%	48%	45%	47%	49%	52%	42%	46%	50%	54%	44%	50%	52%	57%	48%	54%	55%	61%
Tamarack High	27%	27%	27%	27%	33%	36%	37%	40%	40%	45%	45%	53%	34%	41%	41%	47%	34%	36%	36%	39%	33%	34%	32%	31%
Tamarack Low	42%	42%	42%	42%	37%	39%	41%	43%	39%	43%	46%	49%	42%	47%	47%	54%	45%	51%	49%	58%	45%	51%	49%	57%
Red Pine (all)	15%	15%	15%	15%	27%	20%	21%	21%	37%	27%	27%	29%	41%	33%	31%	34%	43%	40%	37%	36%	43%	42%	43%	41%
Lowland Conifer	36%	36%	36%	36%	37%	39%	40%	42%	39%	42%	44%	48%	38%	43%	43%	48%	39%	43%	42%	47%	39%	43%	41%	46%
Upland Conifer	42%	42%	42%	42%	44%	46%	43%	47%	49%	51%	46%	53%	47%	51%	43%	53%	49%	52%	48%	50%	51%	56%	56%	54%
Upland HW	67%	67%	67%	67%	65%	68%	67%	72%	60%	66%	60%	70%	48%	54%	51%	59%	54%	57%	55%	58%	59%	62%	63%	68%