Appendices

Appendix A: Forest Certification Standards

The Forest Stewardship Council standards can be found at the following site:

https://fsc.org/en/fsc-standards

The Sustainable Forestry Initiative standards can be found at the following site:

https://forests.org/standards/

Appendix B: Site Conditions

Available for Management?		Factor / Description	Definition	Comments Needed?
		1. Administrative and Legal Factors		
Unavailable		**1A: Federal / State / Local Law** (e.g. Natural Rivers Act)		Y
			specify Federal / State / Local law in comments (e.g. Natural Rivers Act)	
Unavailable		**1B: Non-DNR agency concerns**		Y
			specify agency and their concerns in comments (e.g. USFS)	
Unavailable		**1C: Other Dept or Div procedures / practices**		Y
			specify Dept or Div (other than FRD) in comments and describe	
Unavailable		**1D: Interest Group / Neighbor**		Y
			specify decision based on input from interest group(s) / neighbor in comments	
		2. Accessibility Factors		
Unavailable		**2A: Adjacent landowner denied access**		
			access has been sought and denied	
Available		**2B: Unknown if access through adjacent landowner(s) is possible**		
			access has not been sought yet	
Available		**2C: Engineered Bridge Needed (Dept. portable bridge not available or inadequate)**		Y
			specify type and length of bridge needed	
Available		**2D: Portable Bridge Needed (Dept. bridge will be adequate)**		Y
			specify length of bridge needed	
Available		**2E: Road needed**		
			resources are not currently available to build road and onus may be too much to put on timber sale contractor	
Unavailable		**2F: Too steep**		
			area cannot be operated on with current equipment capabilities without unacceptable damage to the soil	
Unavailable		**2G: Too wet (sensitive soils, year-round high water table, does not include access issues)**		
			area cannot be operated on with current equipment capabilities without unacceptable damage to the soil or water table	
Unavailable		**2H: Blocked by physical obstacle (e.g. upland stand in a lowland area - marsh islands)**		

Available for Management?		Factor / Description	Definition	Comments Needed?
			area cannot be accessed without crossing an obstacle (e.g. travel through wetlands, topography limitations, etc)	
Available		**2I: Survey needed**		
			A survey is needed before harvests or other management can occur.	
Unavailable		**2J: Blocked by Railroad**		
			area cannot be accessed without crossing a railroad grade	
	3. Special Management or Use Designations			
Unavailable		**3A: Conservation Values incompatible with harvesting at this time**		Y
			SCAs, HCVAs (including ERAs), or other areas where harvests do not maintain or	
			enhance the identified conservation values.	
Unavailable		**3B: Threatened, endangered, and special concern species**		
			Specify in the locked OFS database.	Y
~~Unavailable~~		~~**3C: Legally Designated Quiet Area, Natural Area, or Wilderness***~~		
			*** This Site Condition was marked as 'Inactive' in the database. Any existing records should be recoded 3A or dropped, depending on what is appropriate.**	
Unavailable		**3D: Recreational / Scenic values**		Y
			specify recreational site or scenic values in comments	
Unavailable		**3E: Easement / lease, non-military**		Y
			specify easement / lease in comments (e.g. Luce County managed lands; Consumers Power red pine; undivided interests)	
Unavailable		**3F: Military easement / lease**		Y
			specify easement / lease in comments (e.g. Camp Grayling)	
Unavailable		**3G: Other Influence zones - See comments**		Y
			specify in comments (e.g. travel or water influence zones, etc)	
Unavailable		**3H: Deer Wintering Area - habitat is incompatible with harvesting at this time**		
			Use only on portions of the deer wintering complex where species composition restricts management of the stand, following	
			Deer winter range guidance document.	
Unavailable		~~**3I: Historical / archeological**~~		Y
			*** This Site Condition has been marked as 'Inactive' in the database. Any existing records should be recoded to 1C, with comments added to the "Locked/Sensitive" field. A locked OFS point should be coded if point specific information is known.**	
Unavailable		**3J: Water quality / BMPs (stream, river, or lake)**		
			Not a Natural River, but management is constrained by concerns over the impact of treatment on the quality of nearby watercourses	
Unavailable		**3K: Rare or unique landforms**		Y
			identify in locked comment box	
Unavailable		**3L: Other wildlife concerns**		Y
			wildlife management, other than deer, decisions constrain management of the stand	
	4. Markets and Industrial Factors			
Available		**4A: No merchantable products (see product standards)**		

Available for Management?		Factor / Description	Definition	Comments Needed?
			we can sell everything from small acreage to low volumes, but not unmerchantable products	
	5. Technological/Ecological Factors			
Unavailable		**5A: Not able to obtain desirable regeneration**		Y
			desired regeneration is hampered by ecological factors (e.g. too much deer browse, etc)	
Available		**5B: Maintain for regeneration purposes**		
			e.g. shelterwood cuts	
Available		**5C: Delay treatment for age / size class diversity or exceptional site quality**		
			equalizing age / size class diversity within covertypes	
Unavailable		**5D: Unproductive Forest Land**		
			land supporting trees, but not capable of producing more than 20 cu.ft./acre/year of any timber species (e.g. treed bogs, etc)	
Unavailable		**5E: Long Term Retention**		
			identified as long term 'area' retention for a harvest. Will become available for management when original harvest area is reconsidered for treatment (next rotation).	
Available		**5T: Contingency Treatment for Forest Health Considerations**		Y
			an area that has a significant chance to be impacted by forest health concerns, but it is not desirable to treat until the issue is imminent.	
Available		**5F: Evaluated for Forest Health Considerations**		Y
			an area that has been evaluated for impacts by forest health concerns, but it is not desirable to prescribe for harvest at this time.	
Available		**5G: Research Study**		Y
			an area that is part of a formal research project and/or is being monitored as part of an experimental plan or treatment. Stand comments should identify the name of the research project, research body or institute, and identify a point of contact for questions. Relevant documents should also be uploaded to Stand Documents.	

Appendix C: Cover Type Crosswalk

Level 4 Cover Type Code	Level 4 MiFI Cover Type	MiFI Cover Type Description	MiFI Cover Type Code	SFMP Cover Type	SFMP Cover Type Code
110	110 - Low Intensity Urban	Urban	X	Urban	X
121	121 - Airport	Urban	X	Urban	X
122	122 - Road/Parking Lot	Urban	X	Urban	X
123	123 - Other High Intensity Urban	Urban	X	Urban	X
211	211 - Cropland	Cropland	G	Cropland	G
2111	2111 - Non-vegetated Farmland	Cropland	G	Cropland	G
2112	2112 - Row Crops	Cropland	G	Cropland	G
2113	2113 - Forage Crops	Cropland	G	Cropland	G
2114	2114 - Other Cropland	Cropland	G	Cropland	G
2120	212 - Non-tilled Herbaceous Agriculture	Cropland	G	Cropland	G
2210	221 - Xmas trees	Cropland	G	Cropland	G

Level 4 Cover Type Code	Level 4 MiFI Cover Type	MiFI Cover Type Description	MiFI Cover Type Code	SFMP Cover Type	SFMP Cover Type Code
2220	222 - Orchards/Vineyards/Nursery	Cropland	G	Cropland	G
3100	310 - Herbaceous Openland	Herbaceous Openland	G	Herbaceous Openland	G
3101	3101 - Poverty Grass, Cladonia	Herbaceous Openland	G	Herbaceous Openland	G
3102	3102 - Grass	Herbaceous Openland	G	Herbaceous Openland	G
31021	31021 - Cool Season Grass	Herbaceous Openland	G	Herbaceous Openland	G
31022	31022 - Warm Season Grass	Herbaceous Openland	G	Herbaceous Openland	G
31029	31029 - Grass (Ol)	Herbaceous Openland	G	Herbaceous Openland	G
3103	3103 - Rubus-Fern	Herbaceous Openland	G	Herbaceous Openland	G
3104	3104 - Degraded	Herbaceous Openland	G	Herbaceous Openland	G
3105	3105 - Mixed Upland Herbaceous	Herbaceous Openland	G	Herbaceous Openland	G
3200	320 - Upland Shrub	Upland Shrub	U	Upland Shrub	U

Level 4 Cover Type Code	Level 4 MiFI Cover Type	MiFI Cover Type Description	MiFI Cover Type Code	SFMP Cover Type	SFMP Cover Type Code
3201	3201 - Sweet Fern	Upland Shrub	U	Upland Shrub	U
3202	3202 - Autumn Olive/Honeysuckle	Upland Shrub	U	Upland Shrub	U
3203	3203 - Upland Blueberry	Upland Shrub	U	Upland Shrub	U
3204	3204 - Mast Producing Shrub	Upland Shrub	U	Upland Shrub	U
3205	3205 - Mixed Upland Shrub	Upland Shrub	U	Upland Shrub	U
3209	3209 - Upland Shrub (OI)	Upland Shrub	U	Upland Shrub	U
3300	330 - Low-Density Trees	Low-Density Trees	U	Low-Density Trees	U
3301	3301 - Low Density Deciduous Trees	Low-Density Trees	U	Low-Density Trees	U
3302	3302 - Low Density Conifer Trees	Low-Density Trees	U	Low-Density Trees	U
3303	3303 - Mixed Low Density Trees	Low-Density Trees	U	Low-Density Trees	U
3500	350 - Parks and Golf Courses	Herbaceous Openland	G	Herbaceous Openland	G

Level 4 Cover Type Code	Level 4 MiFI Cover Type	MiFI Cover Type Description	MiFI Cover Type Code	SFMP Cover Type	SFMP Cover Type Code
5000	500 - Water	Water	Z	Water	Z
5100	510- Water (OI)	Water	Z	Water	Z
6210	621 - Floating Aquatic	Water	Z	Water	Z
6220	622 - Lowland Shrub	Lowland Shrub	L	Lowland Shrub	L
6220	6220 - Alder/willow	Lowland Shrub	L	Lowland Shrub	L
6221	6221 - Fen	Lowland Shrub	L	Lowland Shrub	L
6222	6222 - Shrub-Carr	Lowland Shrub	L	Lowland Shrub	L
6223	6223 - Inundated Shrub Swamp	Lowland Shrub	L	Lowland Shrub	L
6224	6224 - Treed Bog	Treed Bog	D	Treed Bog	D
62241	62241 - Treed Bog (OI)	Treed Bog	D	Treed Bog	D
6225	6225 - Bog	Bog	V	Bog	V

Level 4 Cover Type Code	Level 4 MiFI Cover Type	MiFI Cover Type Description	MiFI Cover Type Code	SFMP Cover Type	SFMP Cover Type Code
62259	62259 - Bog (OI)	Bog	V	Bog	V
6229	6229 - Mixed lowland shrub	Lowland Shrub	L	Lowland Shrub	L
6230	623 - Emergent Wetland	Marsh	N	Marsh	N
6230	6230 - Cattail	Marsh	N	Marsh	N
6231	6231 - Phragmites	Marsh	N	Marsh	N
6232	6232 - Wet Prairie	Marsh	N	Marsh	N
6233	6233 - Wet Meadow	Marsh	N	Marsh	N
6239	6239 - Mixed Emergent Wetland	Marsh	N	Marsh	N
62399	62399 - Marsh (OI)	Marsh	N	Marsh	N
6290	629 - Mixed non-forested wetland	Lowland Shrub	L	Lowland Shrub	L
6299	6299 - Lowland Shrub (OI)	Lowland Shrub	L	Lowland Shrub	L

Level 4 Cover Type Code	Level 4 MiFI Cover Type	MiFI Cover Type Description	MiFI Cover Type Code	SFMP Cover Type	SFMP Cover Type Code
7100	710 - Sand, Soil	Sand, Soil	Y	Bare/Sparsely Vegetated	X
7109	7109 - Sand (OI)	Sand, Soil	Y	Bare/Sparsely Vegetated	X
7200	720 - Exposed Rock	Exposed Rock	X	Bare/Sparsely Vegetated	X
7209	7209 - Exposed Rock (OI)	Exposed Rock	X	Bare/Sparsely Vegetated	X
7300	730 - Mud Flats	Sand, Soil	Y	Bare/Sparsely Vegetated	X
7600	760 - Non-stocked Forest	Bare/Sparsely Vegetated	X	Bare/Sparsely Vegetated	X
7900	790 - Other Bare/Sparsely Vegetated	Bare/Sparsely Vegetated	X	Bare/Sparsely Vegetated	X
7909	7909 - Nonstocked (OI)	Bare/Sparsely Vegetated	X	Bare/Sparsely Vegetated	X
4110	411 - Northern Hardwood	Northern Hardwood	M	Northern Hardwood	M
4110	4110 - Sugar Maple Association	Northern Hardwood	M	Northern Hardwood	M
4111	4111 - S. Maple, Hard Mast Association	Northern Hardwood	M	Northern Hardwood	M

Level 4 Cover Type Code	Level 4 MiFI Cover Type	MiFI Cover Type Description	MiFI Cover Type Code	SFMP Cover Type	SFMP Cover Type Code
4112	4112 - Maple, Beech, Cherry Association	Northern Hardwood	M	Northern Hardwood	M
4113	4113 - R. Maple, Conifer	Northern Hardwood	M	Northern Hardwood	M
4114	4114 - Beech, Hemlock	Northern Hardwood	M	Northern Hardwood	M
4115	4115 - Y.Birch, Hemlock NH	Northern Hardwood	M	Northern Hardwood	M
4116	4116 - Mixed N. Hardwood - Aspen	Northern Hardwood	M	Northern Hardwood	M
4117	4117 - Mixed N. Hardwood - Pine	Northern Hardwood	M	Northern Hardwood	M
4119	4119 - Mixed Northern Hardwoods	Northern Hardwood	M	Northern Hardwood	M
41199	41199 - Northern Hardwood (OI)	Northern Hardwood	M	Northern Hardwood	M
4120	412 - Oak Types	Oak	O	Oak Mix	O
4121	4121 - Oak, Aspen	Oak	O	Oak Mix	O
4122	4122 - Oak, Pine	Oak	O	Oak Mix	O

Level 4 Cover Type Code	Level 4 MiFI Cover Type	MiFI Cover Type Description	MiFI Cover Type Code	SFMP Cover Type	SFMP Cover Type Code
4123	4123 - Red Oak	Oak	O	Northern Red Oak	RO
4124	4124 - Red with White Oak	Oak	O	Northern Red Oak	RO
4125	4125 - Black, N. Pin Oak	Oak	O	Black Red Hybrid Oak	HO
4126	4126 - White, Black, N. Pin Oak	Oak	O	Black Red Hybrid Oak	HO
4129	4129 - Mixed Oak	Oak	O	Oak Mix	O
41299	41299 - Oak (OI)	Oak	O	Oak Mix	O
4130	413 - Aspen	Aspen	A	Aspen	A
4130	4130 - Aspen	Aspen	A	Aspen	A
4131	4131 - Aspen, Oak	Aspen	A	Aspen	A
4132	4132 - Aspen, Jack Pine	Aspen	A	Aspen	A
4133	4133 - Aspen, Mixed Pine	Aspen	A	Aspen	A

Level 4 Cover Type Code	Level 4 MiFI Cover Type	MiFI Cover Type Description	MiFI Cover Type Code	SFMP Cover Type	SFMP Cover Type Code
4134	4134 - Aspen, Spruce/Fir	Aspen	A	Aspen	A
4135	4135 - Aspen, Cedar	Aspen	A	Aspen	A
4136	4136 - Aspen, Mixed Conifer	Aspen	A	Aspen	A
4137	4137 - Aspen, Birch	Aspen	A	Aspen	A
4138	4138 - Aspen (OI)	Aspen	A	Aspen	A
4139	4139 - Aspen, Mixed Deciduous	Aspen	A	Aspen	A
4140	414 - Other Upland Deciduous	Paper Birch	B	Mixed Upland Deciduous	MD
4140	4140 - Other Upland Deciduous	Paper Birch	B	Mixed Upland Deciduous	MD
4141	4141 - Birch (OI)	Paper Birch	B	Mixed Upland Deciduous	MD
4190	4190 - Mixed Upland Deciduous with Cedar	Mixed Upland Deciduous	MD	Mixed Upland Deciduous	MD
4191	4191 - Mixed Upland Deciduous with Conifer	Mixed Upland Deciduous	MD	Mixed Upland Deciduous	MD

Level 4 Cover Type Code	Level 4 MiFI Cover Type	MiFI Cover Type Description	MiFI Cover Type Code	SFMP Cover Type	SFMP Cover Type Code
4192	4192 - Mixed Southern Upland Deciduous	Mixed Upland Deciduous	MD	Mixed Upland Deciduous	MD
4193	4193 - Birch, Aspen	Paper Birch	B	Mixed Upland Deciduous	MD
4199	4199 - Other Mixed Upland Deciduous	Mixed Upland Deciduous	MD	Mixed Upland Deciduous	MD
42100	42100 - Planted White Pine	White Pine	W	Planted White Pine	WP
42101	42101 - Planted White Pine, Mixed Deciduous	White Pine	W	Planted White Pine	WP
4211	4211 - Planted Red Pine	Red Pine	R	Planted Red Pine	RP
42110	42110 - Planted Red Pine	Red Pine	R	Planted Red Pine	RP
42111	42111 - Planted Red Pine, Mixed Deciduous	Red Pine	R	Planted Red Pine	RP
4212	4212 - Planted Jack Pine	Jack Pine	J	Planted Jack Pine	JP
42120	42120 - Planted Jack Pine	Jack Pine	J	Planted Jack Pine	JP
42121	42121 - Planted Jack Pine, Mixed Deciduous	Jack Pine	J	Planted Jack Pine	JP

Level 4 Cover Type Code	Level 4 MiFI Cover Type	MiFI Cover Type Description	MiFI Cover Type Code	SFMP Cover Type	SFMP Cover Type Code
42130	42130 - Planted Scotch Pine	Planted Mixed Pines	MC	Planted Mixed Pine	MP
42140	42140 - Planted Mixed Pine	Planted Mixed Pines	MC	Planted Mixed Pine	MP
42141	42141 - Planted Mixed Pine, Mixed Deciduous	Planted Mixed Pines	MC	Planted Mixed Pine	MP
4220	4220 - Natural White Pine	White Pine	W	Natural White Pine	W
42200	42200 - Natural White Pine	White Pine	W	Natural White Pine	W
42201	42201 - Natural White Pine, Mixed Deciduous	White Pine	W	Natural White Pine	W
4221	4221 - Natural Red Pine	Red Pine	R	Natural Red Pine	R
42210	42210 - Natural Red Pine	Red Pine	R	Natural Red Pine	R
42211	42211 - Natural Red Pine, Mixed Deciduous	Red Pine	R	Natural Red Pine	R
4222	4222 - Natural Jack Pine	Jack Pine	J	Natural Jack Pine	J
42220	42220 - Natural Jack Pine	Jack Pine	J	Natural Jack Pine	J

Level 4 Cover Type Code	Level 4 MiFI Cover Type	MiFI Cover Type Description	MiFI Cover Type Code	SFMP Cover Type	SFMP Cover Type Code
42221	42221 - Natural Jack Pine, Mixed Deciduous	Jack Pine	J	Natural Jack Pine	J
42250	42250 - Pine, Oak	Natural Mixed Pines	MC	Natural Mixed Pines	NP
42260	42260 - Natural Pine, Mixed Deciduous	Natural Mixed Pines	MC	Natural Mixed Pines	NP
42290	42290 - Natural Mixed Pine	Natural Mixed Pines	MC	Natural Mixed Pines	NP
42300	42300 - Planted Larch	Tamarack	T	Tamarack	T
42301	42301 - Planted Larch, Mixed Deciduous	Tamarack	T	Tamarack	T
42310	42310 - Planted Spruce	Upland Spruce/Fir	F	Upland Spruce/Fir	F
42311	42311 - Planted Spruce, Mixed Deciduous	Upland Spruce/Fir	F	Upland Spruce/Fir	F
42320	42320 - Upland Spruce	Upland Spruce/Fir	F	Upland Spruce/Fir	F
42330	42330 - Upland Fir	Upland Spruce/Fir	F	Upland Spruce/Fir	F
42339	42339 - Upland Spruce/Fir (OI)	Upland Spruce/Fir	F	Upland Spruce/Fir	F

Level 4 Cover Type Code	Level 4 MiFI Cover Type	MiFI Cover Type Description	MiFI Cover Type Code	SFMP Cover Type	SFMP Cover Type Code
42340	42340 - Upland Spruce/Fir	Upland Spruce/Fir	F	Upland Spruce/Fir	F
42350	42350 - Upland Hemlock	Hemlock	H	Hemlock	H
42359	42359 - Hemlock (OI)	Hemlock	H	Hemlock	H
42360	42360 - Upland Cedar	Cedar	C	Cedar	C
42370	42370 - Upland Cedar, Aspen	Cedar	C	Cedar	C
42380	42380 - Non Pine Upland Conifer, Mixed Deciduous	Upland Conifers	MC	Upland Conifers	MC
42390	42390 - Mixed Non-Pine Upland Conifers	Upland Conifers	MC	Upland Conifers	MC
42497	42497 - White Pine (OI)	White Pine	W	Natural White Pine	W
42498	42498 - Red Pine (OI)	Red Pine	R	Natural Red Pine	R
42499	42499 - Jack Pine (OI)	Jack Pine	J	Natural Jack Pine	J
4290	429 - Mixed Upland Conifers	Upland Conifers	MC	Upland Conifers	MC

Level 4 Cover Type Code	Level 4 MiFI Cover Type	MiFI Cover Type Description	MiFI Cover Type Code	SFMP Cover Type	SFMP Cover Type Code
4310	4310 - Pine, Oak Mix	Upland Mixed Forest	UM	Upland Mixed Forest	UM
4311	4311 - Pine, Aspen Mix	Upland Mixed Forest	UM	Upland Mixed Forest	UM
4312	4312 - Hemlock, Mixed Deciduous	Hemlock	H	Hemlock	H
4319	4319 - Mixed Upland Forest	Upland Mixed Forest	UM	Upland Mixed Forest	UM
6110	611 - Lowland Deciduous Forest	Lowland Deciduous	E	Lowland Deciduous	E
6110	6110 - Cottonwood	Lowland Deciduous	E	Lowland Deciduous	E
6111	6111 - Lowland Balsam Poplar	Lowland Aspen/Balsam Poplar	P	Lowland Aspen/Balsam Poplar	P
61119	61119 - Lowland Aspen/Balsam Poplar (OI)	Lowland Aspen/Balsam Poplar	P	Lowland Aspen/Balsam Poplar	P
6112	6112 - Lowland Aspen	Lowland Aspen/Balsam Poplar	P	Lowland Aspen/Balsam Poplar	P
6113	6113 - Lowland Maple	Lowland Deciduous	E	Lowland Deciduous	E
6114	6114 - Lowland Oak	Lowland Deciduous	E	Lowland Deciduous	E

Level 4 Cover Type Code	Level 4 MiFI Cover Type	MiFI Cover Type Description	MiFI Cover Type Code	SFMP Cover Type	SFMP Cover Type Code
6115	6115 - Lowland Ash	Lowland Deciduous	E	Lowland Deciduous	E
6116	6116 - Lowland Birch	Paper Birch	B	Lowland Deciduous	E
6117	6117 - Lowland Deciduous, Mixed Coniferous	Lowland Deciduous	E	Lowland Deciduous	E
6118	6118 - Lowland Deciduous with Cedar	Lowland Deciduous	E	Lowland Deciduous	E
6119	6119 - Mixed Lowland Deciduous Forest	Lowland Deciduous	E	Lowland Deciduous	E
61199	61199 - Lowland Hardwood (OI)	Lowland Deciduous	E	Lowland Deciduous	E
6120	612 - Lowland Coniferous Forest	Lowland Conifers	Q	Lowland Conifers	Q
6120	6120 - Lowland Cedar	Cedar	C	Cedar	C
61203	61203 - Cedar (OI)	Cedar	C	Cedar	C
6121	6121 - Tamarack	Tamarack	T	Tamarack	T
61219	61219 - Tamarack (OI)	Tamarack	T	Tamarack	T

Level 4 Cover Type Code	Level 4 MiFI Cover Type	MiFI Cover Type Description	MiFI Cover Type Code	SFMP Cover Type	SFMP Cover Type Code
6122	6122 - Black Spruce	Lowland Spruce/Fir	S	Lowland Spruce/Fir	S
61229	61229 - Black Spruce (OI)	Lowland Spruce/Fir	S	Lowland Spruce/Fir	S
6123	6123 - Lowland Fir	Lowland Conifers	Q	Lowland Conifers	Q
6124	6124 - Lowland Spruce-Fir	Lowland Conifers	Q	Lowland Conifers	Q
6125	6125 - Lowland Black Spruce, Jack Pine	Lowland Conifers	Q	Lowland Conifers	Q
6126	6126 - Lowland Jack Pine	Jack Pine	J	Natural Jack Pine	J
6127	6127 - Lowland Pine	Lowland Conifers	Q	Lowland Conifers	Q
6128	6128 - Lowland Coniferous, Mixed Deciduous	Lowland Conifers	Q	Lowland Conifers	Q
6129	6129 - Mixed Coniferous Lowland Forest	Lowland Conifers	Q	Lowland Conifers	Q
61299	61299 - Mixed Swamp Conifer (OI)	Lowland Conifers	Q	Lowland Conifers	Q
6130	613 - Lowland Mixed Forest	Lowland Mixed Forest	LM	Lowland Mixed Forest	LM

Level 4 Cover Type Code	Level 4 MiFI Cover Type	MiFI Cover Type Description	MiFI Cover Type Code	SFMP Cover Type	SFMP Cover Type Code
6130	6130 - Fir, Aspen, Maple	Lowland Mixed Forest	LM	Lowland Mixed Forest	LM
6131	6131 - Hemlock, White Pine, Maple, Birch	Lowland Mixed Forest	LM	Lowland Mixed Forest	LM
6132	6132 - Mixed Lowland Forest with Cedar	Lowland Mixed Forest	LM	Lowland Mixed Forest	LM
6139	6139 - Mixed Lowland Forest	Lowland Mixed Forest	LM	Lowland Mixed Forest	LM

Appendix D: MiFI Classification Rules and Generic Silvicultural Rules

IF GREATER THAN 10% of the land area is covered with man-made structures including parking lots and paved or gravel roads THEN

Urban (1)

IF URBAN and GREATER THAN >25% of the land area is solid impervious cover from man-made materials THEN

High Intensity Urban (12)

IF High Intensity Urban within airport grounds including runways THEN

Airport (121)

IF High Intensity Urban, NOT Airport, but IS road or parking lot THEN

Road/Parking Lot (122)

ELSE (is High Intensity Urban but not above)

Other High Intensity Urban (123)

ELSE (i.e. URBAN and LESS THAN 25% is solid impervious cover)

Low Intensity Urban (11)

ELSE IF land area has > 75% open water THEN

Water (5)

Water (50)

ELSE IF the vegetation is intensively managed for vegetation production excluding forestry THEN

Agriculture (2)

IF AGRICULTURE and LESS THAN 25% of the vegetation is woody THEN

Herbaceous Agriculture (21)

IF Herbaceous Agriculture is tilled for crop production THEN

Cropland (211)

IF Cropland and LESS THAN 25% of land area is vegetated THEN

Non-vegetated Farmland (2111)

IF Cropland and GREATER THAN 25% vegetated, and vegetation is annual crops planted in rows (e.g. corn, soybeans, etc) THEN

Row Crops (2112)

IF Cropland, not above, and vegetation is used for fodder production, alfalfa and hay, THEN

Forage Crops (2113)

ELSE **Other Cropland (2114)**

ELSE IF Herbaceous Agriculture and vegetation is not tilled (includes pasture) THEN

Non-tilled Herbaceous Agriculture (212)

ELSE (Agriculture and GREATER THAN 25% of the vegetation is woody) THEN

Non Herbaceous Agriculture (22)

IF woody trees are grown for Christmas tree production THEN

Christmas trees (221)

ELSE **Orchards/Vineyards/Nursery (222)**

ELSE IF the ground area is LESS THAN 25% vegetated THEN

Bare / Sparsely Vegetated (7)

IF formed from sand or bare soil THEN

Sand, Soil (710)

ELSE IF formed from solid rock THEN

Exposed Rock (720)

ELSE IF periodically flooded THEN

Mud Flats (730)

ELSE **Other Bare/Sparsely Vegetated (790)**

ELSE IF LESS THAN 25% of the ground is covered by tree canopy AND there is no evidence of flooding during the past 5 years AND NOT supporting lowland indicator plants THEN

Upland Openland (3)

IF maintained for recreational purposes THEN

Parks and Golf Courses (350)

ELSE IF GREATER THAN 15% of the ground is covered by tree canopy then

Low-Density Trees (330)

IF AT LEAST 60% tree canopy is in Deciduous species THEN

Low Density Deciduous Trees (3301)

ELSE IF AT LEAST 60% tree canopy is in Coniferous species then

Low Density Coniferous Trees (3302)

ELSE IF low density trees but not above THEN

Mixed Low Density Trees (3303)

ELSE IF the combination of woody shrubs/trees total GREATER THAN 25% of the canopy THEN
Upland Shrub (320)
IF AT LEAST 25% of the ground is covered by sweet fern THEN
Sweet Fern (3210)
ELSE IF AT LEAST 50% of the ground is covered by autumn olive/honeysuckle THEN
Autumn Olive/Honeysuckle (3202)
ELSE IF AT LEAST 50% of the ground is covered by blueberry THEN
Upland Blueberry (3203)
ELSE IF AT LEAST 25% of the ground is covered by mast producing shrubs (cherry spp., juneberry, hazel, dogwood, hawthorn, wild plum) THEN
Mast Producing Shrub (3204)
ELSE **Mixed Upland Shrub (3205)**

ELSE IF LESS THAN OR EQUAL TO 25% of the canopy is in woody shrubs or trees THEN
Herbaceous Openland (310)
IF the ground cover is AT LEAST 60% poverty grass, sweet fern, blueberry, and/or cladonia THEN **Poverty Grass, Cladonia (3101)**
ELSE IF AT LEAST 60% of the herbaceous cover is grass THEN
Grass (3102)
IF AT LEAST 60% of the herbaceous cover is cool season grass/ legume (orchard grass, fescue, timothy, clover, vetch) THEN
Cool Season Grass (31021)
ELSE **Warm Season Grass (31022)**
ELSE IF AT LEAST 60% of the herbaceous cover is bracken fern, strawberry, or raspberry/blackberry then
Rubus-Fern (3103)
ELSE IF AT LEAST 60% of the ground cover is exposed gravel or sand, spotted knapweed, St John's-wort, or other invasive exotics THEN
Degraded (3104)
ELSE **Mixed Upland Herbaceous (3105)**

ELSE IF LESS THAN 25% of the ground is covered by tree canopy AND either there IS evidence of flooding during the past 5 years OR supporting lowland indicator plants THEN
Non-forested Wetlands (62)
IF AT LEAST 60% of the non-water ground cover is floating aquatic vegetation THEN
Floating Aquatic (621)
ELSE IF AT LEAST 60% of the non-water ground cover is shrub THEN
Lowland Shrub (622)
IF AT LEAST 60% of the cover is Alder (*alnus*) or Willow (*salix*) THEN
Alder/Willow (6220)
ELSE IF AT LEAST 60% is Shrubby cinquefoil (*Potentilla fruticosa*), Dogwood (*Cornus*), Willow (*Salix*), Sedge (*Carex*) and/or Sphagnum/Peat moss (*Sphagnum*) then
Fen (6221)
ELSE IF AT LEAST 30% is Dogwood (*Cornus*) and/or Michigan Holly (*Ilex verticillata*) THEN
Shrub-Carr (6222)
ELSE IF AT LEAST 30% Button bush (*Cepalanthus*), Water Plantain (*Alisma*), Smartweed (*Polygonum*), Cattail (*Typha*) THEN
Inundated Shrub Swamp (6223)
ELSE IF AT LEAST 30% is evergreen shrubs, Sphagnum/Peat moss (*Sphagnum*) THEN bog
IF AT LEAST 10% of the cover is trees THEN
Treed Bog (6224)
ELSE
Bog (6225)
ELSE **Mixed Lowland Shrub (6229)**
ELSE IF AT LEAST 60% of the non-water ground cover is non-woody vegetation THEN
Emergent Wetland (623)
IF AT LEAST 60% of the cover is cattail (*typha spp*) THEN
Cattail (6230)
ELSE IF AT LEAST 60% *Phragmites* THEN
Phragmites (6231)

ELSE IF AT LEAST 30% native warm season grasses including Big bluestem, Little bluestem, Broom sedge (*Andropogon spp.*), Indian grass (*Sorgastrum nutans*) THEN
Wet Prairie (6232)
ELSE IF AT LEAST 60% is sedges and grasses including Sedge (*Carex*), Bulrush (*Scirpus*), Reed grass (*Calamagrostis*), Reed canary grass (*Phalaris arundinaceae*), native warm season grasses (see above) THEN
Wet Meadow (6233)
ELSE **Mixed Emergent Wetland (6239)**

ELSE **Mixed Non-Forest Wetland (629)**

ELSE IF AT LEAST 25% of the ground is covered by tree crowns - FOREST
IF NO evidence of flooding during the past 5 years AND not supporting lowland indicator plants THEN
Upland Forest (4)
IF AT LEAST 60% of the tree canopy is deciduous THEN
Upland Deciduous Forest (41)
IF AT LEAST 60% is Maple + Beech + Basswood + White Ash + Cherry + Yellow Birch THEN
Northern Hardwood (411)
IF AT LEAST 80% is Sugar Maple + Basswood + White Ash + Cherry THEN
Sugar Maple Association (4110)
ELSE IF AT LEAST 60% is (Sugar Maple + Basswood) AND AT LEAST 10% is (Beech + Oak) THEN
Sugar Maple, Hard Mast Association (4111)
ELSE IF AT LEAST 80% is Maple spp + Beech + Cherry THEN
Maple Association (4112)
ELSE IF AT LEAST 60% is Beech + Hemlock THEN
Beech, Hemlock (4114)
ELSE IF AT LEAST 20% is Yellow Birch + Hemlock THEN
Yellow Birch, Hemlock (4115)
ELSE IF AT LEAST 50% is Red Maple AND AT LEAST 20% is Conifer THEN
Red Maple, Conifer (4113)
ELSE IF AT LEAST 20% is Pine THEN
Mixed Northern Hardwood-Pine (4117)
ELSE IF AT LEAST 20% Aspen spp. THEN
Mixed Northern Hardwood-Aspen (4116)
ELSE **Mixed Northern Hardwoods (4119)**

ELSE IF AT LEAST 60% Oak THEN
Oak Type (412)
IF AT LEAST 15% Hickory THEN
Oak, Hickory (4120)
ELSE IF AT LEAST 30% Pine THEN
Oak, Pine (4122)
ELSE IF AT LEAST 30% Aspen spp. THEN
Oak, Aspen (4121)
ELSE IF AT LEAST 40% Red Oak THEN Red Oak types
IF AT LEAST 20% White Oak THEN
Red with White Oak (4124)
ELSE
Red Oak (4123)
ELSE IF AT LEAST 40% Northern Pin Oak + White Oak + Black Oak THEN Other Oaks
IF AT LEAST 20% White Oak THEN
White, Black, Northern Pin Oak (4126)
ELSE
Black, Northern Pin Oak (4125)
ELSE **Mixed Oak (4129)**

ELSE IF AT LEAST 40% Aspen Species THEN
Aspen Type (413)
IF AT LEAST 20% Conifer THEN Aspen, Conifer
IF AT LEAST 20% Cedar THEN
Aspen, Cedar (4135)
ELSE IF AT LEAST 20% Spruce or Fir THEN
Aspen, Spruce/Fir (4134)

ELSE IF AT LEAST 20% Pine THEN Aspen, Pine
IF Jack Pine IS GREATER THAN OR EQUAL TO White Pine + Red Pine THEN
Aspen, Jack Pine (4132)
ELSE
Aspen, Mixed Pine (4133)
ELSE
Aspen, Mixed Conifer (4136)
ELSE IF AT LEAST 20% Oak THEN
Aspen, Mixed Oak (4131)
ELSE IF AT LEAST 60% Aspen THEN
Aspen (4130)
ELSE IF AT LEAST 20% Birch spp. THEN
Aspen, Birch (4137)
ELSE **Aspen, Mixed Deciduous (4139)**

ELSE IF AT LEAST 60% any other single species (like paper birch) THEN
Other Upland Deciduous (4140)
ELSE **Mixed Upland Deciduous (419)**
ELSE IF AT LEAST 20% Northen White Cedar THEN
Mixed Upland Deciduous with Cedar (4190)
ELSE IF AT LEAST 20% Coniferous THEN
Mixed Upland Deciduous with Conifer (4191)
ELSE IF primarily southern michigan species THEN
Mixed Southern Upland Deciduous (4192)
EISE IF AT LEAST 60% aspen spp. and paper birch THEN
Birch, Aspen (4193)
ELSE **Other Mixed Upland Deciduous (4199)**

ELSE IF AT LEAST 60% of the tree canopy is coniferous THEN
Upland Coniferous Forest (42)
IF AT LEAST 60% of the tree canopy is Pine THEN Pines
IF Plantation THEN
Planted Pine (421)
IF AT LEAST 60% is White Pine THEN
Planted White Pine
IF AT LEAST 20% Deciduous THEN
Planted White Pine, Mixed Deciduous (42101)
ELSE **Planted White Pine (42100)**
ELSE IF AT LEAST 60% Red Pine THEN
Planted Red Pine
IF AT LEAST 20% Deciduous THEN
Planted Red Pine, Mixed Deciduous (42111)
ELSE **Planted Red Pine (42110)**
ELSE IF AT LEAST 60% Jack Pine THEN
Planted Jack Pine
IF AT LEAST 20% Deciduous THEN
Planted Jack Pine, Mixed Deciduous (42121)
ELSE **Planted Jack Pine (42120)**
ELSE IF AT LEAST 60% Scotch Pine THEN
Planted Scotch Pine (42130)
IF AT LEAST 20% Deciduous THEN
Planted Mixed Pine, Mixed Deciduous (42141)
ELSE **Planted Mixed Pine (42140)**

ELSE non-planted THEN
Natural Pine (422)
IF AT LEAST 30% Oak THEN
Pine-Oak (42250)
ELSE IF AT LEAST 60% White Pine THEN
Natural White Pine
IF AT LEAST 30% Deciduous THEN
Natural White Pine, Mixed Deciduous (42201)
ELSE **Natural White Pine (42200)**
ELSE IF AT LEAST 60% Red Pine THEN
Natural Red Pine

IF AT LEAST 30% Deciduous THEN
Natural Red Pine, Mixed Deciduous (42211)
ELSE **Natural Red Pine (42210)**
ELSE IF AT LEAST 60% Jack Pine THEN
Natural Jack Pine
IF AT LEAST 30% Deciduous THEN
Natural Jack Pine, Mixed Deciduous (42221)
ELSE **Natural Jack Pine (42220)**
IF AT LEAST 30% Deciduous THEN
Natural Mixed Pine, Mixed Deciduous (42260)
ELSE **Natural Mixed Pine (42290)**

ELSE IF AT LEAST 60% Non-Pine (Other) Upland Conifers THEN
Non-Pine (Other) Upland Conifers (423)
IF Plantation THEN
IF AT LEAST 60% Larch THEN
Planted Larch
IF AT LEAST 20% Deciduous THEN
Planted Larch, Mixed Deciduous (42301)
ELSE **Planted Larch (42300)**
ELSE IF AT LEAST 60% Spruce THEN
Planted Spruce
IF AT LEAST 20% Deciduous THEN
Planted Spruce Mixed Deciduous (42311)
ELSE **Planted Spruce (42310)**

ELSE non-planted THEN
IF AT LEAST 50% Hemlock THEN
Upland Hemlock (42350)
ELSE IF AT LEAST 60% Spruce THEN
Upland Spruce (42320)
ELSE IF AT LEAST 60% Fir THEN
Upland Fir (42330)
ELSE IF AT LEAST 60% Spruce + Fir THEN
Upland Spruce/Fir (42340)
ELSE IF AT LEAST 60% Cedar THEN UPLAND CEDAR
IF AT LEAST 20% Aspen spp. THEN
Upland Cedar, Aspen (42370)
ELSE **Upland Cedar (42360)**
ELSE IF AT LEAST 30% Deciduous THEN
Non-Pine Upland Conifer, Mxd Deciduous (42380)
ELSE **Mixed Non-Pine Upland Conifers (42390)**

ELSE **Mixed Upland Conifers (429)**

ELSE **Upland Mixed Forest (43)**
ELSE If AT LEASE 70% Pine and Oak species THEN
Pine, Oak Mix (4310)
ELSE If AT LEASE 70% Pine and Aspen species THEN
Pine, Aspen Mix (4311)
ELSE If AT LEASE 40% Hemlock THEN
Hemlock, Mixed Deciduous (4312)
ELSE **Mixed Upland Forest (4319)**

ELSE IF evidence of flooding during the past 5 years OR supporting lowland indicator plants THEN
Lowland Forest (61)
IF AT LEAST 60% of the tree canopy is deciduous THEN
Lowland Deciduous Forest (611)
IF AT LEAST 20% Cedar THEN
Lowland Deciduous with Cedar (6118)
ELSE IF AT LEAST 20% Coniferous THEN
Lowland Deciduous, Mixed Coniferous (6117)
ELSE IF AT LEAST 60% Maple spp. THEN
Lowland Maple (6113)

	ELSE IF AT LEAST 60% Oak spp. THEN **Lowland Oak (6114)** ELSE IF AT LEAST 60% Ash spp THEN **Lowland Ash (6115)** ELSE IF AT LEAST 60% Cottonwood THEN **Cottonwood (6110)** ELSE IF AT LEAST 60% Birch spp. THEN **Lowland Birch (6116)** ELSE IF AT LEAST 40% Aspen + Balsam Poplar THEN **Lowland Aspen/Balsam Poplar** IF Aspen spp % IS GREATER THAN Balsam Poplar % THEN **Lowland Aspen (6112)** ELSE **Lowland Balsam Poplar (6111)** ELSE **Mixed Lowland Deciduous Forest (6119)**
ELSE IF AT LEAST 60% of the tree canopy is coniferous THEN	**Lowland Coniferous Forest (612)** IF AT LEAST 50% Cedar THEN **Lowland Cedar (6120)** ELSE IF AT LEAST 50% Tamarack THEN **Tamarack (6121)** ELSE IF AT LEAST 50% Black Spruce THEN **Black Spruce (6122)** ELSE IF AT LEAST 50% Fir THEN **Lowland Fir (6123)** ELSE IF AT LEAST 50% Spruce + Fir THEN **Lowland Spruce/Fir (6124)** ELSE IF AT LEAST 50% Jack Pine THEN **Lowland Jack Pine (6126)** ELSE IF AT LEAST 50% Black Spruce + Jack Pine THEN **Lowland Black Spruce, Jack Pine (6125)** ELSE IF AT LEAST 50% Pine THEN **Lowland Pine (6127)** ELSE IF AT LEAST 20% Deciduous THEN **Lowland Coniferous, Mixed Deciduous (6128)** ELSE **Mixed Coniferous Lowland Forest (6129)**
ELSE	**Lowland Mixed Forest (613)** IF AT LEAST 20% Cedar THEN **Mixed Lowland Forest with Cedar (6132)** ELSE IF AT LEAST 60% Fir + Aspen +Balsam Poplar + Maple THEN **Fir, Aspen, Maple (6130)** ELSE IF A LEAST 60% Hemlock + White Pine + Maple + Birch THEN **Hemlock, White Pine, Maple, Birch (6131)** ELSE **Mixed Lowland Forest (6139)**

Appendix E: Silvicultural Methods

- Even-aged Systems: Regenerate and maintain the stand with primarily one age class, though harvests “with reserves” will have retention that enhance or maintain characteristics of a two-aged or all-aged stand.
    - Clearcut Group
    - Clearcut – The cutting of essentially all trees, producing a fully exposed microclimate for the development of a new age class. Regeneration is from stump sprouts, root suckers, natural seeding, direct seeding, planting, or advanced reproduction. Residual basal area (BA) generally runs from 0-10 square feet per acre (sq ft/acre).
    - Seed Tree – The cutting of all trees except for a small number of widely dispersed trees retained for seed production and to produce a new age class in a fully exposed microclimate. Residual trees generally average 6-8 per acre.
    - Shelterwood Group
    - Shelterwood – The cutting of most trees, leaving those needed to produce sufficient shade to produce a new age class in a moderated microenvironment. Can be done uniformly throughout the stand or in groups or strips, in one or more subsequent harvests. Residual BA is generally from 30-

50 sq ft/acre, but residual BA can go down as far as 10 sq ft/ac if the crowns are large enough to achieve 25% canopy cover. Residual trees are removed after regeneration is established.

- Overstory Removal – The removal of all overstory trees, leaving established regeneration. This is often done after a shelterwood harvest once regeneration has become established.

- Intermediate Systems: Done for reasons other than regeneration, in stands usually treated with even or two-aged systems.

  - Thinning

    - Systematic thinning – The removal of trees in rows, strips, or by using fixed spacing intervals to control stand spacing and favor desired trees without regard to crown position. Not a regeneration harvest. Residual BA can vary, but it is generally no less than one half (more often 2/3) of the original BA.

    - Crown Thinning – The removal of trees from dominant and codominant crown classes. Residual BA generally runs from 50-110 sq ft/acre.

- Uneven-aged Systems: Regenerate and maintain the stand with a multi-aged structure by removing some trees in all size classes.

  - Selection

    - Single Tree Selection and small group selection – Individual trees within each size class are removed throughout the stand to promote the growth of remaining trees and to provide space for regeneration. Gaps ranging from 50ft to 100ft radius are installed across approximately 10-20% of the stand. Residual BA in the remainder of the stand is generally 60-90 sq ft/acre.

  - Group Selection

    - Large Group Selection (systematic re-entry) – All trees are generally removed in groups larger than 100 ft radius. This is sometime referred to as a patch clear-cut when the groups are on the larger scale of up to 2 acres in size. In extreme cases the DNR inventory system would allow groups/patches to occur up to 4.5 acres in size because this is threshold of scale for the definition of a stand. The remainder of the stand is often left un-thinned and the stand is restarted over a period of 3-4 entries. When thinning and retention are incorporated this method can also be called an irregular shelterwood.

Appendix F: SFMP Model- Technical Design Summary

Introduction

The Michigan Department of Natural Resources (Michigan DNR) invested in an industry-standard modeling platform to support the revision of the State Forest Management Plan. The software is a suite of applications called the "*Woodstock Optimization Studio*®". It was developed by the Remsoft® corporation. Woodstock, as it's commonly referred to, is the key component to an integrated optimization modeling platform that allows users to build custom models to represent different forest management strategies and evaluate the results. The Michigan DNR also invested in training for several staff and hired a consultant, Mason Bruce & Gerard, to help build the various components of the Woodstock model. The Woodstock model is used to create and evaluate various forest management scenarios and ultimately helps determine a preferred scenario that adds confidence in harvest sustainability while achieving desired future conditions both in terms of landscape-level forest composition and wildlife habitat.
Woodstock is an optimization model that uses linear programming to select from among various scenario characteristics. It finds the mathematically optimal solution for a given scenario based on an objective function (e.g., ???) and a set of forest management goals and constraints. Each scenario or forest-wide

management alternative can contain unique model sections and can be compared side by side with other scenarios. The modeling platform uses the following model sections to define the characteristics of each scenario:

- **Constants**: Used to establish names (e.g., scenario name) and declare values of constants referred to in other sections.
- **Control**: Defines how Woodstock should process input files and establishes planning horizon.
- **Landscape**: Contains the themes (e.g., forest type, age, etc.) that classify the landscape being modeled from a Geographic Information System (GIS) shape file.
- **Lifespan:** The Lifespan section contains the declaration that indicates the maximum age a development type may reach before it is assumed to die or be replaced by another development type through succession.
- **Area**: Individual forest and non-forest stands are aggregated into "development types" based on common attributes and are contained in this section.
- **Yields**: This section contains both simple and complex yield tables which contain coefficients of specific attributes of the forest in terms of volume, value, weight, trees per acre, etc.
- **Actions**: This section is where the events or activities (e.g., harvesting, planting, etc.) are described that manipulate the condition of a development type.
- **Transitions**: This section is where the outcomes of particular actions and resulting changes are defined, such as the development type age being reset to zero or covertype conversion occurring when a clearcut happens.
- **Outputs**: This section contains the declaration of various yield table values or inventory values (e.g., Trees per acre, basal area per acre, volume per acre) that are contributing to a metric that needs to be evaluated or controlled.
- **Graphics**: This section contains the code for each custom graphic used to quickly evaluate outputs.
- **Optimization**: This section is where the formulation for the model occurs using an objective function (e.g., ????) and controls such as goals and constraints (e.g., area of Kirtland's warbler habitat to create ????).
- **Schedule**: This section is produced once a model is executed or run and contains a multi-period harvest schedule for a given scenario.
- **Reports**: This section is where the user controls what content, format, and types of files that get created to summarize outputs generated in a model run.
- **Maps**: The maps section is a GIS display of the shapefile that can be generated for different attributes with different harvest schedules assigned to the GIS polygons, and other spatial optimization routines performed.

Each of these sections contains Woodstock code that helps define how the model interacts with inventory data, which objective is used, what the limitations of a solution are, and what outputs are created after a scenario is executed and a Woodstock solution is generated.

Strategic Modeling Approach

The strategic forest management approach used by the Michigan DNR is technically called area regulation. This approach to forest management can be directly modeled using Woodstock. This general concept of management has been applied on Michigan state forests and forests around the world for decades, and managers feel it is well suited for managing multiple resource values of a public forest owned by the people of the state of Michigan. In simple terms "area regulation", or "area control" as its sometimes called, is the approach taken when managers seek to achieve the desired amount of area (acres) in specific age or density (basal area) categories across a geographic area over time.
The State Forest Management Planning (SFMP) approach uses three distinct silvilcultural systems, each with its own silvicultural methods, to model the management the state forest:

1. Even-aged systems
    a. Clearcut / seedtree
    b. Intermediate thinning
2. Two-aged systems

    a. Shelterwood
    b. Overstory removal
3. Uneven-aged systems
    a. Selection
    b. Group Section

Covertypes, such as jack pine and aspen, managed with even-aged systems primarily rely on clearcut and seed tree harvests as the primary silvicultural method for resetting ages, but can also include intermediate thinnings that are used to maintain basal area goals prior to a clearcut. Covertypes, such as northern hardwoods, that are managed with un-even-aged systems primarily rely on selection and group selection harvests to maintain basal area targets achieving optimal stand densities and diameter distributions. These approaches to management are handled in different ways in the SFMP model by either embedding the treatment regimes in the yield tables or using goals and constraints that rely on inventory attributes like age classes.

The even-aged area regulation approach calls for setting specific age class goals in each planning period. The Michigan DNR used 10-year planning periods along with 10-year age classes for even aged management which makes the creation of desired age class levels straight forward. Harvesting and regenerating a specific amount of a given covertype over a 10-year planning period will result in the establishment of an age class. That process is then repeated during each future planning period resulting in the establishment of desired age class distribution over time. These age class goals are created using a combination of specific outputs and goals discussed in the outputs and optimization sections below.

Both even-aged system and un-even-aged systems use area regulation with respect to achieving desired stand density distributions of cover types across an area over time is very similar, but accomplished with different harvesting techniques that change stand densities rather than resetting ages. A desired basal area distribution is defined by setting basal area thresholds in the timber yield tables that focus on maintaining stands in a condition that sustains optimal growth and stand structure. For example, the northern hardwood cover type is typically managed according to a bell-shaped curve of basal area distribution ranging from 70 square feet of basal area per acre on the low end to 120 square feet of basal are per acre on the high end. Stands are eligible for a selection harvest when they reach the higher density and are thinned to the lower target density allowing for more growth on desirable residual stems. There are many variations of this general thinning approach that favor other management goals like regeneration and recruitment or different diameter distributions, but the basic principle is important to have represented in the yield tables of the SFMP model.

The uneven-aged group selection silvicultural method is a smaller scale approach to area regulation done within a stand. Smaller patches are clearcut in each stand and additional patches are harvested each decade resulting in an uneven-aged stand that can be perpetually managed in this condition. Again, with this approach there are many variations of the system used to achieve desired results and is based on patch size, re-entry period, and cycle completion period. This approach is represented in the SFMP model through a series of constraints, actions, and outputs that simulate a standard group selection system. The process used was to remove 1/5th of the volume of a development type and account for 1/5 of the acres harvested if a group selection action was initiated. The group selection constraints then locked the development type into group selection regime once it was initiated so that each period that same action would happen until the entire development type was treated over 5-decade periods. The stand then transitions to an average age and basal area class representative of the 5 age cohorts created across the stand.

Wildlife habitat management considerations are incorporated into the model by creating custom outputs that add up acres of a specific condition representing a particular habitat. Goals and constraints are then used to reference those habitat outputs when a certain threshold or trend is desired. The outputs are also used to evaluate effects of various model changes and are helpful in determining the preferred scenario.

Evaluation of Model Capabilities and Usefulness – Pilot Area Testing

A pilot area was identified in the early stages of development of the new state forest management plan to test the efficacy of the Woodstock model to represent the management of state forest land. Most forest management goals that were to be represented in the model are set at the management area (MA) scale.

There are XX management areas across the state. Within management areas, individual covertypes have unique age-class goals and silvilcultural regime goals. The pilot area was in the northern Lower Peninsula and consisted of two management areas: the Wolverine Moraines and the Presque Isle Lake and Till Plain. Both management areas had a good representation of diverse covertypes with varying age class goals and silvicultural regimes to be tested.

Two unique features of the pilot area were that there was already a few defined forest management and habitat goals related to the Pigeon River Country's "Concept of Management" and to the Elk Management Plan. These plans contained 2 goals that could be directly incorporated into the model as soft or hard constraints:

1. Maintain the 0-9 age class of a subset of even-aged covertypes at 7% to 8% of the entire Pigeon River Country Forest.
2. Maintain 27% of the Pigeon River State Forest in the aspen covertype.

Because the Elk Management Plan was for an area that did not align with either the forest management unit boundaries or the MA boundaries, it was necessary to come up with an additional geographical unit for these goals. The term "Special Analysis Unit" or SAU for short, was adopted to describe any geographic area that needed to have specific goals assigned to it, if it did not align with an already existing feature. Forest composition and structure goals, in conjunction with habitat related goals, were set for each MA. These goals guided the resulting harvest outputs and schedule in the model. Those harvests are implemented through the administrative units of the Forest Resources Division which are called Forest Management Units (FMU). The FMUs are largely aligned with counties and do not align with the MAs in most cases. The pilot area offered an ideal test for implementing the harvest schedule derived from MA goals in each FMU. The pilot area consisted of the entire Pigeon River Country FMU, as well as parts of the Gaylord and Atlanta forest management units.

The pilot model testing was useful in quickly identifying numerous challenges that needed to be overcome through various modeling strategies and different approaches. The relatively small landscape offered quick Woodstock solve times during the execution model enabling a quick turnaround to analyze the results after a change in the model was made. After several months of testing, it was determined that the *Woodstock Optimization Studio*® was an excellent fit for the Michigan DNR to use for determining a long-term sustainable management scenario resulting in desired future conditions.

Supplying the woodstock model with Forest Inventory Data

The SFMP model needed the best representation of the forest Inventory that could provide a starting point. There are about 5 years of treatments on state forests already prescribed and approved at various stages of implementation / completion in the inventory any time a snapshot (copy) of the database is made. The inventory snapshot that would feed the model would need to reflect what those stands would be like after the prescribed treatments take place. This resulted in a need to "increment" or advance the inventory forward 5 years (the time it takes for a typical treatment to go from prescription to completed and updated inventory) in order to best represent what the inventory will look like at the beginning of the upcoming, first planning period.

The following steps were taken to accomplish this:

1. Stands with no entry in the basal area (BA) field were assigned a typical BA class based on covertype and age (fit to a curve).
2. Stands not prescribed for a regeneration harvest were advanced in age 5 years (6-year-old stand (0-9 age class) became 11 years old (10-19 age class).
3. Any non-forested stand or 0-9 age class forested stand, with a "forested objective" was converted to that covertype and stayed in 0-9 age class.
4. Stands that were not prescribed for a partial harvest were candidates for an advancement to the next BA class. BA classes span 30 to 50 square feet of basal area, and the exact BA for particular stands is unknown. Therefore, a systematic random method was used to determine which stands advance and which do not. Because some covertypes typically grow faster than others, and stands grow different at different basal areas, an ingrowth % were assigned to each covertype and BA combination based on existing growth and yield data derived from FIA data on state forest lands. The following steps were used to accomplish this:

a. Ingrowth % was assigned for each covertype and BA range combination based on growth and yield data. This is the typical percentage of stands within a specific current BA class that will likely graduate to the next BA class in the next 10 years (keeping in mind the "current" BA class would have been recorded up to 10 years ago--the last time the stand was inventoried (figure 1).
b. A random number between 0.0 and 1.0 was generated for each stand.
c. If the random number assigned was less than or equal to the % of ingrowth, then the BA advanced to the next highest class, otherwise it remained the same. (e.g. 66 % (0.66) of NH stands at 81-110 advance, so a random number of .54 would advance that stand to 111-140) This was done only one time and applied to a snapshot of the inventory data that informed the SFMP model.

Table 1. Graphic representing the analysis tool created to set and modify incremented growth percentages.

Cover type

Change Values in this table:% of a current BA Class that will grow into next higher BA class	1-50	51-80	81-110	111-140	141-170	171-200	200+
	2	7	8	3	4	5	6
Northern Hardwood	40%	66%	66%	66%	33%	25%	0%
Natural White Pine	40%	75%	75%	75%	75%	66%	0%
Natural Red Pine	40%	75%	75%	75%	75%	66%	0%
Natural Mixed Pines	40%	75%	75%	75%	75%	66%	0%
Northern Red Oak	40%	75%	75%	75%	75%	66%	0%
Oak Mix	40%	50%	50%	50%	50%	40%	0%
Lowland Deciduous	40%	50%	50%	50%	50%	40%	0%
Mixed Upland Deciduous	40%	66%	66%	66%	66%	50%	0%
Upland Mixed Forest	40%	66%	66%	66%	66%	50%	0%
Aspen	40%	66%	66%	66%	66%	50%	0%
Planted Red Pine	40%	90%	90%	90%	90%	90%	0%
Planted White Pine	40%	80%	80%	80%	80%	80%	0%
Planted Mixed Pine	40%	75%	75%	75%	75%	75%	0%
Planted Jack Pine	20%	30%	30%	30%	30%	30%	0%
Natural Jack Pine	20%	30%	30%	30%	30%	30%	0%
Black Red Hybrid Oak	40%	50%	50%	50%	50%	40%	0%
Lowland Aspen/Balsam Poplar	40%	50%	50%	50%	50%	50%	0%
Lowland Spruce/Fir	40%	33%	33%	33%	33%	25%	0%
Upland Spruce/Fir	40%	66%	66%	66%	66%	50%	0%
Upland Conifers	40%	66%	66%	66%	66%	50%	0%
Lowland Conifers	40%	33%	33%	33%	33%	25%	0%
Lowland Mixed Forest	40%	33%	33%	33%	33%	25%	0%
Hemlock	20%	25%	25%	25%	25%	25%	0%
Cedar	20%	25%	25%	25%	25%	25%	0%
Tamarack	40%	50%	50%	50%	50%	40%	0%

5. Stands prescribed for a harvest had their BA class reset based on the combination of covertype and treatment method applied (Table 2).

Table 2. Incremented Basal area class values for stands prescribed for treatment, by covertype.

Residual Basal Area	Single Tree Selection	Group Selection	Crown Thinning	Systematic Thinning	Low Thinning	Clearcut	Clearcut with Retention	Seed Tree	Seed Tree with Retention	Shelterwood	Shelterwood with Retention	Overstory Removal	Strip/Patch/ Gap Cut (Femelschlag)	Salvage	Other	Other - Specify
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Northern Hardwood	51-80	51-80	51-80	51-80	51-80	1-50	1-50	1-50	1-50	1-50	1-50	1-50	51-80	1-50	51-80	51-80
Natural White Pine	81-110	81-110	81-110	81-110	81-110	1-50	1-50	1-50	1-50	1-50	1-50	1-50	51-80	1-50	51-80	51-80
Natural Red Pine	81-110	81-110	81-110	81-110	81-110	1-50	1-50	1-50	1-50	1-50	1-50	1-50	51-80	1-50	51-80	51-80
Natural Mixed Pines	81-110	81-110	81-110	81-110	81-110	1-50	1-50	1-50	1-50	1-50	1-50	1-50	51-80	1-50	51-80	51-80
Northern Red Oak	51-80	51-80	51-80	51-80	51-80	1-50	1-50	1-50	1-50	1-50	1-50	1-50	51-80	1-50	51-80	51-80
Oak Mix	51-80	51-80	51-80	51-80	51-80	1-50	1-50	1-50	1-50	1-50	1-50	1-50	51-80	1-50	51-80	51-80
Lowland Deciduous	51-80	51-80	51-80	51-80	51-80	1-50	1-50	1-50	1-50	1-50	1-50	1-50	51-80	1-50	51-80	51-80
Mixed Upland Deciduous	51-80	51-80	51-80	51-80	51-80	1-50	1-50	1-50	1-50	1-50	1-50	1-50	51-80	1-50	51-80	51-80
Upland Mixed Forest	51-80	51-80	51-80	51-80	51-80	1-50	1-50	1-50	1-50	1-50	1-50	1-50	51-80	1-50	51-80	51-80
Aspen	51-80	51-80	51-80	51-80	51-80	1-50	1-50	1-50	1-50	1-50	1-50	1-50	51-80	1-50	51-80	51-80
Planted Red Pine	81-110	81-110	111-140	111-140	111-140	1-50	1-50	1-50	1-50	1-50	1-50	1-50	51-80	1-50	51-80	51-80
Planted White Pine	81-110	81-110	111-140	111-140	111-140	1-50	1-50	1-50	1-50	1-50	1-50	1-50	51-80	1-50	51-80	51-80
Planted Mixed Pine	81-110	81-110	111-140	111-140	111-140	1-50	1-50	1-50	1-50	1-50	1-50	1-50	51-80	1-50	51-80	51-80
Planted Jack Pine	81-110	81-110	111-140	111-140	111-140	1-50	1-50	1-50	1-50	1-50	1-50	1-50	51-80	1-50	51-80	51-80
Natural Jack Pine	81-110	81-110	111-140	111-140	111-140	1-50	1-50	1-50	1-50	1-50	1-50	1-50	51-80	1-50	51-80	51-80
Black Red Hybrid Oak	51-80	51-80	51-80	51-80	51-80	1-50	1-50	1-50	1-50	1-50	1-50	1-50	51-80	1-50	51-80	51-80
Lowland Aspen/Balsam Poplar	51-80	51-80	51-80	51-80	51-80	1-50	1-50	1-50	1-50	1-50	1-50	1-50	51-80	1-50	51-80	51-80
Lowland Spruce/Fir	51-80	51-80	51-80	51-80	51-80	1-50	1-50	1-50	1-50	1-50	1-50	1-50	51-80	1-50	51-80	51-80
Upland Spruce/Fir	51-80	51-80	51-80	51-80	51-80	1-50	1-50	1-50	1-50	1-50	1-50	1-50	51-80	1-50	51-80	51-80
Upland Conifers	51-80	51-80	51-80	51-80	51-80	1-50	1-50	1-50	1-50	1-50	1-50	1-50	51-80	1-50	51-80	51-80
Lowland Conifers	51-80	51-80	51-80	51-80	51-80	1-50	1-50	1-50	1-50	1-50	1-50	1-50	51-80	1-50	51-80	51-80
Lowland Mixed Forest	51-80	51-80	51-80	51-80	51-80	1-50	1-50	1-50	1-50	1-50	1-50	1-50	51-80	1-50	51-80	51-80
Hemlock	81-110	81-110	81-110	81-110	81-110	1-50	1-50	1-50	1-50	1-50	1-50	1-50	51-80	1-50	51-80	51-80
Cedar	111-140	111-140	111-140	111-140	111-140	1-50	1-50	1-50	1-50	1-50	1-50	1-50	51-80	1-50	51-80	51-80
Tamarack	81-110	81-110	81-110	81-110	81-110	1-50	1-50	1-50	1-50	1-50	1-50	1-50	51-80	1-50	51-80	51-80

6. Stands prescribed for a regeneration harvest had their age class reset to 0-9 and the new covertype was based on the treatment management objective.

It is important to note that this method likely resulted in an artificially inflated 0-9 age class, especially in the planted red pine covertype. The reestablishment of the planted red pine covertype takes a long time to get from a prescribed stand in the treatments database to an established forested stand (3' tall at 25% tree canopy) captured in the inventory. A typical timeline from prescription to a re-established stand will likely resemble the following timeline:

- Prescription made and approved during inventory in 2020
- Timber sale prepared in 2022 (year of entry)
- Timber sale sold in 2023
- Harvested in 2026
- Trenched in 2028
- Herbicide application in 2029
- Planted in 2030
- 3 ft tall, forested stand in 2033

This timeline spans beyond the decade long planning period, but the incrementation process assumes that all stands that were currently prescribed for a clearcut and replant to red pine would become planted red pine covertype within the planning period. It is very likely that a significant portion of the incremented 0-9 will actually end up as either 0-9 in the next planning period or be 10-19 in this planning period, depending on where that particular stand was in its implementation phase when the snapshot was taken. The compensatory approach used during the last planning period was however significant and did call for a significant increase in 0-9 age class acres when there was a deficit in the "current" 0-9 and 10-19 age classes, meaning it is not all from this method of incrementation described above.

The impact of this exaggerated 0-9 age class has little effect on the model solution for projecting harvest levels of current merchantable timber and regenerating that to build a new 0-9 age class in this upcoming planning period. The impact is more noticeable in projected future age class distributions once that age class is part of the merchantable and available pool of acres that can receive a treatment. While we are paying attention to long term harvest sustainability, we are not relying on this model run to set up a treatment plan 50+ years into the future. The projected future age class distributions would look slightly different if this exaggeration was not present and more spread out over 2 age classes. The model will be periodically updated with new inventory information and re-executed for each new planning period at a minimum, and likely more often than that as we adapt our management to changing conditions.

Model Design Summary by Section

The Woodstock model contains 14 sections that each serve a specific purpose in model design and control. All of these sections work together to represent the preferred scenario providing a projected harvest level that supplies a sustainable level of harvest and meets the habitat needs of numerous featured species. The following sections will be described in the order in which they are scanned when executing a model scenario.

1. Constants
2. Control
3. Landscape
4. Lifespan
5. Areas
6. Yields
7. Actions
8. Transitions
9. Outputs
10. Graphics
11. Optimize
12. Schedule
13. Reports
14. Maps

Constants

The Constants section is used to declare values that will be used in more than one section of the model. The SFMP model uses several harvest removal fractions to help represent the amount of volume removed from a grow-only yield value when various actions are performed. The following Harvest Removal fractions are applied in the SFMP model:
CC_Frac 1.00 (100% for clearcut)
SW_Frac 0.60 (60% for shelterwood)
OR_Frac 0.30 (30% for other removals)
GS_Frac 0.20 (20% for group selection harvest)
Sel_Frac 0.25 (25% for selection harvest)

Other constants are used to assign abbreviated values to full names of themes found in the Landscape Section as seen in these examples shown below for MA names:

cAvery_Hills	AveryH
cBois_Blanc_Island	BoisBl
cBrule_River	BruleR
cCadillac_Moraines	Cadill
cCamp_Grayling	CampGr

Control

The Control section is used to declare how Woodstock should process model input files and the length of the planning horizon. The SFMP model uses 10-year periods, and the length of the model run is 15 periods, providing a 150-year planning horizon (Figure 1).

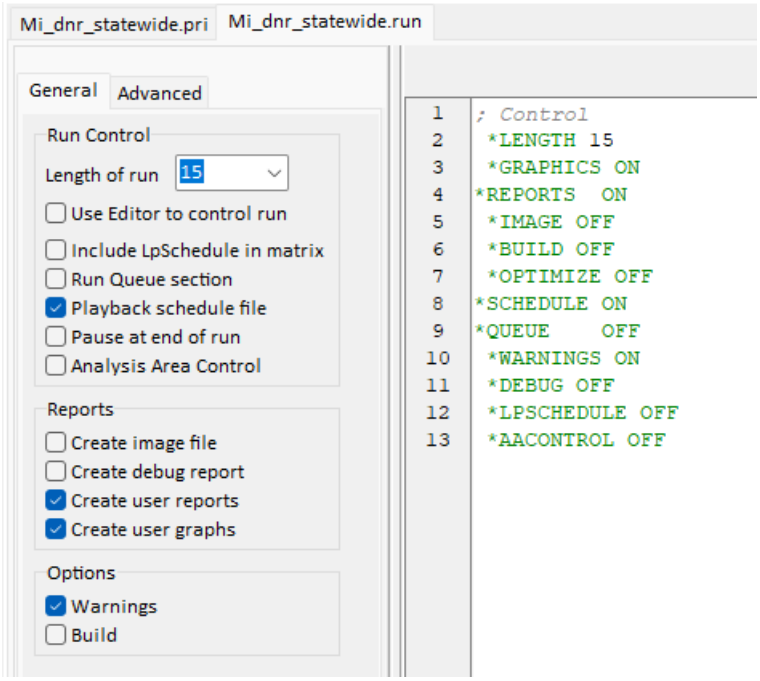


Figure 1. Screenshot of the control section of the SFMP Model in Woodstock.

Landscape

The Landscape section contains the themes to describe the land classification scheme in the SFMP model– similar to the fields containing attributes in a database file used in a GIS environment. The Woodstock model contains the following themes and attribute options (aggregates of individual attributes are not shown):

*THEME *{1}* Eco-Region
EUP *; Eastern Upper Peninsula Eco-Region*
WUP *; Western Upper Peninsula Eco-Region*
NLP *; Northern Lower Peninsula Eco-Region*
ALL *; All Eco-Regions*

*THEME *{2}* District
ELP *; Eastern Lower Peninsula District*
EUP *; Eastern Upper Peninsula District*
WLP *; Western Lower Peninsula District*
WUP *; Western Upper Peninsula District*
ALL *; All Districts*

*THEME *{3}* **Forest** Management Unit
Atlanta
Baraga
Cadillac
Crystal_Falls
Escanaba
Gaylord
Gladwin
Grayling
Gwinn
Newberry
Pigeon_River_Country
Roscommon
Sault_Ste_Marie

Shingleton
Traverse_City
ALL

*THEME *{4}* Management Area
Avery_Hills
Beaver_Island
Bois_Blanc_Island
Brule_River
Cadillac_Moraines
Camp_Grayling
Cassidy_Creek
Drummond_Island
Emmet_Moraines
Escanaba_Lake_and_Till_Pl
Gladwin_Lake_Plain
Grand_Marais_Moraine_Comp
Grand_Traverse_Moraine
Green_Bay
High_Sand_Plains
Houghton_Hardwoods
Huron_Sandy_Lake_Plain
Kalkaska_Sandy_Moraines
Keewenaw
Keweenaw_Bay
Lake_County_Outwash
Menominee-Marquette
Michigamme_Highlands
Presque_Isle_Lake_and_Til
Ralph_Moraine
Rudyard_Silty_Lake_Plain
Seney_Lake_Plain
St_Ignace_Lake_Plain
Suomi_Till_and_Outwash_Pl
WayDam_Complex
Wolverine_Moraines

*THEME *{5}* Compartment (Note: Details not presented due to number of compartments (# total)
ALL *; all compartments*
; 11001 ; compartment number = FMU/compartment

*THEME *{6}* Stand ID (Note: Details not presented due to number of stands (158,871 total)
ALL *; all stands*
; 11001001 ; Stand ID = FMU/compartment/stand (FFCCCSSS)

*THEME *{7}* Yield ID (Note: Details not presented due to number of yield tables: *There are 750 Unique Yield Table Ids)*
ALL
1
3
6
*THEME *{8}* Cover Type
Aspen

Bare_Sparsely_Vegetated
Black_Red_Hybrid_Oak
Bog
Cedar
Cropland
Hemlock
Herbaceous_Openland
Low_Density_Trees
Lowland_Aspen_Balsam_Popl
Lowland_Conifers
Lowland_Deciduous
Lowland_Mixed_Forest
Lowland_Shrub
Lowland_Spruce_Fir
Marsh
Mixed_Upland_Deciduous
Natural_Jack_Pine
Natural_Mixed_Pines
Natural_Red_Pine
Natural_White_Pine
Northern_Hardwood
Northern_Red_Oak
Oak_Mix
Planted_Jack_Pine
Planted_Mixed_Pine
Planted_Red_Pine
Planted_White_Pine
Tamarack
Treed_Bog
Upland_Conifers
Upland_Mixed_Forest
Upland_Shrub
Upland_Spruce_Fir
Urban
Water

*THEME *{9}* Age Class (Note: 10 years per age class)
ALL *; All age classes*
0-9
10-19
20-29
30-39
40-49
50-59
60-69
70-79
80-89
90-99
100-109
110-119
120-129
130-139
140-149

150+
NF
*THEME *{10}* BA Range
ALL *; All ranges of basal area*
1-50 *; 1-50 Sq. Ft. Basal Area*
51-80 *; 51-80 Sq. Ft. Basal Area*
81-110 *; 81-110 Sq. Ft. Basal Area*
111-140 *; 111-140 Sq. Ft. Basal Area*
141-170 *; 141-170 Sq. Ft. Basal Area*
171-200 *; 171-200 Sq. Ft. Basal Area*
201+ *; 201 and above Sq. Ft. Basal Area*
NF

*THEME *{11}* Availability
Avail *; Available Lands for Harvest*
UnAvail *; Unavailable Lands for Harvest*

*THEME *{12}* Special Analysis Units (DWC =Deer Wintering Complex, etc.
DWC-Arnold-Ford_River
DWC-Cusino
DWC-Dead_Horse-North_Perk
DWC-Deerfoot_Lodge
DWC-Gulliver_Scott_Point_
DWC-Hulbert_Hendrie_Sage_
DWC-Indian_Lake
DWC-Iron-Floodwood
DWC-McMillan_Ten_Curves
ELK
GEM-Backus_Creek
GEM-Bill_Rollo_Memorial_G
GEM-Cedar_River
GEM-Drummond
GEM-Garden_Grade
GEM-Greasy_Creek
GEM-Halifax
GEM-Hazel_Swamp
GEM-Lame_Duck_Foot_Access
GEM-LeeGrande_Ranch
GEM-Little_Betsie
GEM-Mark_Knee_Memorial_GE
GEM-Melstrand
GEM-Ralph
SAU-KW
None
ALL *; not in use*

*THEME *{13}* Purchased Land
Y
N
ALL

*THEME *{14}* Treatment Sequence Completed
None *; initial existing condition*

XXXX *; immediately after regeneration harvest*
SEL1 *; 1st selection entry*
SEL2 *; 2nd selection entry*
SEL3 *; 3rd selection entry*
SEL4 *; 4th selection entry*
SEL5 *; 5th selection entry*
SEL6 *; 6th selection entry*
SEL7 *; 7th selection entry*
SEL8 *; 8th selection entry*
SEL9 *; 9th selection entry*
SEL10 *; 10th selection entry*
GRP1 *; 1st group selection entry*
GRP2 *; 2nd group selection entry*
GRP3 *; 3rd group selection entry*
GRP4 *; 4th group selection entry*
GRP5 *; 5th group selection entry*
Thin1 *; 1st thin*
Thin2 *; 2nd thin*
Thin3 *; 3rd thin*
Thin4 *; 4th thin*
Thin5 *; 5th thin*
Thin6 *; 6th thin*
OVSTR1 *; 1st rotation OR*
OVSTR2 *; 2nd rotation OR*
OVSTR3 *; 3rd rotation OR*
OVSTR4 *; 4th rotation OR*
OVSTR5 *; 5th rotation OR*
PCT *; pre-commercial thin in existing PJP*

*THEME *{15}* Rotation Status
None *; Existing stand starting conditions*
REGEN1 *; 1st rotation CC*
REGEN2 *; 2nd rotation CC*
REGEN3 *; 3rd rotation CC*
REGEN4 *; 4th rotation CC*
REGEN5 *; 5th rotation CC*
REPCT1 *; 1st rotation CC+PCT in KW PJP*
REPCT2 *; 2nd rotation CC+PCT in KW PJP*
REPCT3 *; 3rd rotation CC+PCT in KW PJP*
REPCT4 *; 4th rotation CC+PCT in KW PJP*
REPCT5 *; 5th rotation CC+PCT in KW PJP*
SHELT1 *; 1st rotation SW*
SHELT2 *; 2nd rotation SW*
SHELT3 *; 3rd rotation SW*
SHELT4 *; 4th rotation SW*
SHELT5 *; 5th rotation SW*
SHELT6 *; 6th rotation SW*
GRP7 *; Group Selection starting @ age 7*
GRP8 *; Group Selection starting @ age 8*
GRP9 *; Group Selection starting @ age 9*
GRP10 *; Group Selection starting @ age 10*
GRP11 *; Group Selection starting @ age 11*
GRP12 *; Group Selection starting @ age 12*

GRP13 *; Group Selection starting @ age 13*
GRP14 *; Group Selection starting @ age 14*
GRP15 *; Group Selection starting @ age 15*
DEATH *; acres reaching lifespan*

*THEME *{16}* Treatment Type
NIU *; not in use (yet) initial condition*
EA *; even aged regime*
UE *; uneven aged regime*

*THEME *{17}* Year of Entry
ALL
;2013
;2014
;2015
;2016
;2017
;2018
;2019
;2020
;2021
;2022

*THEME *{18}* Regime
GrowOnly
RegimeA
RegimeB
RegimeC
RegimeD
RegimeE

*THEME *{19}* Stand Origin
EX
RE

Lifespan

The Lifespan section contains the declaration that indicates the maximum age a development type may reach before it is assumed to die or be replaced by another development type through succession. The SFMP model has the following short lived covertypes senescing if they are marked as unavailable for commercial timber harvest in the forest inventory system and exceed the age shown in 10-year increments (21 = 210 years). The biological rotation age for each covertype was used to define when death is represented in the model:

? ? ? ? ? ? ? Northern_Red_Oak ? ? Unavail ? ? ? ? ? ? ? ?	21
? ? ? ? ? ? ? Black_Red_Hybrid_Oak ? ? Unavail ? ? ? ? ? ? ? ?	16
? ? ? ? ? ? ? Oak_Mix ? ? Unavail ? ? ? ? ? ? ? ?	16
? ? ? ? ? ? ? Aspen ? ? Unavail ? ? ? ? ? ? ? ?	13
? ? ? ? ? ? ? Planted_Jack_Pine ? ? Unavail ? ? ? ? ? ? ? ?	13
? ? ? ? ? ? ? Natural_Jack_Pine ? ? Unavail ? ? ? ? ? ? ? ?	13
? ? ? ? ? ? ? Lowland_Aspen_Balsam_Popl ? ? Unavail ? ? ? ? ? ? ? ?	13

The masking above indicates the covertype and the availability of the development type in order to undergo the "_Death" action. These covertypes have all been assigned a more mid to late successional covertype to transition into and is defined in the transitions section.

Area

The Area section is where the forest area included in the scenario or model run is defined and where the development type structure is initialized using the themes listed in the Landscape section. The SFMP model shape file contains 155,092 polygons that total 3,999,054 acres (including Beaver Island which was excluded from all scenarios as Wildlife Division is now the Land administering Division and it is no longer part of the State Forest). The following is an example of the code representing individual development types (individual polygons with the same attributes are aggregated into development types) in the area section and values represented are:
Eco-region, district, forest management unit, management area, compartment #(not used), Stand # (not used), yield table identification, cover type, age class, basal area class, availability for commercial harvest, special analysis unit, purchased land flag, treatment sequence, space holder (NIU), year of entry (all), regime, stand origin, age (in 10-year periods), acres of the development type.
;*A Th1 Th2 Th3 Th4 Th5 Th6 Th7 Th8 Th9 Th10 Th11 Th12 Th13 Th14 Th15 Th16 Th17 Th18 Th19 Age Area
*A EUP EUP Newberry Grand_Marais_Moraine_Comp ALL ALL 1000 Lowland_Spruce_Fir 80-89 51-80 Avail None N None None NIU ALL GrowOnly EX 9 18.1(Acres)

The Area section also contains all future development types of the forest representing future conditions once actions and transitions have occurred. The SFMP model has 653,347 total development types (current and future combined).
Key attributes from the forest inventory system were captured and represented as themes in the Landscape section and eventual attributes Area section. Administrative designations like "Forest Management Unit" combined with planning designations like "Management Area" help to build a crosswalk for implementing harvest goals created at the planning level with resources assigned to the administrative units.
Site condition data were used to determine "Availability" which is the area eligible to receive a harvest once other criteria are met like age and basal area for certain silvicultural treatments. This was a key attribute in determining sustainable harvest flow in the SFMP model because it defines the portion of the state forest that can be actively managed over the long term.
The combination of each covertype, age class, and basal area class also represented key components that are used in determining operable areas and treatments each unique combination was eligible to receive.

Yields

The Yields section is the part of the Woodstock model for including per acre stand volumes, basal area estimates, cultivation costs, species-product stumpage prices, and revenues associated with the development types.
The forest inventory data collected by the Michigan DNR is qualitative in nature and provides a great deal of valuable information about the State Forest, but it does not contain the quantitative data necessary to produce growth and yield tables. The variables necessary to represent the current condition of various covertypes in different conditions are, however, contained in the USFS Forest Inventory and Analysis (FIA) data. The key attributes from the Michigan Forest Inventory (MiFI) data that were necessary to create yield tables for individual representative stratum were covertype, age class, and basal area class. These three attributes could also be calculated for a collection of FIA plots that contained the necessary volumetric data to be used in the generation of growth and yield tables. FIA plots located on state forest land were included in an analysis that used individual tree canopy percentage, size class, and species data to calculate a MiFI covertype using the same covertype rules as are in the MiFI system. Other fields in the FIA data were used to determine the basal area class and age class of each plot.

The result was a collection of FIA plots that could be used to determine average beginning conditions of each covertype-age-BA stratum. More common types like aspen and northern hardwoods are represented by hundreds of FIA plots while less common types/conditions may only have one or two plots, and in some cases, there were no FIA plots that represented a specific combination of covertype, age class, and BA class. These strata were represented using a nearest neighbor approach where the closest combination of younger age class and lower basal area values were used as the starting condition to represent the null current condition within the covertype. This imputation process resulted in a representative yield table for each combination of covertype, age class, and basal area class in twenty, ten-year periods.

Future conditions for each stratum were created to simulate growth by feeding current conditions into the USFS Forest Vegetation Simulator (FVS). Various controls were used (Max BA, growth modifier) to moderate growth and resulting conditions until each strata closely resembled timber sale harvest data for equivalent types in terms of basal area and cords per acre.

It is important to note that the yield tables are relatively coarse and represent an average condition of each stratum across a range of soil productivity and spatial distribution. The coarseness of the yield tables can often lead to significant swings in conditions from one period to the next and is often observed in inventory-based outputs using yield table variable thresholds to describe certain conditions (many wildlife outputs use these).

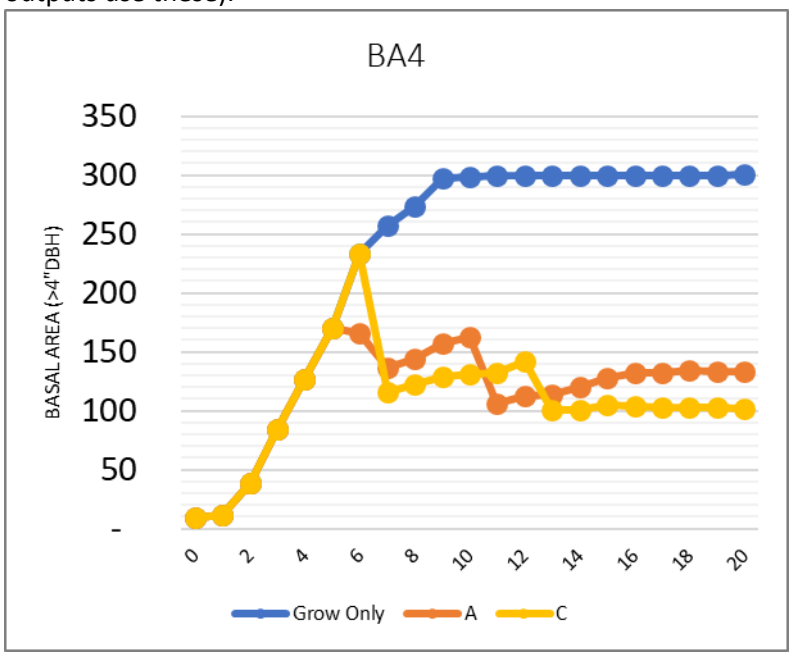


Figure 2. Yield Table showing BA4 values for planted red pine in all 20 periods.

"Grow only" tables were created for all strata to represent current and future conditions of each stratum if no harvesting were to occur. Conversion to other longer-lived or more shade tolerant species can be observed in the yield tables for shorter-lived covertypes by examining the volume by individual species product variables.

Various partial harvest regimes were then created in FVS to simulate common thinning regimes (Figure 2) applied to various covertypes that are more thoroughly described in the Actions section. The example in Figure 2 shows yields for planted red pine where the model can be referred to the grow only yield table or one of the harvest regimes (A or C) depending on the actions selected for a particular scenario:

Year
Period
Age
Standid
Stocking Class
Cover Type

Age Class
CordsPerAcreChange
a) TPA (Trees per acre)
b) TPA4
c) BA
d) BA4
e) QMD (Quadratic mean diameter)
f) QMD4
g) Total Cords/ac
h) Saw MBF/ac (Thousand board feet per acre of sawtimber)
h) Saw Cords/ac
i) Pulp Cords/ac (Cords per acre of pulpwood)
j) MIXED ASPEN Pulpwood
k) MIXED HARDWOOD Pulpwood
l) RED PINE Pulpwood
m) MIXED OAK Pulpwood
n) JACK PINE Pulpwood
o) WHITE PINE Pulpwood
p) MIXED SPRUCE Pulpwood
q) MIXED SOFTWOOD Pulpwood
r) MIXED ASPEN Sawtimber
s) RED PINE Sawtimber
t) MIXED OAK Sawtimber
u) WHITE PINE Sawtimber
v) BASSWOOD Sawtimber
w) RED OAK Sawtimber
x) WHITE OAK Sawtimber
y) SUGAR MAPLE Sawtimber
z) RED MAPLE Sawtimber
Aboveground Total Carbon Tons/ac
Aboveground Merchantable Carbon Tons/ac
Belowground Live Carbon Tons/ac
Belowground Dead Carbon Tons/ac
Standing Dead Carbon Tons/ac
Percent Canopy Cover
Number of Species Present
Total Harvest Carbon Tons/ac

The simple stumpage value yield table provides an adjustable stumpage price for 17 unique species product combinations. Statewide average stumpage prices were calculated using a 5-year moving average ending in 2022 and can be updated to reflect current prices at any time. Species product prices included in the SFMP model are as follows:

```
;;; Pulpwood harvest volume by species in $/cord
*YT ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ?
 y$AS_P     1    35.78     ; MIXED ASPEN Pulpwood
 y$HW_P     1    49.59     ; MIXED HARDWOOD Pulpwood
 y$JP_P     1    33.91     ; JACK PINE Pulpwood (normal rotation)
 y$OAK_P    1    28.74     ; MIXED OAK Pulpwood
 y$RP_P     1    73.27     ; RED PINE Pulpwood
 y$SOFT_P   1    22.66     ; MIXED SOFTWOOD Pulpwood
 y$SPR_P    1    34.88     ; MIXED SPRUCE Pulpwood
 y$WP_P     1    33.79     ; WHITE PINE Pulpwood
```

```
;;; Sawtimber harvest volume by species in $/MBF
*YT ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ?
 y$AS_S     1   121.20    ; MIXED ASPEN Sawtimber
 y$BW_S     1   158.94    ; BASSWOOD Sawtimber
 y$OAK_S    1   216.74    ; MIXED OAK Sawtimber
 y$RM_S     1   165.91    ; RED MAPLE Sawtimber
 y$RO_S     1   292.96    ; RED OAK Sawtimber
 y$RP_S     1   163.94    ; RED PINE Sawtimber
 y$SM_S     1   448.21    ; SUGAR MAPLE Sawtimber
 y$WO_S     1   102.94    ; WHITE OAK Sawtimber
 y$WP_S     1    91.11    ; WHITE PINE Sawtimber
```

Some average estimated costs were also included in the SFMP model to capture cultivation efforts but are not used in any financial valuation as many costs are not captured and factored into the model. Most costs are incurred at the time of stand establishment. Costs used in the SFMP model are represented in this simple yield table on a per acre basis:

```
 y$Herb     1   150.00    ; Herbicide
 y$Trench   1    67.00    ; Trenching
 y$Plant    1   234.00    ; Planting
 y$Seed     1    67.00    ; Seeding
 y$Scar_JP  1    86.00    ; Scarification in Jack Pine Covertype
 y$Scar_NH  1   292.00    ; Scarification in Northern Hardwood Covertype
 y$PCT      1   300.00    ; Pre-Commercial Thinning in KW SAU Jack Pine
 y$Masticate 1  300.00    ; Mastication in Jack Pine for KW SAU
```

Actions

The Actions section defines the activities or events that change the dynamics of forest development. The Actions section only describes and defines the actions each development type is eligible for while the Transition section (next) describes what happens to those development types after the action is executed. Five partial harvest regimes were generated as described in the Yields section and eligibility for each of those regimes (A-E) are described below:

i. Harvest Regime Eligibility – establishes which development types are eligible for various treatment regimes and/or silvicultural methods.

1. Regime A – thinning is defined in yield tables and starts in period 1 and contains specific regimes for the following covertypes:
    a. Northern Hardwood - Selection
    b. Northern Red Oak – Intermediate Thinning
    c. Planted Red Pine – Intermediate Thinning
    d. Planted White Pine – Intermediate Thinning
    e. Planted Mixed Pine – Intermediate Thinning
    f. Natural Red Pine – Intermediate Thinning
    g. Natural White Pine – Intermediate Thinning
    h. Natural Mixed Pine – Intermediate Thinning
    i. Lowland Deciduous – Intermediate Thinning
    j. Upland Conifer – Intermediate Thinning

2. Regime B – same as above but thins start in period 2 as a 2nd timing choice (allows for more even flow of harvests)
3. Regime C – 3rd timing choice for planted and natural pine types
4. Regime D – Selection harvest for lowland deciduous only
5. Regime E – Same as D, but provides second timing choice

ii. Silvicultural Methods or Type of Harvest that are described in the SFMP model are listed below:

1. aClearcut — Clearcut-only action in regime – resets age to 0
2. aCC_after_Thin — Clearcut after a thin has occurred, resets age to 0
3. aShelterwood — Shelterwood– remove 80% of volume
4. aOverstoryRem — Overstory removal- 2 periods after shelterwood
5. aThin_b4_CC — Intermediate thinning prior to clearcut
6. aSelect — Selection in NH – regeneration after third entry
7. aGrpSel_Int*x* — Group Selection (x of 5) 20% volume-100% area
8. aGrpSel_Final — Final Group Selection – resets age to 30 yr old

iii. Other parts of the Actions section define if a development type is operable for an Action, for instance:

1. Aspen Age class >=5 to be eligible for clearcut (40+ years old)
   a. For each existing stand and regenerated stands
2. Planted Red Pine yTotThn>= 1 in assigned yield table means a thinning is represented in the yield table.
   a. yTotThin is a calculated coefficient in the yield tables, generated by FVS when a beginning stand table is grown forward in periods and specific metrics hit trigger points
   b. Ytotthin is triggered to be set to 1 when Age >= 30 and BA >= 160 for Planted Red Pine
3. Shelterwood Harvest – specific covertypes and age requirements
4. Development types are eligible for Overstory removal after Rotation status is set to "SHELT1" meaning a shelterwood harvest was actioned on that development type.

Transitions

The Transitions section presents outcomes of the activities or events declared in the Actions section. Transitions can be as simple as defining what happens to a development type after a simple clearcut action is performed where the age is reset to zero and the development type is now a regenerating type with no other changes. This new development type is then assigned to a new yield table that represents that condition and will stay there if and when another action is performed. Transitions can also describe what happens after a partial harvest occurs assigning the development type to one of the regimes in the yield tables representing that condition.

A key component of this SFMP model is the ability to represent transitions that result in a change in covertype, or covertype conversions. This is defined in the Transitions section of the model, and the changes are unique to each covertype in each MA and Special Analysis Unit. Default regional values were used in the transition section if a unique MA value was not requested through the series of local Michigan DNR"DFC Meetings". Those default values were a representation of current covertype trends or desired trends moving forward. An example code representing a covertype conversion occurring is shown below where existing mixed upland deciduous development types scheduled for a clearcut harvest in the Avery Hills MA are transitioned to regenerating stands. The proportion staying in the mixed upland deciduous covertype is 40%, while 50% is converting to aspen, and 10% is projected to convert to planted red pine and assigned to the regime A yield tables.

```
*SOURCE ? ? ? Avery_Hills ? ? ? Mixed_Upland_Deciduous ? ? ? None ? ? NONE EA ? GrowOnly EX
 *TARGET ? ? ? Avery_Hills ? ? ? Aspen ? ? ? ? ? XXXX REGEN1 EA ? GrowOnly RE          50
 *TARGET ? ? ? Avery_Hills ? ? ? Mixed_Upland_Deciduous ? ? ? ? ? XXXX REGEN1 EA ? GrowOnly RE  40
 *TARGET ? ? ? Avery_Hills ? ? ? Planted_Red_Pine ? ? ? ? ? XXXX REGEN1 EA ? RegimeA RE      10
```

Outputs

The Outputs section includes the values used to exert management control and to evaluate management implementation. The SFMP model contains nearly 1,000 outputs that help to describe values for both timber and wildlife habitat. They can be categorized in the following general types (with examples for each):

Area Outputs:

Inventory Area Outputs

*OUTPUT oFMU_Acres(_TH3) Total Forest Management Unit Acres
*SOURCE *? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ?* _INVENT _AREA

Harvest Area Outputs

*OUTPUT oCT_HarvestThinAc(_TH8) Thinning Acres by Covertype
*SOURCE *? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ?* aThin_b4_CC _AREA

Volume Outputs:

Inventory Volume Outputs

*OUTPUT oTotalInventory Total Inventory in ??? units
*SOURCE *? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ?* _INVENT yxInvVol

Harvest Volume Outputs

*OUTPUT oEX_CC_Vol Existing Development Type Clearcut Volume in ??? units
*SOURCE *? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? EX* aClearcut yxInvVol

Graphics

The Graphics section contains the declaration of what outputs are displayed in graphical format in the compiler graphics screen. Graphics that help users evaluate model behavior are especially helpful to build in the graphics section and enable quick analysis of various scenarios based on key outputs. An example of a Woodstock graphic is shown below showing the overall acreage (800,000+) and age-class distribution of aspen across the state forest over 15 periods (Figure 3).

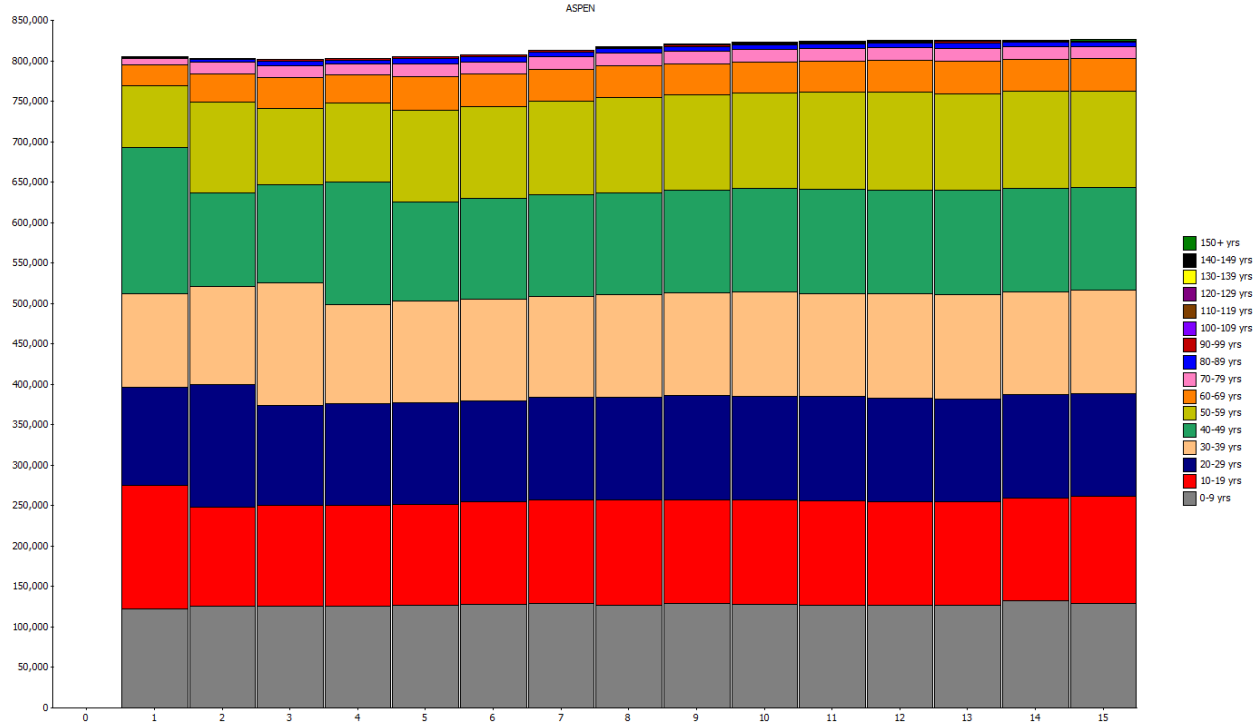


Figure 3. Aspen age class distribution for the entire State Forest in all 15 ten-year periods.

Optimize

The Optimize section formulates the model as a linear programming (LP) model by declaring an objective function and constraints on outputs. This section is key to representing the management strategies used on the forest and provides methods to either control the model through the use of "hard" constraints (e.g., KW jack pine clearcut acres = 3200 in period 1) or by incentivizing the model through the use of goals (e.g., Aspen age class 1 = 16% of all available acres of aspen in all periods) – not feasible in all periods given the current condition, but the model is incentivized to reach this goal as soon as possible. The objective function is defined here and is used by the LP solution algorithm for finding a mathematically optimal solution. The statewide SFMP model uses an objective function that maximizes harvest acres over 15 decades while penalizing the objective function when goals are not satisfied in each period (e.g., The age class goals of age classes 2, 3, and 4 (age 10-39) cannot be changed because they are too young for harvest in the 1 period, but once they become merchantable in subsequent periods, then the model can allocate harvests to achieve those goals and regenerate a new 0-9 age class that also meets the age class goal).
The following objective function is used in the SFMP Model:

```
*OBJECTIVE
 _MAX oTotalHarvestAc - _PENALTY(_ALL)  1.._LENGTH
```

Other objective functions (e.g., to minimize costs or maximize other outputs in SAU modeling efforts) have been used for sub-state areas, but the statewide model is best represented with a maximize harvest acres objective function to represent area regulation models. The harvests can only occur on acres available for harvest, XXX of YYY totl forest acres statewide.
Several hard constraints are used to control model behavior and ensure certain constraints are met or to mediate unintended consequences of the objective function that otherwise would result in negative impacts to harvest flow across a specific area or create unfavorable habitat conditions. One example of these is an even-flow constraint that helps provide a relatively stable flow of harvest acres in each 10-year period. In the following example, the total harvest acres output cannot deviate more than 5% in each period:

```
_EVEN(oTotActHarvAc,5%) 1.._LENGTH
```

Other examples include constraints that ensure harvest regimes are executed as desired helping to ensure actions represent management intentions. The following example ensures that group selection continues on a development type once it is first scheduled, resulting in a sequence of five harvests to complete the cycle:

```
 oGrpSel7_GRP2_Ac = oGrpSel7_GRP1_Ac[-1] 2.._LENGTH
 oGrpSel7_GRP3_Ac = oGrpSel7_GRP2_Ac[-1] 3.._LENGTH
 oGrpSel7_GRP4_Ac = oGrpSel7_GRP3_Ac[-1] 4.._LENGTH
 oGrpSel7_GRP5_Ac = oGrpSel7_GRP4_Ac[-1] 5.._LENGTH
```

The harvest regime goals are a key component of the SFMP model and designate what proportion of eligible silvicultural regimes are applied to each covertype. These controls are set up as goals, sometimes called "soft" constraints, and incentivize the model to achieve these goals by accruing penalty points when not met. These points reduce the value of the objective function which the model is trying to maximize. Hence, the model tries to achieve these goals thereby avoiding the negative points. These goals exist for each MA and covertype that has multiple options for silvicultural regimes. The following goal statement incentivizes the model to allocate 77% of the total harvest acres to the clearcut, 7% to shelterwood, and the remaining 16% to thinning treatment in the Black / red hybrid oak cover type in the Cadillac Moraines management area.

```
oMA_Cadill_CC(Black_Red_Hybrid_Oak) >= 0.77 *
oMA_Cadill_HarvAc(Black_Red_Hybrid_Oak)  1.._LENGTH _GOAL(GR_Cadill_BRH_CC,100)
oMA_Cadill_SW(Black_Red_Hybrid_Oak) >= 0.07 *
oMA_Cadill_HarvAc(Black_Red_Hybrid_Oak)  1.._LENGTH _GOAL(GR_Cadill_BRH_SW,100)
oMA_Cadill_TH(Black_Red_Hybrid_Oak) >= .16 *
oMA_Cadill_HarvAc(Black_Red_Hybrid_Oak)  1.._LENGTH _GOAL(GR_Cadill_BRH_Thn,100)
```

The age class goals are also one of the most influential sets of goals in the SFMP model. These goals provide incentive for the optimal solution to conform to an area regulation system based on age class goals. There are also several goals related to specific habitat needs of featured species like elk, Kirtland's Warbler, and white-tailed deer (food and shelter). These goals are described in detail in section 5. Special Analysis Units.

Each covertype and MA combination has a unique set of age class goals that define what the ideal age class distribution looks like, in essence, describing the desired future condition of the state forest in terms of age distribution. The penalty points associated with these goals vary depending on the overall abundance of each covertype in each MA. The more significant covertypes carry a high goal weight as there is greater opportunity to achieve a desired age class distribution. Smaller populations of covertype acres use a smaller goal weight, resulting in less penalty points accrued against the objective function if goals are not met. Desired age class distributions are not always as attainable in small populations and are less realistic to achieve in an area regulation system. The following example shows a set of age-class goals and corresponding age class distribution in each period for that same covertype and MA, showing the progress toward and achievement of the desired age class distribution in the Cadillac Moraines MA for aspen of approximately 15.2% of the available aspen is contained in the first 6 age classes. The next 3 oldest age classes have a goal of containing 6%, 1.6%, and .3% of the available population of acres.

oAsp_Age_1_Ac_Av(Cadillac_Moraines) >= 0.152222 *
oMA_Asp_Ac_Av(Cadillac_Moraines) 1.._LENGTH _GOAL(ACG_Cadill_Asp_1,25)
oAsp_Age_2_Ac_Av(Cadillac_Moraines) >= 0.152222 *
oMA_Asp_Ac_Av(Cadillac_Moraines) 1.._LENGTH _GOAL(ACG_Cadill_Asp_2,25)
oAsp_Age_3_Ac_Av(Cadillac_Moraines) >= 0.152222 *
oMA_Asp_Ac_Av(Cadillac_Moraines) 1.._LENGTH _GOAL(ACG_Cadill_Asp_3,25)
oAsp_Age_4_Ac_Av(Cadillac_Moraines) >= 0.152222 *
oMA_Asp_Ac_Av(Cadillac_Moraines) 1.._LENGTH _GOAL(ACG_Cadill_Asp_4,25)
oAsp_Age_5_Ac_Av(Cadillac_Moraines) >= 0.152222 *
oMA_Asp_Ac_Av(Cadillac_Moraines) 1.._LENGTH _GOAL(ACG_Cadill_Asp_5,25)
oAsp_Age_6_Ac_Av(Cadillac_Moraines) >= 0.152222 *
oMA_Asp_Ac_Av(Cadillac_Moraines) 1.._LENGTH _GOAL(ACG_Cadill_Asp_6,25)
oAsp_Age_7_Ac_Av(Cadillac_Moraines) >= 0.066667 *
oMA_Asp_Ac_Av(Cadillac_Moraines) 1.._LENGTH _GOAL(ACG_Cadill_Asp_7,25)
oAsp_Age_8_Ac_Av(Cadillac_Moraines) >= 0.016667 *
oMA_Asp_Ac_Av(Cadillac_Moraines) 1.._LENGTH _GOAL(ACG_Cadill_Asp_8,25)
oAsp_Age_9_Ac_Av(Cadillac_Moraines) >= 0.003333 *
oMA_Asp_Ac_Av(Cadillac_Moraines) 1.._LENGTH _GOAL(ACG_Cadill_Asp_9,25)

The results of these goals are presented in Figure 4.

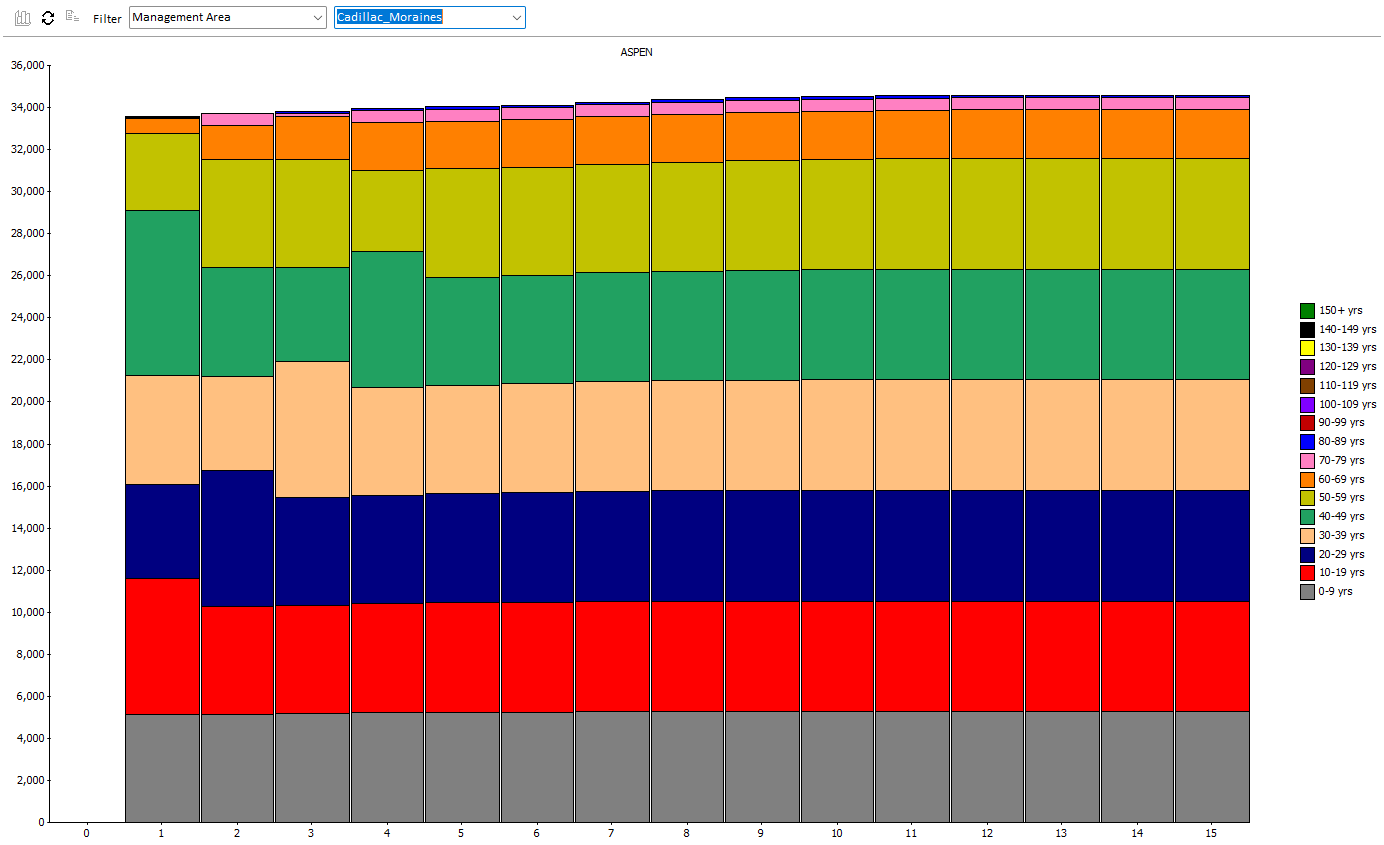


Figure 4. A stacked bar graph of the area of aspen in each age class over the 15-period model run, showing the achievement of desired age class distribution.

Similar age-class goals are also applied in special analysis units (SAUs) where there may be different age-class distribution objectives when compared to the remainder of the MA.

Schedule

The Schedule section is used to generate reports on an optimal solution found by the LP solver used by Woodstock. The resulting harvest schedule contains a comprehensive list of harvest activities that were scheduled on development types for the entire model run. This harvest schedule is an integral part of the implementation process for the SFMP planning process and is further described in the implementation section of the SFMP. Below is an example of the harvest Schedule viewed as a table and showing mixed upland deciduous development types with a selection harvest in the Newberry FMU (Figure 5).

Record	Theme3	Theme4	Theme5	Theme6	Theme7	Theme8	Theme9	Theme10	Theme11
31,366	Newberry	Grand_marais_moraine_comp	All	All	1016	Mixed_upland_deciduous	100-109	111-140	Avail
31,367	Newberry	Grand_marais_moraine_comp	All	All	1022	Mixed_upland_deciduous	100-109	81-110	Avail
31,368	Newberry	Grand_marais_moraine_comp	All	All	1099	Mixed_upland_deciduous	60-69	81-110	Avail
31,369	Newberry	Grand_marais_moraine_comp	All	All	1099	Mixed_upland_deciduous	60-69	81-110	Avail
31,370	Newberry	Grand_marais_moraine_comp	All	All	1100	Mixed_upland_deciduous	70-79	111-140	Avail
31,371	Newberry	Grand_marais_moraine_comp	All	All	1102	Mixed_upland_deciduous	110-119	51-80	Avail

Theme12	Theme13	Theme14	Theme15	Theme16	Theme17	Theme18	Theme19	Age	Area	Action
None	Y	None	None	Ea	All	Growonly	Ex	11	15.96572	Aselect
None	N	None	None	Ea	All	Growonly	Ex	11	71.01213	Aselect
None	N	None	None	Ea	All	Growonly	Ex	7	3.50000	Aselect
None	Y	None	None	Ea	All	Growonly	Ex	7	17.10000	Aselect
None	N	None	None	Ea	All	Growonly	Ex	8	11.47816	Aselect
None	N	None	None	Ea	All	Growonly	Ex	12	3.49512	Aselect

Figure 5. Example of the harvest schedule allocated to development types in the woodstock model.

Reports

The Reports section identifies the outputs to include in report files. The SFMP model contains several custom reports that produce csv file types for thousands of output values for each period. These reports are generally imported into an Excel document and used to support the writing efforts of the this plan through various graphs and tables.

Maps

The maps section provides several GIS tools to interact with the spatial data (Figure 6) that was used to create the Area section of the model. There are several tools and options that help to spatially analyze results by spatially assigning the harvest schedule to the polygons creating a potential harvest solution that is spatially represented across state forest lands. This section is heavily used in the implantation process and is described in section 6 – Implementation.

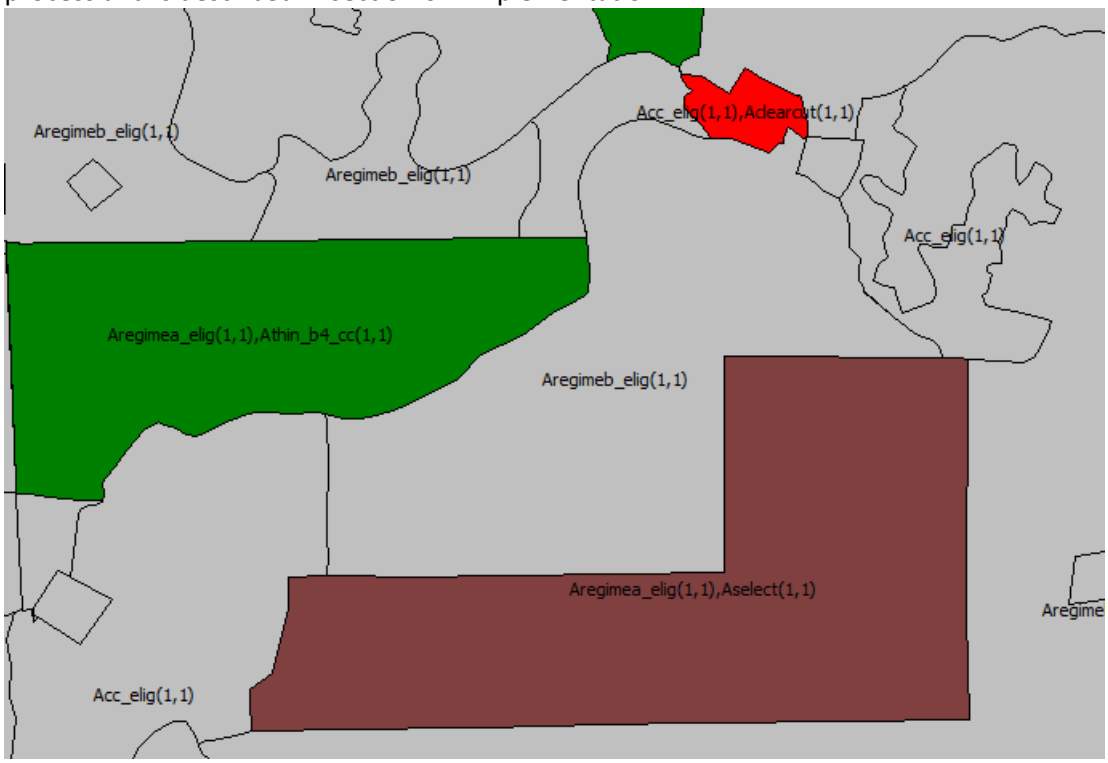


Figure 1. A screen shot of the spatial allocation of treatments from the maps section.

Appendix G: Forest Habitat Type (Kotar) Classifications Systems

Classification systems are needed to effectively manage forest resources. Traditionally, resource classifications have been developed only for specific uses. Forest cover types, for example, traditionally a standard unit for forest management, have serious limitations as an ecological basis for developing management prescriptions. They are based entirely on current dominant and most often successional tree species. Thus, stands of a given cover type encompass a wide range of environmental conditions and therefore have different productivity potentials and respond differently to the same management techniques. Similarly, systems that classify or map landscapes based entirely on physical factors (e.g., physiographic maps or soil surveys) are inadequate for management if they do not include ecological interpretations of communities (e.g., composition, growth, dynamics) that are associated with individual physical landscape units. A system that delineates and explains some basic ecological units is needed to place management on an ecological foundation. This habitat classification system uses natural vegetation (potential as well as current) to recognize ecologically equivalent vegetation communities and landscape units.

The Forest Habitat Type (Kotar) Classification System is a site classification system based on the identification of repeatable patterns in the composition of the understory vegetation. It is a system based on the study of floristic composition of vegetation that groups communities and their environments into categories useful for management interpretation. The habitat types are developed independently from the current tree species composition and condition and can be applied to most upland forest stands.

The Kotar classifications for each ecoregion are listed below.

Western Upper Peninsula Ecoregion Habitat Types

Habitat Type	Name	Primary Landform and Soils
PVCx/PVDc	White pine/Blueberry – Hairgrass and White pine/Blueberry - Sedge	Excessively drained sandy soils on outwash plains.
PQE	White pine – Red Oak/Trailing arbutus	Deep sandy soils on outwash and lacustrine deposits or shallow soils over bedrock.
PArV	White Pine – Red maple/Blueberry	Excessively well drained soils of lacustrine deposits.
PArV(w)	White Pine – Red maple/Blueberry (Wisconsin variant)	Sands and loamy sands on glacial outwash and moraines.
PArVAa	White pine – Red maple/Blueberry – Wild sarsaparilla	Excessively well drained soils of lacustrine deposits.
PArVAa(w)	White pine – Red maple/Blueberry – Wild sarsaparilla (Wisconsin variant)	Sand to sandy loam on glacial outwash and moraines.
PArV-Co	White pine – Red maple/Blueberry – Bunchberry variant	Excessively well drained sands on lacustrine deposits of sand and gravel.
AArAst	Sugar maple – Red maple/Large-leaved aster	Sandy soils formed in coarse till and shallow till over bedrock.
AArLy	Sugar maple – Red maple/Stiff club-moss	Loamy soils over deep sands on coarse till deposits and thin till over bedrock.
AVVb	Sugar maple/Blueberry – Maple-leaved viburnum	Well drained sandy loams on rolling moraines and glaciofluvial deposits.
AVb	Sugar maple/Maple-leaved viburnum	Sandy loams on medium textured end moraines.
TMC	Eastern hemlock/Wild lily-of-the-valley – Goldthread	Somewhat poorly drained soils on a variety of landforms.
ATM	Sugar maple-Eastern hemlock/Wild lily-of-the-valley	Loamy sand and sandy loam soils on end moraines and outwash covered moraines.
ATM-Sm	Sugar maple-Eastern hemlock/Wild lily-of-the-valley – False Solomon's seal variant	Loamy sand and sands on medium and coarse texture tills.
ATM-O	Sugar maple-Eastern hemlock/Wild lily-of-the-valley – Sweet cicely variant	Sandy loam soils over clay on clay and lacustrine deposits.
ATFAs	Sugar maple-Eastern hemlock-American beech/Jack-in-the-pulpit	Sandy soils with subsurface clayey, gravelly or cemented layers.
ATD	Sugar maple-Eastern hemlock/Spinulose shield fern	Loamy soils on coarse textured till and loess.
ATD-Hp	Sugar maple-Eastern hemlock/Spinulose shield fern-Sharp-lobed hepatica variant	Sandy soils with subsurface clayey, gravelly or cemented layers on medium textured glacial till.
ATD-Ca	Sugar maple-Eastern hemlock/Spinulose shield fern-Blue cohosh variant	Loamy cap soils on clay deposits
AOCa	Sugar maple/Sweet cicely - Blue cohosh	Well drained loamy till and loess

Eastern Upper Peninsula Ecoregion Habitat Types

Habitat Type	Name	Primary Landforms and Soils
PVE	White pine/Blueberry – Trailing arbutus	Excessively drained soils on lacustrine deposits of sand and gravel.

PArV	White pine - Red maple/Blueberry	Excessively drained to well drained soils on deep lacustrine deposits of sand and gravel.
PArV-Ao	White pine – Red maple/Blueberry – Spreading dogbane variant	Excessively drained to somewhat excessively drained soils on glacial outwash.
PArVAa	White pine – Red maple/Blueberry – Wild sarsaparilla	Excessively to well drained sandy soils on deep lacustrine deposits of sand and gravel.
ATFD	Sugar maple – Eastern hemlock – American beech/Spinulose shield fern	Well to moderately well drained deep sands and loamy sands on outwash, lacustrine deposits, glacial till and end moraines.
AFPo	Sugar maple – American beech/Hairy Solomon's seal	Well to somewhat excessively drained deep sands and loamy sands on a variety of landforms. Gravelly, cemented and mottled layers are common.
AFOAs	Sugar maple – American beech/Sweet cicely – Jack-in-the-pulpit	Moderately well to somewhat excessively drained soils on end moraines and till plains. Gravelly, cemented and mottled layers are common. Also, thin till over bedrock.

Northern Lower Peninsula Ecoregion Habitat Types

Habitat Type	**Name**	**Primary Landforms and Soils**
PVCd	White pine/Blueberry – Reindeer lichen	Sandy outwash plains, very dry/very poor nutrient.
PARVHa	White pine – Red maple/Blueberry – Witch hazel	Level plains and gentle slopes, associated with glacial outwash plains, sandy beach ridges and coarse textured moraines, very dry to dry/poor nutrient.
PArVVb	White pine – Red maple/Blueberry – Maple-leaved viburnum	Beach ridges along Lake Huron, dry to dry-mesic/poor to medium nutrient.
AFO	Sugar maple – American beech/Sweet cicely	Coarse textured end moraines, ground moraines, outwash plains, till plains and undifferentiated end moraine – ground moraine complexes. Mesic/medium to rich nutrient.
AFOCa	Sugar maple – American beech/Sweet cicely – Blue cohosh	End moraine, drumlins and ground moraines. Mesic/rich to very rich nutrient.
PArVCo	White pine – Red maple/Blueberry – Bunchberry	Poorly drained outwash sands. Mesic to wet-mesic/poor nutrient.

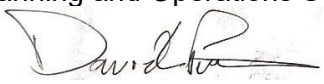
Appendix H: Interim Guidance

MICHIGAN DEPARTMENT OF NATURAL RESOURCES

INTEROFFICE COMMUNICATION

April 8, 2024

TO: Forest Resources Division District Managers and Unit Managers FROM: David Price, Forest Planning and Operations Section Manager



SUBJECT: Interim Guidance - Increased Minimum Gap Size and Regeneration Accountability for Uneven-Aged Management

This memo is aimed at communicating interim guidance for two objectives: 1) changes to gap harvesting criteria for northern hardwood management and 2) establishing recruitment and age accountability at the gap scale. This guidance replaces guidance for group selection in the DNR Silvics and Management Guidance Manual (IC4111) and will be incorporated into future revisions of the guidance manual.

The update to gap size is based on research and management experience over the last two decades. The rationale for better accounting of the resource is related to the age imbalance and a lack of a system to track it at a scale smaller than stands. It is critical that we track recruitment efforts closely so that we can begin to develop the structure desired. In many cases, this effort will take more than just monitoring. This communication is broken into categories that provide background for these changes and explanation of their purpose.

Research: In 2007, Forest Resources Division (FRD) began investing in research for northern hardwood management due to a lack of desirable recruitment across the majority of the acreage on the State Forest. The current project that began in 2016 aims to test alternative silvicultural systems, and the minimum gap sizes for the current project were based on the previous research. However, FRD never updated our minimum gap size for operational purposes.
Results from the more recent project will continue to inform this guidance.

Silviculture: 1994 FRD guidance suggested that proper implementation of single tree selection would result in regulation 30 years later. As we approach on this anniversary, it has become clear that this was not a practical goal. Furthermore, it is also becoming clear that single-tree selection may not be the most efficient way to convert even-aged stands to uneven-aged structure, even in places with abundant desirable advanced regeneration. The increased gap size outlined in this guidance is a fundamental shift from single tree selection to small group selection. Under this new approach, we will be accountable to recruit the acreage within the gap, as opposed to an even distribution of regeneration across a stand. The latter was a poor metric for developing uneven-aged structure, and thus led to some of the accountability problems.

To maximize natural regeneration outcomes, new gap sizes for northern hardwood management are required to have a minimum radius of 50 ft (0.18 acre) to the bole of trees on the gap edge with a recommended maximum radius of 85 ft. (0.52 acre), or up to 100 ft (0.72 acre) in cases where intolerant species are desirable and can be promoted with available local seed/sprout sources.

In addition to providing an increased likelihood of desirable regeneration in problem areas, creating larger gaps can also be used to promote vigorous growth into small poles in stands where desirable advance regeneration is abundant, but pole timber is lacking. The proportion of a stand to include in gaps will vary based on the age and condition of a stand, but the guidance for a typical log-sized hardwood stand will be **10-20% of the area**, with the remaining 80-90% subject to thinning or no harvesting. Additional guidance on tree selection methods within the remainder of the stand will be provided in an updated version of The Complete Marker (IC 4039).

Forest Certification: Regeneration accountability has surfaced in several forest certification audits, but until recently it has been recognized as an area of improvement rather than a corrective action. A recent internal audit finding specific to natural regeneration has prompted more-timely implementation of this guidance. Additional guidance for even-aged natural regeneration monitoring will follow later. The changes for uneven-aged management outlined in this guidance will be incorporated into revision of Forest Certification Work Instructions.

Timber Sales: Staff will begin implementing the minimum gap size during timber sale preparation. Gap locations will be collected using a point or polygon feature. Within stands, there is considerable latitude regarding gap placement. The only requirement is that gaps should be separated by >75 feet of intact forest. It is encouraged that gaps be located where it makes the most sense; for example, maximizing the proportion of high-risk timber to be harvested, presence of well-stocked advance regeneration of desirable species, placement adjacent to seed-bearing trees of uncommon desirable species, or to optimize other management goals. As a reference, average gap density based on the 10% of stand target is approximately one 50-ft radius gap per two acres or one 75-ft radius gap per four acres, and for the 20% target one 50-ft radius gap per acre or one 75-ft radius gap per two acres. Painting gap boundaries prior to individual tree marking is an approach that should be considered at all scales. This can be efficient, as fewer trees need to be marked at the upper end of the minimum gap size and it eliminates the need to have a device on hand while marking. It also creates an opportunity to more evenly stratify gaps and creates a way to use timber sale specifications (cut all stems >1 inch dbh) to create a uniform flush of sprouts from advanced regeneration that was previously of varying form and size. In the example of a 100-acre treatment, individual tree marking can be reduced by 10-20 acres through use of this tactic.

Timber cruising will not change significantly, but it is important to point out some situations that will become increasingly common. The cruising options generally fall into two categories. The first scenario is when gaps are exclusively being created and the remainder of the stand is NOT being marked. This is becoming increasingly common in larger gaps with artificial regeneration objectives. In gaps larger than the minimum size for natural regeneration the cruiser would increase plot density to a minimum of 2 points per acre and the walk-through method would need to be incorporated. The second scenario is when the remainder of the stand is being marked. In the second scenario, the cruiser would increase the plot density and ignore the gap boundaries when determining cruise plot locations. Cruise plots would include trees from both inside and outside the gaps even if a separate paint color is used to identify gaps.

Treatment Tracking and Inventory: When the timber sale closes point data will be converted into polygons for the creation of monitoring or cultivation treatments in MiFI. Each gap will become its own treatment to provide clarity of scale for contractors and because different gaps within stands may need/not need treatments or may need different treatments.

Plans are being developed to convert regeneration survey data in Inventory Manager to a regeneration status that is specific to each gap. This platform will also provide the space to add other attributes such as age and size once the regeneration surveys are complete. The fundamental shift toward small group selection coincides with an opportunity to explore area regulation as compared to basal area regulation in the next planning cycle. The latter method for determining a sustainable harvest level was more suitable for single tree selection systems.

Cultivation: Achieving desirable regeneration is largely dependent upon having desirable advanced regeneration present before harvest. Unfortunately, a significant portion of the northern hardwood cover type has low advanced regeneration stem densities of desirable species, and often high densities of less desirable competitors, including beech and ironwood. Some of these stands are ideal candidates for conversion to other cover types for the next rotation, where practical. Otherwise, management toward uneven-aged northern hardwoods will continue to be the most common path over the next decade even when undesirable understory conditions dominate. Therefore, novel silvicultural treatments aimed at tipping the balance in favor of desirable well stocked regeneration will be required in many circumstances, including controlling undesirable regeneration with herbicides, scarifying to increase seedling establishment, brush saw release when stocking of desirable regeneration is present, and planting with browse protection when chances of natural establishment are low or have already failed. We have some of these tools at our disposal now and others will develop as funding becomes available for restoration. Gaps larger than the minimum size for natural regeneration are recommended once the decision has been made to use artificial regeneration.

Regeneration Monitoring: Regeneration surveys will continue to be scheduled in MiFI. Gaps requiring artificial regeneration will be scheduled for regeneration monitoring in the first and third growing season similar to how this works at the stand scale. Natural regeneration surveys will be scheduled at 5 growing seasons and 10 growing seasons post-harvest regardless of the re-inventory schedule for the compartment review process. The 5-year regeneration survey window allows for time to install an efficient release treatment if desirable regeneration is becoming established but is overtopped by competing shrubs and/or undesirable tree species. This window also allows for efficient planning of alternative treatments aimed at securing regeneration if desirable natural regeneration is clearly not establishing. The timing of the 10-year survey is intended to assess if desirable regeneration is expected to be well stocked and free-to-grow (i.e. taller than the browse line at >4.5 feet tall and not overtopped by competing vegetation). If the gaps are fully stocked with free-to-grow saplings then monitoring can be discontinued, and the harvest gaps can be considered successfully regenerated.

Regeneration surveys will always follow quantitative methods (installation of plots) because the costs are largely influenced by the need to travel to the site. The detail of the survey methods and the stocking thresholds are being developed through the northern hardwood research and will be incorporated into the Forest Regeneration Survey Manual (IC 4145). Established gaps that meet the minimum gap size requirement and have 5 years of growth can begin to be scheduled for regeneration surveys in the fall of 2024.