7 STATEWIDE IMPLICATIONS: 7 MILLION CORD ANNUAL HARVEST

This section of the study describes the modelling assumptions used, and the outputs from the highest level of harvesting modelled which is termed the *high* level of harvest. This scenario was developed specifically in response to the FSD requirement to assess the consequences of a level of harvest that approximated the estimated maximum annual volume of timber production. This level was intended to provide an upper bound to the analysis and accordingly should not be viewed as a viable option or *target* being considered for a future level of forest industry development.

As with the previous two sections, this section is intended to provide an understanding of what was harvested and why; what effects this had on the forests and their associated resources and values as defined in the FSD issues of concern; and lastly, what mitigations should be used to ameliorate the significant adverse impacts that result from this level of timber harvesting and forest management activity.

A substantial amount of additional background information was provided in section 5 (base level scenario) which is not repeated in this section. The *changes to the levels and types* of impacts projected to occur at the high level of harvesting are contrasted with those discussed under the base and medium levels of timber harvesting and forest management activities.

This section draws heavily on information and analyses presented in the GEIS technical and background papers. The papers set out in greater detail the methodology used and also identify the limitations of the methodology and the data used to undertake the analyses.

7.1 Description of Harvesting Activities

7.1.1 Underlying Assumptions

The high scenario differs from the base and medium scenarios because it is *supply driven* not *demand driven*. The surplus volumes by species and location at the end of the medium scenario were used to identify opportunities for new industries to be developed to make use of these resources. These opportunities may not represent prudent investments and these developments should not be construed as suggesting that such developments are feasible in any sense other than certain volumes of resources might be available.

To achieve the high scenario harvest level, the existing USDA Forest Service ASQ constraints that were used in modelling the base and medium scenarios had to be relaxed. Also, the base and medium scenario assumptions regarding the shift of 25 percent of the aspen demand to other hardwoods was required (see section 5.1.1). Table 7.1 describes the assumed roundwood consumption levels by species group and market for all scenarios.

7.1.2
Covertypes and Species Harvested

Table 7.2 summarizes the output from all scenarios that describes the total acres, acres uncut, acres clearcut once in 50 years, acres clearcut twice, acres thinned but never clearcut, acres thinned and clearcut for both the southern and the northern study regions, and the state as a whole. These data indicate that approximately 10.5 million acres of timberland would be harvested under the high scenario over the next 50 years. Conversely, adding the area of productive land *not cut* to the productive land *not considered* in the scheduling model, shows that a total of 4.3 million acres of timberland *would not* be harvested over this same period under this scenario. In addition, the 1.9 million acres of reserved and unproductive forest acreage (not included in table 7.2) would not be disturbed by harvesting. This means that under the high scenario 10.5 million acres would experience some form of harvesting and 6.2 million acres would not be harvested over the 50-year study period. By comparison, the corresponding values for the medium scenario are 8.6 and 8.4 million acres; while those for the base scenario are 7.2 and 9.5 million acres.

Table 7.3 shows the acreage harvested and not harvested by covertype under the high scenario. Much of the harvesting activity is concentrated in the aspen and other hardwood covertypes in the medium and high scenarios. However, the high scenario shows a trend towards increases in the area harvested for nearly all covertypes.

Notable increases in acres harvested by covertype for the high versus the medium scenario included: Jack pine (182,600); black spruce (123,000); balsam fir (123,500); tamarack (188,600); oak-hickory (102,800); elm-ash-soft maple (202,200); maple basswood (310,800); and paper birch (206,600).

Breakdown of Harvest Volumes by Product Group
Table 7.4 summarizes the scheduled harvests for products within each group for the northern and southern regions of the state.

Table 7.1. Comparison of assumed roundwood consumption levels by species group and market for the three harvest scenarios (thousands of cords per year).

Species Group Market	Period 1 (1990 - 1999)			Period 2 (2000-2009)			Periods 3-6 (2010-2049)		
	Base	Medium	High	Base	Medium	High	Base	Medium	High
Aspen									
Bemidji	572	572	572	522	522	522	435	435	450
Brainerd	256	256	256	260.1	287.1	287.1	216.75	239.25	300
Cook	210	210	210	182.7	182.7	182.7	152.25	152.25	300
Duluth	506	532	532	454.5	531	531	378.75	442.5	450
Grand Rapids	433	433	433	390.6	467.1	467.1	325.5	389.25	400
I. Falls	415	415	415	412.2	412.2	412.2	343.5	343.5	400
subtotal	2,392	2,418	2,418	2,222.1	2,402.1	2,402.1	1,851.75	2,001.75	2,300
Spruce-fir									
Brainerd	70	70	70	70	100	100	70	100	150
Duluth	220.5	220.5	220.5	219.5	379.5	379.5	219.5	379.5	400
Grand Rapids	115.5	115.5	115.5	118.5	163.5	163.5	118.5	163.5	300
subtotal	406	406	406	408	643	643	408	643	850
Pine									
Bemidji	159	159	159	188	188	188	188	188	370
Duluth	151	171	171	153	218	218	153	218	370
I. Falls	111	111	111	98	98	98	98	98	260
subtotal	421	441	441	439	504	504	439	504	1,000
Northern Hdwds									
Bemidji	83	83	83	147	147	147	234	234	400
Brainerd	190	190	190	226.9	229.9	229.9	270.25	277.75	600
Cook	51	51	51	79.3	79.3	79.3	109.75	109.75	250
Duluth	93	171	171	145.5	414	414	221.25	502.5	550
Grand Rapids	61	61	61	112.4	120.9	120.9	177.5	198.75	400
I. Falls	48	48	48	94.8	94.8	94.8	163.5	163.5	250
subtotal	526	604	604	805.9	1,085.9	1,085.9	1,176.25	1,486.25	2,450
Total, North	3,745	3,869	3,869	3,875	4,635	4,635	3,875	4,635	6,600
Southern Region									
Red oak sawlogs	50	50	50	50	65	70	50	65	70
Other wood	250	250	250	250	300	330	250	300	330
Total, South	300	300	300	300	365	400	300	365	400
Total, Statewide	4,045	4,169	4,169	4,175	5,000	5,035	4,175	5,000	7,000

Source: Jaakko Pöyry Consulting, Inc. (1992a).

Table 7.2. Summary of original timberland acres clearcut and/or thinned for three timber harvesting scenarios, 1990–2040.

Action Category*		Base Scenario			Medium Scenario			High Scenario		
		North	South	Total	North	South	Total	North	South	Total
1	Total Timberland			14,773,400			14,773,400			14,773,400
2	Not Considered			1,356,500			1,356,500			1,356,500
3	Considered	12,409,900	1,007,000	13,416,900	12,409,900	1,007,000	13,416,900	12,409,900	1,007,000	13,416,900
4	Not cut	5,591,300	652,200	6,243,500	4,217,100	582,800	4,799,900	2,416,600	535,100	2,951,700
5	Clearcut once	5,775,300	320,700	6,096,000	6,931,200	376,900	7,308,100	8,182,900	408,800	8,591,700
6	Clearcut twice	846,000	0	846,000	970,200	0	970,200	1,353,000	0	1,353,000
7	Thinned but not clearcut	197,300	34,100	231,400	291,400	47,300	338,700	457,400	63,100	520,500
8	Thinned and clearcut	2,100	19,900	22,000	7,300	37,400	44,700	17,700	46,500	64,200
9	Total not cut, sum (2+4)			7,600,000			6,516,400			4,308,200
10	Total cut, sum (5-7)			7,173,400			8,617,000			10,465,200

Source: Jaakko Pöyry Consulting, Inc. (1992a).
**Not considered* are those plots representing young stands, old growth or areas assumed not available and therefore not considered for harvest in the period 1990-2040. *Considered* are those plots representing stands that are available and in terms of age, etc., feasible to consider for harvest during the 50-year study period. Action category 8, thinned and clearcut, is included in the clearcut once category.

Table 7.3. Projected timberland acres harvested and not harvested by initial FIA covertype under the high scenario (1990-2040).

Forest Type	Clearcut Once	Clearcut Twice	Thinned	Total Acres Harvested	Total Acres	Acres Never Harvested	Harvest Acres as % of Total Acres	Harvest Acres as % of Total Harvest	Forest Type Acres as % of Acres
High Scenario									
Jack pine	337,100	18,300	11,100	366,500	446,600	80,100	82.1	3.5	3.0
Red pine	218,900	23,800	17,000	259,700	354,700	95,000	73.2	2.5	2.4
White pine	43,100	5,500	0	48,600	68,600	20,000	70.8	0.5	0.5
Black spruce	748,600	39,700	50,100	838,400	1,349,900	511,500	62.1	8.0	9.1
Balsam fir	556,900	60,500	47,100	664,500	809,200	144,700	82.1	6.3	5.5
Northern white cedar	101,800	13,400	7,600	122,800	648,400	525,600	18.9	1.2	4.4
Tamarack	298,400	0	9,100	307,500	719,400	411,900	42.7	2.9	4.9
White spruce	46,900	1,700	2,900	51,500	91,700	40,200	56.2	0.5	0.6
Oak-Hickory	622,900	0	53,900	676,800	1,124,700	447,900	60.2	6.5	7.6
Elm-Ash-Soft maple	550,900	2,300	60,200	613,400	1,124,600	511,200	54.5	5.9	7.6
Maple-Basswood	772,800	700	66,100	839,600	1,470,200	630,600	57.1	8.0	10.0
Aspen	3,382,000	1,038,300	144,600	4,564,900	5,242,200	677,300	87.1	43.6	35.5
Paper birch	638,800	18,400	29,200	686,400	819,000	132,600	83.8	6.6	5.5
Balsam poplar	272,600	130,400	21,600	424,600	504,200	79,600	84.2	4.1	3.4
Total	8,591,700	1,353,000	520,500	10,465,200	14,773,400	4,308,200	70.8	100.0	100.0

Source: Jaakko Pöyry Consulting, Inc. (1992a).

Table 7.4. Scheduling model harvest summary for the northern region under the high scenario, (thousands of cords per year).

Product Group	Component	Period					
		1990-99	2000-09	2010-19	2020-29	2030-39	2040-49
a) Northern Region							
Aspen	Aspen pulp	1,277.1	1,344.9	1,441.3	1,665.5	1,653.7	1,639.9
	Aspen saw	1,120.9	1,043.1	816.4	578.0	611.8	635.4
	Total	2,398	2,387.8	2,257.9	2,243.4	2,265.6	2,275.2
	Target	2,418	2,402.1	2,300	2,300	2,300	2,300
Spruce-fir	S-fir pulp	247.4	345	399.9	373.1	399.8	352
	S-fir saw	160.3	301.6	443	474.8	441.5	474.7
	Total	407.6	646.4	842.8	847.9	841.3	826.7
	Target	406	643	850	850	850	850
Pine	Pine pulp	92.4	130.9	239.5	245.2	286.4	394.4
	R&W saw	281.5	233.5	487.2	512.2	466.1	218.9
	Other saw	65.7	140.1	265.8	236.3	219.5	360.7
	Total	439.6	504.6	992.5	993.7	971.9	974.1
	Target	441	504	1,000	1,000	1,000	1,000
N. Hardwoods	Pulp	453	761.3	1,498.5	1,412.3	1,371.1	1,338.1
	R Oak saw	43.8	59.7	257.9	172.6	80.5	46.4
	Other saw	108.9	266	647.8	776	875.8	884.2
	Total	605.6	1,087.1	2,404.1	2,360.8	2,327.3	2,268.8
	Target	604	1,085.9	2,450	2,450	2,450	2,450
All Groups	Total	3,850.8	4,625.9	6,497.3	6,445.8	6,406.1	6,344.8
	Target	3,869	4,635	6,650	6,600	6,600	6,600
b) Southern Region							
Red oak	Sawlogs	49.9	70.6	68.5	71.6	66.7	70.8
	Target	50	70	70	70	70	70
Other wood	Various	249.6	330.5	328.8	334.8	329.8	333.8
	Target	250	330	330	330	330	330
All Groups	Total	299.5	401.1	397.3	406.6	396.5	404.6
	Target	300	400	400	400	400	400

Source: Jaakko Pöyry Consulting, Inc. (1992a).

7.1.3
Harvesting by Ownership

As discussed in section 2.3.1 the second model runs assumed that allocation of timberlands to be harvested was constrained by assumed levels of availability by ownership category. These constraints reflect agency existing and prospective policies and land management practices as well as past trends in availability for ownerships with no articulated policies. Table 7.5 shows the total area harvested from timberlands on each ownership under the three scenarios.

The projected harvesting activities by ownership must be considered in the context that the GEIS is not a *planning* document and that the harvesting scenarios are not meant to predict that specific stands will or will not be harvested. The scenarios were developed as a tool to determine how much of the forest would have to be harvested statewide to meet the supply target specified in the FSD. In this case, 7 million cords per year. The emphasis is on *statewide,* as this is the level of analysis that the GEIS is directed toward.

The data in table 7.5 shows that with the ASQ constraints removed, the two national forests assumed far larger roles in meeting timber demand than under either of the two earlier scenarios. In percentage terms, the proportion of the harvest taken from the national forests more than doubled under the high scenario when compared with the medium scenario. In acreage terms, the area harvested was approximately tripled. The area harvested on the other ownerships also increased significantly, but dropped in percentage terms reflecting the increased level of harvesting on the national forests.

7.1.4 Spatial Distribution

Table 7.6 describes the level of harvesting by ecoregion for all scenarios. Figure 7.1 shows the plots harvested during the first ten-year period, and figure 7.2 shows the total number of plots harvested under the high scenario. Comparison of the output from all three scenarios shows that the largest increases are projected to occur in ecoregion 4. In that ecoregion, an additional 889,600 acres are projected to be cut under the high scenario when compared with the medium scenario. In contrast, the jump from base to high scenarios in ecoregion 4 was close to 1.7 million acres. Notable increases between the medium and high scenarios for the other ecoregions include increases of 214,600 acres in ecoregion 1, nearly 335,200 in ecoregion 2, an increase of 188,800 in ecoregion 3 and up by 144,700 in ecoregion 5.

Table 7.5. Original acres harvested by ownership by scenario, second runs, 1990-2040.

	Scenario							
	Base		Medium		High		Timberland	
Ownership	Acres Harvested	Percent	Acres Harvested	Percent	Acres Harvested	Percent	Total Acres	Percent
Chippewa National Forest	160,200	2.23	170,200	1.98	451,800	4.32	567,200	3.84
Superior National Forest	349,500	4.87	352,100	4.09	991,000	9.47	1,253,900	8.49
Miscellaneous federal	53,700	0.75	62,900	0.73	82,800	0.79	197,700	1.34
Native American	171,200	2.39	193,800	2.25	234,500	2.24	490,600	3.32
State	1,296,900	18.08	1,741,400	20.21	1,958,400	18.71	3,077,900	20.83
County and municipal	1,612,800	22.48	1,924,700	22.34	2,057,800	19.66	2,505,600	16.96
Forestry industry	451,400	6.29	561,200	6.51	597,900	5.71	751,300	5.09
Other private	3,077,700	42.90	3,610,700	41.90	4,091,000	39.09	5,929,200	40.13
Total	7,173,400	100.00	8,617,000	100.00	10,465,200	100.00	14,773,400	100.00

Source: Jaakko Pöyry Consulting, Inc. (1992a).

Table 7.6. Original forest acreage and timberland acres cut and not cut by ecoregion and scenario, 1990-2040.

	Ecoregion							
	1	2	3	4	5	6	7	Total
Total forest land acres	3,372,000	2,023,700	903,000	8,172,900	934,700	637,200	666,300	16,714,800
Reserve/unproductive	509,600	973,900	36,300	359,800	24,400	17,300	20,100	1,941,400
Timberland acres (1-2)	2,862,400	1,049,800	871,700	7,813,100	910,300	619,900	646,200	14,773,400
Acres not cut, **base**	1,566,000	619,200	546,900	3,447,300	629,200	408,200	378,200	7,600,000
Acres cut, **base**	1,296,400	430,600	319,800	4,365,800	281,100	211,700	268,000	7,173,400
Acres not cut, **medium**	1,207,500	566,800	413,100	2,668,600	567,800	364,400	363,200	6,156,400
Acres cut, **medium**	1,654,900	483,000	453,600	5,144,500	342,500	255,500	283,000	8,617,000
Acres not cut, **high**	992,900	231,600	224,300	1,779,000	423,100	330,700	321,600	4,308,200
Acres cut, **high**	1,869,500	818,200	642,400	6,034,100	487,200	289,200	324,600	10,465,200

Source: Jaakko Pöyry Consulting, Inc. (1992a).

Figure 7.1. Location of high scenario harvested plots for 1990–2000.

Figure 7.2. Location of all high scenario harvested plots, 1990–2040.

The increased harvests on national forests accounts for the large increases seen in ecoregions 2 and 4. Other increases can be explained by a move into less productive covertypes that were not economically attractive under the demand levels specified in the base and medium scenarios.

7.1.5
Temporal Distribution

The patterns describing the distribution of harvesting activities across the state under the high scenario showed distinguishable differences from those projected to occur under the base and medium scenarios. The main differences were an increasing intensity of harvesting within the national forest lands. However, harvesting activities were still spread across the state. As discussed in section 5.1.5, the well-developed road transport network makes most timberland accessible for harvesting.

7.1.6
Relationship to Long-term Sustainable Timber Removal

Based on a long-term sustained yield analyses similar to the techniques used by the MNDNR (see section 5.1.6 for details of methodology), virtually all timberlands would be required to yield a level of harvest that still falls over 1.5 million cords below the targeted 7 million cords level. This indicates that the 7 million cord level is not sustainable in the long-term unless there are significant increases in the levels of investment in forest management.

These results suggest that an annual harvest level of 5.5 million cords is the maximum that could be sustained. However, as described in section 5.1.6, this conclusion is subject to several important assumptions.

The high level of harvest is still below the estimated maximum level of tree and forest growth potential. However, harvest levels above 5.5 million cords appear sustainable only if (1) the loss of forest land projected in the north is halted, (2) substantial investments in forest management are made to improve productivity, and (3) such investment includes the site specific and other mitigations needed to mitigate otherwise significant impacts. Also, such harvest levels would probably also require continued relaxation of the U.S. Forest Service allowable sale quantities on the two national forests in Minnesota (as was assumed for the high scenario).

7.2
Characterization of Future Forest Resource Conditions

Forests, as with any living entity, change over time irrespective of human intervention. In addition to these natural changes, human activities such as harvesting can also change the forests. The GEIS has been structured to identify the key characteristics that are likely to change; to project the extent of these changes under the three levels of harvesting; and to examine the implications of such changes for the identified issues of concern.

This section describes the projected changes to these key characteristics that occur as a consequence of harvesting at the 7.0 million cord level, as well as those associated with the background levels of change that would occur over a 50-year period. The characteristics discussed include age class, acres under different covertypes, abundance and diversity of tree species within covertypes, and structural changes in the patterns of forest cover.

7.2.1
Forest Area and Covertype Abundance

Forest Area
These data were independent of harvest level and therefore, the discussion in section 5.2.1 is also relevant to the high scenario.

Covertype Acreages
Table 7.7 describes the projected covertype acreages for timberland, reserved, and unproductive forest land. Table 7.8 compares the base, medium, and high scenarios. The key projected changes for timberlands as a consequence of the level of harvesting projected under the three scenarios are:

- The jack pine type continues to decline in acreage, due to both succession to other types and with increased harvesting (from 307,400 for the medium scenario to 272,600 acres for timberland in the high scenario).
- The red pine covertype on timberland increases by approximately 80,000 acres, but the increase is less than for the medium scenario. The increase appears due more to retention of that long-lived species and succession than to planting or natural regeneration.
- The white pine covertype on timberland declines from the acreage under the base and medium scenarios.
- The acreage in the black spruce covertype declined from 1990 to 2040 with subsequent gains to the tamarack and aspen covertype acreages. However, the timberland acreage increased slightly in the high scenario as compared to the medium scenario.
- The balsam fir acreage for timberland declined from 1990 to 2040 from 1,012,500 to less than 600,000 acres under the high scenario. The aspen covertype appears to be a major recipient of that acreage.
- The northern white cedar type acreage appears to increase slightly over the study period and across the harvest scenarios.
- The acreage of tamarack appears to increase slightly over the study period for the medium and high harvest scenarios.
- The white spruce covertype acreage decreases as harvesting level increases, however, it is higher than that for 1990 for all harvest scenarios.

Table 7.7. Forest type acreage (as determined by GEIS covertype algorithm) for timberland, reserved, and unproductive plots under the high scenario, 1990 and projected 2040, statewide (thousand acres).

Forest Type	1990				2040			
	Timberland	Reserved	Unproductive	Total	Timberland High Scenario	Reserved	Unproductive	Total High Scenario
Jack pine	487.1	125.9	1.2	614.2	272.6	56.2	1.2	330.0
Red pine	350.6	78.6	0.9	430.1	433.2	87.7	.9	521.8
White pine	137.3	9.7	1.3	148.3	120.2	32.6	1.3	154.1
Black spruce	1,320.8	129.6	527.5	1,997.9	957.8	88.3	547.5	1,593.6
Balsam fir	1,012.5	117.0	21.9	1,151.4	589.6	72.9	18.5	681.0
Northern white cedar	322.4	8.2	37.3	367.9	370.6	8.5	40.7	419.8
Tamarack	696.2	7.9	118.1	822.2	701.7	6.9	118.2	826.8
White spruce	137.0	43.9	0	181.0	158.2	106.7	0	264.9
Oak-Hickory	1,288.0	13.6	14.0	1,315.6	1,354.1	18.6	18.8	1,391.5
Elm-Ash-Soft maple	1,564.2	64.9	33.4	1,662.5	1,721.5	95.4	35.2	1,852.1
Maple-Basswood	1,301.8	30.6	2.1	1,334.5	1,255.2	34.8	2.1	1,292.1
Aspen	4,496.0	358.1	33.9	4,888.0	5,730.0	393.5	36.8	6,160.3
Paper birch	1,179.3	109.7	6.1	1,295.1	741.7	123.6	6.5	871.8
Balsam poplar	480.1	15.4	10.6	506.1	473.0	14.5	9.5	497.0
Nonstocked	0	0	0	0				
Other	0	0	0	0				
Total	14,773.4	1,113.1	828.3	16,714.8	14,879.4	1,140.2	837.3	16,857.0

Source: Jaakko Pöyry Consulting, Inc. (1992a).

Table 7.8. Forest type acreage for timberland and all forest plots under the base, medium, and high scenarios, 1990 and projected 2040, statewide (thousand acres).

Forest Type	1990		2040					
	Timberland	Total	Timberland Base Scenario	Timberland Medium Scenario	Timberland High Scenario	Total Base Scenario	Total Medium Scenario	Total High Scenario
Jack pine	487.1	614.2	329.6	307.4	272.6	387.0	364.8	330.0
Red pine	350.6	430.1	452.4	454.4	433.2	541.0	543.0	521.8
White pine	137.3	148.3	141.0	136.0	120.2	174.9	169.9	154.1
Black spruce	1,320.8	1,997.9	1,001.2	945.4	957.8	1,637.0	1,581.2	1,593.6
Balsam fir	1,012.5	1,151.4	657.4	598.4	589.6	748.8	689.8	681.0
Northern white cedar	322.4	367.9	360.9	370.4	370.6	410.1	419.6	419.8
Tamarack	696.2	822.2	678.7	704.4	701.7	803.8	829.5	826.8
White spruce	137.0	181.0	227.9	202.7	158.2	334.6	309.4	264.9
Oak-Hickory	1,288.0	1,315.6	1,370.2	1,322.3	1,354.1	1,407.6	1,359.8	1,391.5
Elm-Ash-Soft maple	1,564.2	1,662.5	1,744.0	1,714.8	1,721.5	1,874.6	1,845.5	1,852.1
Maple-Basswood	1,301.8	1,334.5	1,460.2	1,368.6	1,255.2	1,497.1	1,405.5	1,292.1
Aspen	4,496.0	4,888.0	5,238.7	5,496.5	5,730.0	5,669.0	5,926.8	6,160.3
Paper birch	1,179.3	1,295.1	803.4	806.2	741.7	933.5	936.4	871.8
Balsam poplar	480.1	506.1	413.7	451.8	473.0	437.7	475.8	497.0
Nonstocked	0	0						
Other	0	0						
Total	14,773.4	16,714.8	14,879.4	14,879.4	14,879.4	16,857.0	16,857.0	16,857.0

Source: Jaakko Pöyry Consulting, Inc. (1992a).

- Oak-hickory covertype acreage appears to increase over 1990 for all harvest scenarios.
- Elm-ash-soft maple covertype acreage increased substantially over 1990 for all scenarios, in part due to forest area increase in the southern portion of the state.
- Maple-basswood covertype acreage increased for the base scenario, then declined slightly for the high harvest level.
- Aspen covertype acreage on timberlands appears to increase 16.5, 22, and 27 percent over its initial extent (4,496,000 acres) for the base, medium, and high scenarios, respectively, considered over the 50-year study period. However, interpretation should recognize that several other covertypes, notably paper birch and balsam fir, have stands with high proportions of aspen that could, by a slight change in species composition or the algorithm for determining that, be called aspen. Likewise, much of the aspen acreage is mixed and could change slightly and be reclassified as paper birch, balsam fir, jack pine, etc.
- The paper birch covertype appears to decline by several hundred thousand acres as harvesting level increases. However, as with aspen, many acres are composed of mixed species. Consequently, while the acreage classified as *paper birch covertype* has changed, the overall species composition change of the original areas was probably less than the covertype area change would suggest. Aging of this type is a factor contributing to succession to other species.
- The balsam poplar covertype acreage declined with the base scenario and then increased to near original conditions with the high harvesting level.
- When the harvesting level increased from the base to the medium scenario, covertype acreage for timberland declined for eight covertypes. When the harvesting level increased from the medium to the high scenario, five of these eight continued to decline and three others also declined. Six covertypes showed an increase in acreage from the medium to the high scenario (black spruce, northern white cedar, oak-hickory, elm-ash-soft maple, aspen, and balsam poplar).
- Projections for reserved and unproductive forests were unchanged from those noted for the base scenario.

Overall, results suggest that future covertype area *is* sensitive to the level of harvesting and that the response is either species or covertype specific.

7.2.2 Covertype Size and Age Class Structure

Summaries of age classes from 1977-2040 for all harvest scenarios are shown in table 7.9. Forest development indicates the average age of six covertypes continued to increase over 1990 despite the harvesting that took place under the high scenario during that period. The other eight covertypes show trends of reducing average ages. The drop in the average age of the aspen covertype from the present 41 years to 28 years is a significant change.

Table 7.9. Average stand age by covertype and harvest scenario for timberland 1977-2040.

Forest Type	Average Age of FIA Plots*				
			2040		
	1977	1990	Base	Medium	High
Jack pine	42	48	77	69	42
Red pine	43	44	54	54	41
White pine	73	80	104	102	87
Black spruce	46	59	89	61	50
Balsam fir	42	46	82	71	58
Northern white cedar	82	97	116	106	94
Tamarack	52	57	99	85	55
White spruce	33	42	90	82	76
Oak-Hickory	63	69	78	71	63
Elm-Ash-Soft maple	56	56	86	75	60
Maple-Basswood	61	58	90	80	58
Aspen	38	41	34	33	28
Paper birch	49	58	92	81	61
Balsam poplar	39	41	33	31	31

Source: Jaakko Pöyry Consulting, Inc. (1992a). Projected ages for stands not clearcut were determined by adding 50 years. See appendix 2, table 2.2 for more detail.
* weighted by acreage.

These changes are even more pronounced when compared with the outputs from the base and even medium scenarios. Because the age class distributions include the areas of timberland designated as *not available*, which includes old growth and other areas assumed to be unavailable, and ERF and other silvicultural constraints, the average ages on those designated as *available* will tend to be skewed to the lower end of the range. Thus the average age is the result of combining two increasingly different types of stands. The change in the aspen covertype is particularly important because much of Minnesota's forests are comprised of this covertype.

Changes in age class structure will have important implications for many other values of the forest. Certain characteristics only begin to be expressed after forests reach certain stages. These stages have been recognized for most covertypes, and specific management objectives have been developed. Section 5.2.2 discussed these stages and the consequences for the base level of harvesting.

The implications of the trend for average age under the high scenario is reflected in table 7.10, which shows recruitment of stands into old forest and old growth forest.

Table 7.10. Area of old forest for 1990 and projected to 2040 for the base, medium, and high harvest scenarios, all forest lands (acres).*

Forest type (threshold age)	Current 1990	Base Scenario 2040	Medium Scenario 2040	High Scenario 2040
Red pine (120)	21,200	107,496	110,344	96,944
White pine (120)	12,300	91,674	87,743	73,643
Black spruce (120)	157,800	614,219	471,636	436,736
White cedar (120)	60,000	225,600	211,569	183,990
Tamarack (120)	73,000	299,604	268,390	156,307
White spruce (90)	27,400	211,815	185,720	149,583
Oak-Hickory (120)	51,400	342,702	293,044	241,232
Elm-Ash-Soft maple (120)	69,400	483,185	416,120	295,024
Maple-Basswood (120)	37,000	404,502	344,407	181,618
Jack pine (70)	115,100	244,518	207,612	99,269
Balsam fir (70)	304,000	452,468	335,385	256,276
Aspen (70)	467,500	982,911	961,039	837,726
Balsam poplar (70)	24,900	76,629	74,129	73,029
Paper birch (70)	324,400	643,809	559,835	352,494

Source: Jaakko Pöyry Consulting, Inc. (1992a,e).
* Acreages are those determined from GEIS covertype algorithm.

Despite the increased harvesting under the high scenario, more old forest and old growth forest is projected to be present in 2040 than 1990 for all covertypes except jack pine and balsam fir. The drop in jack pine is due to successional changes on reserved lands, and the nearly 50,000 acre drop in balsam fir is not very meaningful because most balsam fir stands greater than 70 years old in Minnesota are infected with spruce budworm.

7.2.3
Tree Species Abundance and Diversity

Tree species composition changes can occur in the form of species composition within a covertype, often related to stand age or stage of development, and in terms of covertype acreage. Table 7.11 presents a summary of species composition in 1990 and that projected to occur in 2040 for all scenarios across all covertypes.

Table 7.11. Summary of projected tree species composition for 1990 and 2040 for base, medium, and high harvest scenarios on timberlands for the second runs (thousands of trees ≥1.0 inch dbh).*

Species	1990	2040		
		Base	Medium	High
Ailanthus	39	15	14	13
American hornbeam	14,419	12,049	12,500	11,521
American basswood	192,090	191,702	184,698	176,313
American elm	150,006	147,215	146,216	148,778
Apple	386	430	509	641
Balsam fir	979,317	863,263	849,201	796,018
Balsam poplar	266,466	283,080	314,295	358,967
Bigtooth aspen	73,184	82,074	88,197	97,201
Bitternut hickory	8,044	8,573	8,590	9,880
Black ash	527,482	662,467	640,214	607,040
Black cherry	35,429	46,605	48,805	52,004
Black locust	455	133	129	135
Black maple	154	125	101	82
Black oak	710	792	735	799
Black spruce	1,039,098	911,752	769,542	686,000
Black walnut	2,289	2,222	2,277	2,443
Black willow	5,702	4,721	5,453	6,373
Boxelder	66,672	82,430	81,689	83,114
Bur oak	190,446	183,028	186,455	189,174
Butternut	2,941	4,442	4,235	4,409
Chokecherry	33,848	36,689	39,035	42,337
Eastern cottonwood	2,735	2,272	2,340	2,363
Eastern redcedar	14,051	17,977	19,194	20,913
Green ash	86,474	79,551	80,027	84,869
Hackberry	14,714	14,842	14,054	13,220
Hawthorn	8,810	8,922	9,476	11,435
Ironwood	117,990	130,328	134,496	143,275
Jack pine	164,593	93,530	98,865	126,646
Ky. coffee tree	445	142	143	157
Mountain ash	1,497	3,273	3,122	2,366
Mountain maple	105,825	115,557	107,763	89,360
N. white-cedar	386,818	615,904	530,282	416,061
Northern pin oak	5,975	5,541	5,865	6,465
Northern red oak	111,893	97,402	97,153	97,435

Table 7.11. (continued)

Species	1990	2040		
		Base	Medium	High
Other hardwood	41,155	32,342	27,419	20,636
Paper birch	570,934	440,801	459,276	461,745
Peachleaf willow	489	642	678	706
Pincherry	13,140	16,541	17,905	19,499
Ponderosa pine	398	387	434	795
Quaking aspen	1,986,789	2,730,630	2,930,033	3,418,737
Red maple	290,717	223,765	237,572	249,212
Red mulberry	988	985	1,172	1,532
Red pine	97,800	107,691	112,701	132,128
River birch	185	1,682	1,660	1,408
Rock elm	1,572	1,881	1,609	891
Scotch pine	1,630	1,123	1,346	1,746
Shagbark hickory	9,145	11,075	11,376	12,691
Siberian elm	399	391	562	699
Silver maple	9,552	8,890	8,239	7,550
Slippery elm	23,016	27,284	27,220	27,155
Striped maple	463	397	370	367
Sugar maple	283,728	266,355	243,789	213,820
Swamp white oak	454	1310	1,118	776
Tamarack	361,461	299,180	306,991	291,762
White ash	2,494	2,835	2,936	2,701
White oak	10,058	11,377	10,607	10,519
White pine	29,566	29,709	29,298	23,520
White spruce	78,620	76,604	77,665	73,822
Wild plum	5,331	5,361	5,824	6,953
Yellow birch	11,746	20,882	19,500	14,772
Grand Total	8,442,827	9,029,168	9,022,970	9,283,949

Source: Jaakko Pöyry Consulting, Inc. (1992a).
* The numbers in the 1990 column differ from those for the first runs because the second runs used the GEIS rather than the FIA covertype algorithm.

The ownership constraints and mitigations used in the projections appear to have been very effective in moderating changes in species statewide. This is evident for upland, lowland, and riparian species. Changes, as a percent of 1990 values, are small for most species. Black spruce shows a major decline of 34 percent below 1990 tree numbers. The paper birch covertype also shows a decline of nearly 20 percent. The projected 72 percent increase in aspen tree numbers is a combination of the lower average age (and hence numbers of trees per acre) of these stands and projected increases in the area under the aspen covertype.

Because most species are found in many covertypes, results across covertypes are emphasized here. The pattern was also found to be similar for trees with a girth, or dbh, of $\geq$4.5 inches.

Section 5.2.2 discussed the difficulty of determining whether or not a reduction in the conifer component of aspen stands would occur. Concern for this possibility is greatest at the high level of harvest.

7.2.4 Forest Fragmentation

The assessment of forest fragmentation is qualitative, not quantitative. Therefore, no specific acreage totals could be developed.

As discussed in section 5.2.4, fragmentation of forests changes the structural diversity of forested landscapes and can affect biodiversity. When compared with the base scenario, the distribution of timber harvesting and forest management activities *at the statewide level* is not expected to change under the high scenario, except that the intensity of harvesting on national forests was projected to increase significantly following lifting of the ASQ constraints. This change, as well as the requirement to harvest most stands assumed to be available, means the patterns of harvested and unharvested stands at localized levels will change. Therefore, at any time there will likely be more sites affected by harvesting in any given landscape. In addition, as previously noted the average age of most covertypes will not increase as much under the high scenario as was projected to occur under the base or medium scenarios (see section 7.2.2). This will affect *within forest* fragmentation or the juxtaposition of forests of different covertypes and stand ages on the landscape.

7.3 Physical Resource Impacts

Harvesting activities will change aspects of the physical or nonliving environment including forest soils and water resources (water quantity and quality). The consequences of timber harvesting and forest management activities for these resources were discussed at length in section 5.3 in reference to the base level scenario. The *type* of impact will likely not change with the changes in the level of harvesting. However, the *area affected* will change with increasing levels of harvesting. Impacts on these resources tend to be related linearly to the area harvested. This is particularly so for soil impacts. Therefore, the information presented in section 5.3 is not repeated. The significant impacts under the high scenario are fully assessed in section 7.6.

7.4
Biological Resource Impacts

7.4.1
Plant and Animal Species Abundance and Diversity

Animals

This section compares changes to animal populations projected under the base and medium level scenarios with those under the high scenario. As discussed in section 5.4.1, timber harvesting and forest management activities can alter the habitat value of stands for these various species and species groups. A wide range of habitat factors can change as a consequence of harvesting. Changes in these factors can either reduce or enhance habitat values with the potential to then impact populations of animals accordingly.

There are two key factors affecting the habitat value of forests that are of relevance to wildlife populations, that are likely to change as a consequence of timber harvesting and for which statewide data were available. These factors are stand tree species mix and the age or size classes of these trees. Based on these factors, the direction and magnitude of population change in each animal species of interest can be estimated by examining projected acreage of forest types and size classes.

Section 7.2 provided a characterization of the future forest condition under the high scenario, and contrasted this with that projected under the base and medium scenarios. The major differences between the medium and high scenarios are fewer acres reaching older age classes, more acres affected by harvesting, and an increase in aspen covertype acreage.

In addition, the reduction in the average ages of the aspen and balsam poplar covertypes would also have an impact on stand composition and therefore the habitat values for some species. These changes will increase habitat values for some species and will diminish values for others. As discussed in section 5.4.1, nearly all species projected to increase under this scenario are early-succession species that have considerable habitat outside of forests (open areas, brushland, etc.).

The major emphasis in assessing wildlife impacts was at the ecoregion level and results are developed in section 7.6.4. However, for illustration, table 7.12 describes the general direction of projected population levels by harvest scenario. Statewide over the 50-year study period, 97, 94, and 72 percent of the total number of species are projected to remain stable or increase under the base, medium, and high scenarios, respectively. The number of species projected to decrease in population level ranges from 5 in the base scenario to 48 under the high scenario.

Table 7.12. Number of species of interest that are projected to decrease by 25 percent or more, remain stable, or increase by 25 percent or more, statewide on all forest lands by harvest scenario.*

Species Group (number of species)	Decreasing			Stable			Increasing		
	Base	Med.	High	Base	Med.	High	Base	Med.	High
Small Mammals (22)	0	2	4	21	19	16	1	1	2
Large Mammals (5)	0	0	0	5	4	4	0	1	1
Birds (138)	5	8	43	111	106	61	22	24	34
Herps (8)	0	1	1	6	5	6	2	2	1
All (173)	5	11	48	143	134	87	25	28	38

Source: Jaakko Pöyry Consulting, Inc. (1992f).
* *Stable* is a change of less than 25 percent.

Endangered, Threatened, or Special Concern Species

Animals. The assessment of changes to wildlife populations as a consequence of timber harvesting and forest management activities is centered on changes to habitat. Two species were projected to decline under the base, medium, and high scenarios: Red-shouldered Hawk and Louisiana Waterthrush. An additional species that would be adversely impacted under the high scenario is the pine marten.

Plants. The threat of disturbance and/or damage to a population of rare plants will increase as the area of the state subjected to harvesting increases. This is because the forest dependent rare plant species of Minnesota are typically poorly adapted to trampling types of injury. Most (except for the one tree species listed) are of small stature and easily broken. Any harvest that would allow heavy equipment to drive through a population of any rare plant species would cause impacts. Therefore, the high level of harvest would likely cause additional impacts that are proportional to the additional area affected by harvesting.

The lack of data concerning these species and the level of resolution of the GEIS analysis precluded quantification of these impacts

7.4.2 Aquatic Ecosystems

As the level of harvesting increases, it is reasonable to conclude that harvesting activities that remove or alter forest cover and other types of forest management activities will increase within any given watershed. The differences are likely to be marginal for most watersheds. These activities can have wide ranging effects on waterbodies and the plants and animals that live within them. These changes are therefore likely to be proportional to the area affected. The general discussion of impacts on aquatic ecosystems under the base scenario (section 5.4.2) adequately characterizes the *types* of impacts likely under the medium scenario. The *extent* of aquatic ecosystems that experience these impacts will increase under the medium scenario when compared with the base scenario.

7.4.3 Riparian Corridors

The relationship between the level of harvest and the type and extent of likely impacts under the base and medium scenarios that was described under aquatic ecosystems would similarly apply to riparian corridors which are the strips of land and associated plant communities that are located adjacent to waterbodies. When compared with the base and medium scenarios, the high scenario would likely affect additional areas with the same types of impacts.

7.4.4 Forest Insect and Disease Concerns

As discussed in section 5.4.4, the risk to a forest stand of a pest attack or infestation (susceptibility) and the likelihood of damage if an attack occurs (vulnerability) are frequently related to stand age and the incidence of multiple entries into a stand may also increase risk.

The possible effects of an increase in timber harvesting and associated management practices on forest health in Minnesota include changes in the proportion of susceptible/vulnerable age classes, and the incidence of multiple entry harvesting operations.

The timber harvesting activities projected under the high level scenario shows the aging of the forest as was described for the base level and the majority of covertypes show a decrease in average age as compared to 1990.

The high level of harvesting clearly reduced the area in the older age classes and will tend to reduce the incidence of many insect pests and diseases that are favored by older forests. Insect species in this category include spruce and jack pine budworm and two-lined chestnut borers. In addition, diseases such as white trunk rot of aspen are also likely to be reduced. Other diseases including cankers and decay of upland hardwoods and oak wilt will probably decrease in the short-term but may ultimately increase.

In contrast, the incidence of insect pests, such as white pine weevil, are likely to increase as a consequence of the high level harvests. This is due to an increase in acreage of susceptible younger stands. The incidence of some diseases are also likely to increase, including *Diplodia* shoot blight and canker, and *Scleroderris* canker of red pine.

7.5
Socioeconomic Resource Impacts

7.5.1
Outdoor Recreation Opportunities

Timber harvesting will likely have an impact on the quality of the recreational experience and on the number of hours of recreational activity at a given site. These impacts are related to the recreational user's visual perception and the attractiveness of the forest setting. Some of the impacts are long-term while others are short-term and/or subject to change from forest growth and dynamics on that site or over a broader context or area. Section 5.5.1 discussed the nature and extent of likely impacts.

Table 7.13 describes the harvesting extent by recreational opportunity classes. Harvesting at the high scenario would subject 69.5 percent of the timberland plots to harvesting which compares with the 50.4 and 59.2 percent of plots projected to be harvested under the base and medium scenario. Harvesting beyond the year 2040 would tend to concentrate on the accessible and productive plots harvested in the first 50 years. However, additional acres would likely need to be harvested to achieve sustainability in the long-run.

7.5.2
Aesthetics and Visual Quality

Given the constraints and mitigations assumed on state and federal lands, there appears to be a tendency to harvest areas of high visual sensitivity at a lower rate than areas of moderate to low sensitivity. The converse was found on private lands (see table 7.14).

Timberlands not in federal or state ownership do not have VMGs in place and therefore, there is a stronger likelihood of adverse impacts on these lands. Under the base scenario 38 percent of nonfederal and nonstate owned timberland plots were projected to be impacted. By comparison, under the medium scenario 44 percent are projected to be impacted. Under the high scenario, 48.1 percent are projected to be impacted.

In terms of dynamics over time under the high scenario, the forests of Minnesota in 2040 would look similar to the present. Ownership constraints and mitigations that preclude certain areas from clearcutting would increase

Table 7.13. Distribution of FIA forest and timberland plots and plots projected to be harvested, by ownership and ROS class for the base, medium, and high scenarios, 1990–2040.

ROS Class	Total number of plots, all forest	Total number of timberland plots	Percent of timberland plots by ROS class	Number and (percent) of timberland plots harvested by ROS class					
				Base Scenario		Medium Scenario		High Scenario	
				State/federal lands	Other lands	State/federal lands	Other lands	State/federal lands	Other lands
Primitive	425	53	.4	8 (15.1)	15 (28.3)	10 (18.7)	15 (28.3)	12 (22.6)	23 (43.4)
Semiprimitive nonmotorized	1,306	876	7.2	150 (17.1)	173 (19.7)	211 (24.1)	201 (22.9)	316 (36.1)	217 (24.8)
Semiprimitive motorized	3,409	3,074	25.4	529 (17.2)	925 (30.1)	691 (22.5)	1,119 (36.4)	1,003 (32.6)	1,185 (38.5)
Roaded natural	5,232	5,049	41.7	662 (13.1)	2,121 (42.0)	777 (15.4)	2,428 (48.1)	1,081 (21.4)	2,611 (51.7)
Rural	3,107	3,030	25.0	140 (4.6)	1,366 (45.1)	158 (5.2)	1,548 (51.1)	179 (5.9)	1,779 (58.7)
Urban	57	36	.3	1 (2.8)	18 (50.0)	1 (2.8)	19 (52.8)	2 (5.6)	20 (55.6)
All classes	13,536	12,118	100.0	1,490 (12.3)	4,618 (38.1)	1,848 (15.2)	5,330 (44.0)	2,593 (21.4)	5,835 (48.1)

Table 7.14. Percent of FIA timberland plots projected to be harvested (1990–2040) by visual sensitivity rank and by ownership (excluding primitive, semiprimitive nonmotorized, and urban ROS classes).

Visual Sensitivity Rank	Percent of timberland plots harvested by visual sensitivity rank					
	Base Scenario		Medium Scenario		High Scenario	
	State/federal lands	Other lands	State/federal lands	Other lands	State/federal lands	Other lands
High	10.4	49.6	11.3	56.0	18.9	62.0
Moderate	11.4	44.5	12.3	50.4	19.6	56.0
Low	12.7	37.3	15.2	43.7	20.4	47.6
Very low	13.0	32.5	17.5	38.5	21.4	41.2
All ranks (high to very low)	12.1	39.6	14.6	45.7	20.3	50.0

the area of older forest in many cases. Under the high scenario, the future forest would have an average age like that of today for most covertypes.

However, the oldest ages, given 50 years of growth, would be greater than found today for many areas. It follows that average tree size, which is an important component of attractiveness, would be similar to conditions today for most covertypes. The covertypes that would be adversely impacted are those subject to substantial harvesting including aspen, balsam fir, balsam poplar, and black spruce.

7.5.3
Unique Cultural and Historical Resources

Heritage resources can be divided into five main categories which include: cultural landscapes, standing structures, archaeological sites, cemeteries, and traditional use sites. These were discussed under section 5.5.3. The impacts on archaeological sites are closely linked to the likelihood of impacts on soil physical structure. As discussed above, the types of impacts are likely to stay the same irrespective of the level of harvesting; however, the area affected will increase and thus the number of sites will also increase.

The predicted maximum number of sites affected under the high scenario would be 142,000 sites up from the 121,000 predicted to be affected under the medium scenario. It must be stressed that these estimates are the maximum values.

Traditional Use Sites are locations which have been historically used by one or more groups of people for some type of activity. They may lack the physical evidence of artifacts or structures, and are often characterized by plants, animals, and/or topography which are of cultural and religious significance to Native Americans. The impacts on these sites could not be quantified.

7.5.4
Economic Impacts

Economic impacts were measured in terms of changes in employment, personal income, and the level of output for various sectors of the state economy and for the regions directly affected by the modeled increases in timber harvests. The impacts for the high scenario are summarized in table 7.15.

Statewide economic model (IMPLAN) projections indicated that the high level of timber harvest and forest industry expansion would produce approximately 35,100 additional jobs in the state, an increase of 1.7 percent over the baseline level of employment. Of this, about 25,400 jobs (72

Table 7.15a. Minnesota—employment. Increase in number of jobs above baseline employment.

IMPLAN sector	Baseline Employment	Medium Scenario				High Scenario			
		Direct Effect	Indirect Effect	Total* Effect	Percent of Base	Direct Effect	Indirect Effect	Total Effect	Percent of Base
Sectors Contributing Most to Employment									
461 Other Wholesale Trade	114,921		750	871	1		3,783	4,412	4
463 Other Retail Trade	213.626		67	574	0		320	2,958	1
160 Logging Camps and Log	2,016		488	489	24		2,007	2,008	100
188 Paper Mills, Except Building	8,252	352	0	352	4	2,812	0	2,812	34
491 Eating and Drinking Pla	109,412		95	323	0		478	1,663	2
448 Motor Freight Transport	34,880		197	218	1		995	1,102	3
456 Electric Services	12,116		173	192	2		873	976	8
470 Real Estate	54,807		45	155	0		226	800	1
504 Hospitals	47,838		0	152	0		0	793	2
446 Railroads and Related	8,732		135	138	2		684	698	8
490 Accounting, Auditing an	17,615		105	133	1		527	674	4
24 Forestry Products	1,386		131	132	10		551	559	40
74 Maintenance and Repair	14,951		108	118	1		540	593	4
480 Personnel Supply Services	19,810		69	104	1		347	529	3
464 Banking	23,073		53	96	0		264	493	2
467 Insurance Carriers	29,417		24	96	0		122	495	2
465 Credit Agencies	23,161		43	91	0		218	465	2
503 Doctors and Dentists	25,632		0	82	0		1	427	2
482 Management and Consu	14,406		68	82	1		342	414	3
508 Colleges, Universities	19,806		31	80	0		158	410	2
Total	795,857	352	2,582	4,477	1	2,812	12,436	23,281	3
Selected Forest Products and Forestry Sectors									
27 Landscape and Horticul	8,827		44	49	1		173	199	2
199 Paperboard Containers	8,002		21	23	0		105	117	1
26 Agricultural, Forestry	3,293		12	15	0		52	64	2
22 Forest Products	75		6	6	7		24	24	32
161 Sawmills and Planing Mills	941		10	10	1	247	56	316	34
170 Wood Pallets and Skids	193		4	4	2		19	19	10
164 Millwork	6,579		2	2	0		10	11	0
172 Wood Products, N.E.C.	1,459		2	2	0		9	11	1
23 Greenhouse and Nursery	844		0	3	0		2	13	2
173 Wood Containers	213		1	1	1		7	7	3
Total	30,426	0	102	115	0	247	457	782	3
Total, All Sectors in Minnesota	2,085,517	352	3,788	6,752	0	3,059	18,424	35,094	2

Note: Sectors 160, 446, 464, 27, 161, 172, and 23 adjusted to reflect IMPLAN revisions in the North region. Units are number of jobs above baseline employment.
* Total refers to direct, indirect and induced effects.

Table 7.15b. Minnesota—employee compensation. Increase in employee compensation above baseline compensation ($ millions).

IMPLAN sector	Baseline Compensation	Medium Scenario Direct Effect	Medium Scenario Indirect Effect	Medium Scenario Total* Effect	Medium Scenario Percent of Base	High Scenario Direct Effect	High Scenario Indirect Effect	High Scenario Total Effect	High Scenario Percent of Base
Sectors Contributing Most to Employee Compensation									
461 Other Wholesale Trade	3,413.14		22.28	25.87	1		112.35	131.04	4
188 Paper Mills, Except Building	380.22	16.19	0.01	16.20	4	129.35	0.06	129.41	34
463 Other Retail Trade	3,356.52		1.06	9.02	0		5.04	46.47	1
456 Electric Services	455.54		6.49	7.23	2		32.82	36.68	8
446 Railroads and Related	384.95		5.86	6.04	2		29.73	30.64	8
160 Logging Camps and Log	23.13		5.60	5.61	24		23.03	23.05	100
448 Motor Freight Transport	775.02		4.38	4.83	1		22.10	24.48	3
504 Hospitals	993.51		0.00	3.16	0		0.00	16.46	2
503 Doctors and Dentists	873.74		0.01	2.79	0		0.05	14.54	2
467 Insurance Carriers	845.22		0.70	2.76	0		3.51	14.23	2
491 Eating and Drinking Places	919.33		0.80	2.71	0		4.02	13.98	2
74 Maintenance and Repair	314.84		2.27	2.49	1		11.37	12.50	4
464 Banking	547.90		1.23	2.29	0		6.17	11.70	2
465 Credit Agencies	562.50		1.05	2.20	0		5.31	11.29	2
516 U.S. Postal Service	471.69		1.36	2.15	0		6.86	10.97	2
454 Communications, Except	508.30		0.90	1.97	0		4.53	10.12	2
488 Legal Services	452.03		0.94	1.82	0		4.71	9.32	2
482 Management and Consu	318.38		1.50	1.81	1		7.56	9.16	3
77 Ammunition, Except For	246.09		1.73	1.74	1		8.74	8.78	4
521 Other State and Local	180.14		1.35	1.75	1		6.82	8.92	5**
Total	16,022.19	16.19	59.52	104.44	1	129.35	294.78	573.74	4
Selected Forest Products and Forestry Sectors									
199 Paperboard Container	317.08		0.82	0.92	0		4.16	4.64	1
27 Landscape and Horticulture	116.23		0.56	0.62	1		2.19	2.50	2
24 Forestry Products	1.89		0.18	0.18	10		0.75	0.76	40
26 Agricultural, Forestry	29.32		0.11	0.13	0		0.47	0.57	2
161 Sawmills and Planing Mills	9.64		0.16	0.16	2	3.85	0.86	4.73	49
164 Millwork	205.29		0.06	0.07	0		0.30	0.35	0
170 Wood Pallets and Skids	2.34		0.05	0.06	3		0.27	0.28	12
193 Paper Coating and Glaz	159.20		0.04	0.05	0		0.19	0.24	0
172 Wood Products, N.E.C.	31.03		0.04	0.05	0		0.19	0.24	1
173 Wood Containers	4.42		0.03	0.03	1		0.15	0.15	3
Total	876.44	0	2.05	2.26	0	3.85	9.53	14.46	2
Total, All Sectors in Minnesota	43,230.86	16.19	84.42	146.38	0	133.20	418.87	790.41	2

Note: Sectors 188, 160, 521, 27, 161, 170, and 172 adjusted to reflect IMPLAN revisions in the North region. Units are employee compensation above baseline compensation ($ millions).
* Total refers to direct, indirect and induced effects.
** Less than 5.0 percent, but rounded up to 5 percent.

Table 7.15c. Minnesota—TIO. Increase in TIO above baseline TIO ($ millions).

IMPLAN sector	Baseline TIO	Medium Scenario Direct Effect	Medium Scenario Indirect Effect	Medium Scenario Total* Effect	Medium Scenario Percent of Base	High Scenario Direct Effect	High Scenario Indirect Effect	High Scenario Total Effect	High Scenario Percent of Base
Sectors Contributing Most to TIO									
188 Paper Mills, Except Building	1,568.1	611.2	0.3	611.4	39	3,062.1	1.3	3.063.4	195
461 Other Wholesale Trade	7,288.6		47.6	55.3	1		239.9	279.8	4
456 Electric Services	2,814.1		40.1	44.7	2		202.8	226.6	8
160 Logging Camps and Logging	126.9		30.7	30.8	24		126.3	126.4	100
470 Real Estate	7,710.1		6.3	21.9	0		31.8	112.6	1
463 Other Retail Trade	7,933.6		2.5	21.3	0		11.9	109.8	1
457 Gas Production and Distribution	885.0		13.5	15.2	2		68.2	76.9	9
448 Motor Freight Transport	2,147.4		12.1	13.4	1		61.2	67.8	3
235 Petroleum Refining	1,038.0		11.4	13.1	1		57.3	66.0	6
446 Railroads and Related Se	758.6		11.6	11.9	2		58.6	60.4	8
469 Owner-Occupied Dwelling	4,111.2		0.0	11.2	0		0.0	58.1	1
491 Eating and Drinking Place	3,676.8		3.2	10.8	0		16.1	55.9	2
74 Maintenance and Report O	1,058.5		7.6	8.4	1		38.2	42.0	4
467 Insurance Carriers	2,397.2		2.0	7.8	0		10.0	40.3	2
504 Hospitals	2,003.4		0.0	6.4	0		0.0	33.2	2
24 Forestry Products	65.7		8.7	8.8	13		31.1	31.5	48
464 Banking	1,476.6		3.4	6.2	0		16.9	31.5	2
454 Communications, Except R	1,523.5		2.7	5.9	0		13.6	30.3	2
521 Other State and Local Go	550.1		4.4	5.6	1		22.0	28.8	5
503 Doctors and Dentists	1,596.1		0.0	5.1	0		0.1	26.6	2
Total	50,729.5	611.2	208.1	915.0	2	3,062.1	1,007.3	4,568.1	9
Selected Forest Products and Forestry Sectors									
199 Paperboard Containers A	1,123.6		2.9	3.2	0		14.7	16.4	1
27 Landscape and Horticulture	238.4		1.2	1.3	1		4.7	5.4	2
161 Sawmills and Planing Mills	47.8		0.9	0.9	2	21.9	4.9	26.9	56
26 Agricultural, Forestry, F	88.1		0.3	0.4	0		1.4	1.7	2
22 Forest Products	4.7		0.3	0.4	7		1.4	1.5	32
164 Millwork	710.9		0.2	0.2	0		1.0	1.2	0
193 Paper Coating and Glazing	657.4		0.2	0.2	0		0.8	1.0	0
170 Wood Pallets and Skids	8.6		0.2	0.2	2		1.0	1.1	13
172 Wood Products, N.E.C.	95.2		0.1	0.1	0		0.6	0.7	1
195 Die-cut Paper and Board	546.5		0.1	0.1	0		0.5	0.6	0
Total	3,521.2	0.0	6.4	7.0	0	21.9	31.0	56.5	2
Total, All Sectors in Minnesota	140,462.7	611.2	297.0	1,059.5	1	3,084.0	1,451.2	5,324.1	4

Source: IMPLAN runs 08/21/92. Jaakko Pöyry Consulting, Inc. (1992h).
Note: Sectors 188, 160, 24, 521, 464, 27, 161, 170, and 172 adjusted to reflect IMPLAN revisions in the North region. Units are increase in TIO above baseline ($ millions).
* Total refers to direct, indirect and induced effects.

percent) would be added within the northern region. The high level of timber harvest would produce an estimated $800 million (in 1985 dollars) in additional employee compensation in the state, an increase of 1.8 percent. Of this, $560 million (69 percent) would be in the north region. Finally, the high level of timber harvesting would produce an estimated $5,300 million (in 1985 dollars) of increased TIO in the state, an increase of 3.8 percent. Of this, $4,600 million (87 percent) would occur in the north region.

7.5.5 Land Management Organization Service Delivery

In order to meet the increased consumption being considered for the high scenario, forest landowners will need to increase their level of timber sales. Harvest levels would have to increase by 75 percent over the base scenario to meet the high scenario. Such increases could have substantial impacts on public forest land management agencies. The high level of harvest would require more planning and supervision, capital expenditures on roading and investments in replanting. Additional income would also be generated. These changes would be reflected in an increased workload for personnel and a need for additional budget allocations.

Projections of the timber volumes harvested from various land ownerships over time were made with the assumption that timber harvests would be constrained and/or mitigated by environmental, aesthetic, socioeconomic, and other concerns. The *constrained or mitigated projections* reflect major existing land use policies and practices.

The potential impacts of increased timber harvesting on forest management organizations in the state under these constraints are summarized below.

Timber harvests from the national forests in Minnesota are projected to decline by roughly 10 to 15 percent from the current level of harvest under both the base and the medium scenarios. Under the high scenario, timber harvests are projected to more than double current harvest levels within two decades. This would undoubtedly require more resources in terms of personnel and funds to handle the increased planning and administration of timber sales.

Constrained projections of timber harvest from MNDNR lands indicate little change from current harvest levels during the first decade under both the base and medium scenarios. The high scenario projects an increase in timber harvest from state lands of more than 50 percent above current levels during the second and subsequent decades. This would require a substantial increase in support for timber sale planning and administration.

Sales of timber from county lands are projected to increase during the first decade over current levels under the high scenario. Subsequently, sales would increase to more than double current levels and then decline slightly by the fifth decade. This large immediate increase in timber harvest would have a major impact on county forest management, and would require substantial increases in funding and personnel to handle the increased timber sale activity while meeting environmental and aesthetic constraints.

Constrained projections of timber harvests from forest industry lands indicate that timber harvests would remain roughly at current harvest levels during the first two decades for all three scenarios, followed by sharp increases during the third and fourth decades, and a substantial decline during the fifth decade.

Timber harvests from Native American lands are projected to rise considerably for the base and medium scenarios and especially for the high harvest level. Such large increases in timber harvests under the high scenario would require substantial increases in funding and personnel to plan and administer sales, and to avoid environmental degradation.

Constrained projections of timber harvests from other private lands indicate a substantial rise in timber harvest under all three scenarios during the first two decades and continue to do so for the high scenario. Achieving these increases in timber harvests from other private lands will require considerable timber sale and land management assistance from forest industry and the state and federal government if potential environmental and aesthetic degradation is to be avoided or minimized.

7.6
Identification of Significant Impacts

Criteria were developed and used by the study groups to assess the significance of impacts projected to occur at each level of harvesting. The criteria and relevant background information are reproduced in full in appendix 1.

The following lists the criteria and presents the significant impacts that are projected to occur at the high level of harvesting. Where meaningful, these impacts are compared with those projected to occur under the base and medium scenarios. The significant impacts have been drawn from the assessments in the technical papers. Criteria have been grouped under the same headings as were used in section 5.

7.6.1 Forest Resources - Extent, Composition, and Condition

The criteria in this section were used by the Maintaining Productivity and the Forest Resource Base, Forest Health, Wildlife, and Biodiversity study groups to identify projected significant changes in the extent, composition, and condition of Minnesota's forest resources.

These criteria cover a wide range of issues ranging from the size of the forests to their genetic makeup. Impacts on federal- and state-listed species of special concern, threatened, or endangered or their habitats were assessed for plants in this section and for animals under the wildlife section following.

Changes to Minnesota's Forests - Size and Composition of Forest Land Base (public and private)

An impact is considered significant if it is projected that there will be cumulative over the 50-year study period:
- A change of 3 percent in the size of the total Minnesota forest land base.
- A change of 3 percent in the area of timberland (commercial forest land) available for wood production.
- A change of 7 percent in the area of the total forest land base by ecoregion.
- A change of 7 percent in the area of timberland by ecoregion.

The estimated trends by ecoregions were presented in section 5.6.1. Since changes in forest area is projected to be independent of the level of harvest, the analysis presented in this section also describes the significant impacts for the medium scenario.

Projecting estimates of forest area change are always difficult and can seem exaggerated. However, the history of forest clearing, regrowth, harvesting, and reservation here and in other regions, notably from Wisconsin to New England to Europe, suggests changes can be large and rapid. Additionally, the U.S. and state population is expected to grow substantially over the period to 2040.

Changes to Minnesota Forests - Patterns of Forest Cover in Areas of Mixed Land Use

An impact is considered significant if noncontiguous forested tracts or patches less than 300 acres in size are projected to experience clearcutting of more than 20 percent of the tract or patch in any one decade.

Statistics on the regrowth of the oak and elm-ash-cottonwood forest types common to agricultural regions suggest that forest cover is returning to ecoregions 5, 6, and 7 quite rapidly on a percentage basis. However, even the large percentage increases estimated for the next 50 years would just return these regions to the forest acreage levels of the 1950s. Additionally, the concentration of oak-hickory in older age classes (see appendix 8, Jaakko Pöyry Consulting, Inc. 1992a) coupled with currently high harvest levels could negatively affect the overall habitat value of existing forest patches. Given the small average stand sizes in this covertype and these ecoregions and the projected acreage of harvested stands by scenario, it is evident that this is occurring and that it is a significant impact. However, data limitations in this study preclude the ability to document it on a site-specific basis.

The covertypes likely to be present in such patches (i.e., oak-hickory and elm-ash-soft maple) show increased levels of harvesting under the high scenario when compared with levels projected under the medium scenario. Data presented in table 7.3 indicates that approximately 305,000 more acres were harvested under the high scenario than were harvested in the oak-hickory and elm-ash-soft maple covertypes under the medium scenario. Intuitively, greater impacts on these resources are likely as the area harvested increases.

These changes in forest patterns have implications for several mammal species as well as forest interior birds occurring largely or entirely in these more developed portions of the state. Note that significant declines were projected for several species in ecoregions 5, 6, and 7. The projected significant impacts on these species discussed in the following section can be assumed to be closely related to this criterion, i.e., further fragmentation of remnant forest patches. Some of the species in question are: gray and fox squirrels, Ovenbird, Cerulean Warbler, and Yellow-throated Vireo. The Red-shouldered Hawk, a species of special concern, will be significantly impacted if further fragmentation of forest cover in mixed land use regions of the state occurs.

Changes to Minnesota Forests—Tree Species Mix

> An impact is considered significant if projected gross changes in the relative proportion of any tree species exceeds 25 percent for the respective covertypes over the 50-year planning period.

The harvesting scenarios would affect the age class structure and thereby the species composition of Minnesota's forests. Under the changes projected at the high level scenario the following tree species are projected to experience significant adverse impacts, black spruce, black locust, black maple, and other hardwoods.

Future covertypes appear to be sensitive to the level of harvesting, both in retaining covertypes and in favoring change to other species. Results are clouded because of an imprecision in determining forest covertypes both now and in the future. This imprecision is due in large part to the mixed species composition of Minnesota's forests. However, results suggest the high level of harvesting will contribute to a continued decrease in area of the jack pine, balsam fir, and paper birch covertypes beyond that projected for the medium scenario. However, some of these changes are a consequence of successional changes as stands age, and are not due to harvesting per se. Furthermore, because many stands have very mixed species composition, some of these changes will not necessarily drastically change the vegetation at a regional level or on specific sites. Instead, a major species may simply become less abundant or be reduced to a minor species on a particular site.

Minor Tree Species

Minor tree species are an important component of biodiversity. In many cases they are species near the edge of their range, or are species that simply are not abundant within their range.

The analysis of stem numbers for the high level timber harvesting scenario in the year 2040 reveals that Kentucky coffeetree would be significantly impacted (>25 percent reduction in stem number) for all three scenarios. Additionally, rock elm would be significantly impacted in the high scenario. Also, in the judgement of the study group, significant impacts on honeylocust, yellow oak, and sycamore (if investigation shows it to be native) are likely under all three levels of harvesting.

Reduction of Conifer Component in Aspen Stands

As discussed in section 5.2, the issue of retention of conifers in aspen stands cannot be resolved due to a lack of data. Therefore, it is not possible to predict whether conifers will be lost in short rotation or other harvest of aspen (and therefore whether the significance criterion is triggered). However, if such a reduction in conifer component were to occur, the impact on biodiversity would be significant and proportional to the level of harvest.

Changes to Minnesota Forests - Age Class Structure.

> An impact is considered significant if the projected replacement age class structure of forests, by covertype, at the end of the 50-year planning period, is insufficient to provide replacement of mature stand acreage (i.e., sustainability of forest communities).

This criterion requires examination of age class structures at the end of the 50-year study to assess the feasibility of relatively short-term sustainability. Upon doing so it is apparent that the replacement age class structure for timberland appears deficient for paper birch in all three scenarios. This covertype remains unbalanced through the study period because of its current age class structure imbalance. Thus, this covertype is considered to exhibit a significant impact.

Results show increased or stable acreages for white pine, northern white cedar, and white spruce as compared to the present. White cedar is projected to have a very low harvest so the concerns are not a direct consequence of harvesting. Concerns regarding white pine center on the very limited acreage under this covertype. It is likely that much of that acreage increase referred to above is due to covertype definition or determination procedure or succession from other covertypes. Thus, concern for the present or 1990 acreage remains.

The area of old forest of all covertypes is expected to remain stable or increase substantially (see table 7.10). The exceptions are a 14 and 16 percent decline for jack pine and balsam fir, respectively.

Old growth forests.

> An impact is considered significant if there is projected to be any net loss of area of forest meeting the DNR definition for old growth by covertype by ecoregion over the 50-year study period.

Timber harvesting per se, will have no significant impact on old growth in upland forest types since each candidate stand and future old growth stand is assumed to be either officially reserved or officially released for harvest after the appropriate administrative procedures. However, some areas of old growth may be harvested if they are not identified by an inventory. To add to that concern, we note that considerable acreage of lowland conifer stands that meet old growth age criteria is projected to be harvested under the high scenario.

Forest species - genetic variability.

> An impact is considered significant if there is projected to be a loss of genetic variability in forest plant or animal species as measured by:
> 1. a reduction or isolation of habitat or communities supporting a species, or
> 2. a reduction of geographic ecotypes such that a species now present as a viable population disappears or is approaching extirpation from any ecoregion.

The genetic factors relevant to the criterion were discussed in section 5.6.1. These factors cannot be quantified and as a consequence, the details provided in that section are not repeated. The base, medium, and high scenarios differ in several ways that are relevant to forest genetics. The rise in harvesting operations projected under the medium and high scenarios will increase the likelihood that a particular stand would be harvested at some period and also increase the number of harvested stands within a given landscape.

The increased likelihood that a site will be harvested will increase the chances that plants will be physically disturbed or destroyed. Similarly, the increase in harvesting operations at a landscape level will likely increase the degree of fragmentation. Both increase the likelihood of significant impacts, but to an unknown degree.

Federal- or state-listed plant species of special concern, threatened, or endangered or their habitats.

An impact is considered significant if any harvest or forest management activity is projected to diminish the habitat and disturb a species listed as of special concern, threatened, or endangered (either federal or state).

In general, the forest dependent rare plant species of Minnesota are poorly adapted to trampling types of injury. With the exception of the one tree species on the list, all species are of small stature and easily broken. Operation of harvesting equipment can significantly impact populations of rare plant species within areas harvested. The lack of knowledge regarding the locations of rare species in the state makes it impossible to undertake a more quantitative analysis. In any case, the comparatively coarse level of resolution of the model output would preclude such an analysis.

Table 7.6 in section 7.1.4 shows that the aggregate area harvested under the high scenario will increase by 21 percent when compared with the medium scenario, and that the additional harvest will be spread across all the ecoregions. Therefore, the high scenario will likely result in additional (but unquantified) impacts above those projected to occur at the base and medium levels of harvesting.

Forest Health—change in susceptibility or vulnerability

An impact is considered significant if projected changes to the forest and activities undertaken lead directly or indirectly to changed susceptibility (risk of an outbreak/infection) or vulnerability (damage if an outbreak occurs) to more than 10 percent by area by covertype.

All timber harvesting and forest management activities affect forest health; all have impacts. Those impacts range from nearly none (where the management activity is minimal) to very significant (where major changes are brought about in the forest). That continuum of impacts is impossible to treat in any quantitative sense so a threshold must be established to aid in communication. Impacts that are greater than that threshold merit attention; impacts below the threshold are not large enough to justify further consideration.

Certain assumptions were made as part of the analysis of significant impacts on forest health. In particular, it was assumed that the MNDNR pest management guidelines and other guidelines would be followed by all ownerships. If the guidelines are not followed, impacts of harvesting on the health of Minnesota's forests could be more severe. The following assess the significant impacts projected to occur under the high level harvesting scenario.

Aspen-birch forest type group. The area of the aspen-birch forest type group more than 40 years old would be reduced by more than 10 percent when comparing the final age class distribution projected at the high harvest level with the existing distribution. This change will alter the susceptibility and vulnerability of this forest type group to outbreaks of specific insect and disease pests. This change is similar to that experienced under the medium level of harvesting and the consequences would also be similar. These include a reduction in vulnerability to forest tent caterpillar; and a reduction in susceptibility to white trunk rot and hypoxylon canker (if disease control guidelines are followed). In addition there is a risk of an increase in Armillaria root rot.

Black spruce forest type group. The substantial increase in the level of harvest in black spruce forest type group under the high scenario is projected to increase the acreage in age classes less than 40 years old by more than 10 percent, and the area over 60 years old would decline by more than 10 percent in the year 2040. These changes are likely to decrease the incidence of root and butt rots caused by *Inonotus tomentosus* which become more prevalent in stands older than 60 years. Therefore, this is a significant positive impact and in direct contrast to the significant negative impact projected to occur under the base level harvesting.

Lowland conifers forest type group. Under the high level of harvest, the area of lowland conifers less than 40 years old is projected to increase by more than 10 percent, while the area older than 60 years is projected to decrease by more than 10 percent. Impacts on balsam fir stands are as discussed under spruce-fir below. For the remaining species, whether significant changes in harvest intensity are likely to change susceptibility or vulnerability of lowland conifer stands to insect and disease pests is unknown.

Lowland hardwoods forest type group. The area of lowland hardwoods forest type group less than 40 years old is projected to increase by more than 10 percent under the high scenario. This is a substantial change from that projected to occur under the base scenario. In addition, the area in the more than 60-year-old age class would decrease by more than 10 percent. Although this represents a major decrease in extent of the 60-year-old-plus age class, there are relatively few major pests that are likely to be affected by changing the level of harvest in lowland hardwood types.

Pine forest type group. Changes would be 10 percent or less under the high scenario. Such change is similar to that projected under the base scenario. Incidence of *Diplodia* shoot blight and canker and *Scleroderris* canker on young (<40 years old) red pine may increase if the areas replanted to red pine are not carefully chosen. Both of these pests are not major problems on older red pine so the projected increase in area of pine more than 40 years old should not have a significant effect on disease incidence in older red pine. There is a potential for an increase in diseases such as needlecasts and gall rust as nursery seedlings are planted to replace the trees that have been harvested.

Lophodermium needlecast on red pine and gall rust of jack pine are two diseases that can be introduced into the field on infected nursery stock.

An increase in area of older pine forest type group may increase the amount of pine that is less vigorous and less able to resist Ips beetles following damage by wind, lightning, flooding, defoliation, or pathogens. Incidence of Ips may therefore increase.

At the high harvest levels, harvested white pine stands are projected to be replaced by younger stands which are more susceptible and vulnerable to white pine weevil. Therefore, this is a significant adverse impact. The increase in younger white pine could increase the incidence of white pine blister rust, especially if white pine is regenerated in northern Minnesota.

Spruce-fir forest type group. In contrast to the projections under the base level of harvesting, the area of spruce-fir forest type less than 40 years old is projected to increase by more than 10 percent under the high harvesting level, and the area more than 40 years old would decrease by more than 10 percent at that level. The overall decrease in tree age within this forest type group will decrease vulnerability and susceptibility of stands to budworm damage. Probability of wildfire should decrease since mortality, breakage, and windthrow that follow budworm outbreaks will decrease. Therefore, this is a significant positive impact and an important change from the base scenario.

The decrease in area of older spruce-fir forest type group will lead to an decrease in the level of susceptibility and vulnerability of these species to trunk, root and butt rots and can be considered a significant positive impact.

Upland hardwoods forest type group. The area of upland hardwoods forest type group less than 40 years old is projected to increase under the high harvest level, and the area more than 60 years old would decrease by more than 10 percent.

Under the high harvest level, the area of younger trees will increase. Younger trees are generally more vigorously growing and have more starch reserves than older trees. They are therefore less affected by drought and other environmental stress and presumably less susceptible to severe damage by two-lined chestnut borer. The reduced susceptibility of the younger trees will be offset by an increase in the area of older forest.

Clearcutting stands of upland hardwoods forest type group should reduce the incidence of decay in the mid-term (10 to 50 years) and cankers in the short-term (<10 years) as decayed and cankered trees are removed from the stand. However, selection and shelterwood cuts are often preferred methods of regenerating stands of upland hardwood forest type groups. If some type of multiple entry harvest is chosen, the chances of wounding residual trees increases; the incidence of decay and cankers is also likely to increase. Thinning and other stand entries are projected to increase substantially in stands of upland hardwood forest type. Hence the overall impact of increased harvesting is a likely increase in decays and cankers.

Under the high level timber harvest, a medium-term (10 to 50 years) decrease in the incidence of oak wilt is expected if clearcutting is the method of harvest. Clearcutting would eliminate oak wilt pockets within the clearcuts. Multiple stand entries may tend to injure oak, and make them more susceptible to infection. Given that multiple entry harvest will predominate, the amount of oak wilt is therefore projected to increase (with high uncertainty of prediction).

7.6.2 Soil Resources

Nutrients

> An impact is considered significant if nutrients removed and/or redistributed during harvest and followup activities are not replaced over the term of the projected rotation.

Impacts of the high level of harvesting were assessed by determining the area of each covertype that was harvested on each soil. More area of aspen-birch was harvested than of any of the other types; aspen-birch is also the dominant covertype in the state. Similarly, the extent of harvesting was greatest on well-drained medium-textured soils; that is also the dominant soil type in the state. Harvest of merchantable bole did not remove either nitrogen nor phosphorus beyond their rates of replenishment. Areas at risk for loss of calcium are most closely associated with harvest of aspen-birch and upland hardwoods, on both medium- and, especially, coarse-textured soils. Thus under the high scenario, the area at risk for nutrient loss increased compared to the base scenario. The increased calcium loss is primarily associated with increased harvest of upland hardwoods. As a result, over 7.0 million acres are at risk of calcium loss under the high scenario. Increased harvest of black spruce on organic soils, and increased harvest of most species on coarse-textured soils under the high scenario, leads to an increase of about 0.5 million acres at risk for magnesium loss (up to a total of 4 million acres). Finally, increased area at risk for potassium loss is also associated with increase in harvest on coarse-textured soils, leading to a small increase in area at risk for potassium loss.

Compaction and Related Disturbances

> An impact is considered significant if the proportion of the harvest unit projected to be moderately to severely compacted/puddled exceeds the following threshold proportions:
> - 5 percent on highly sensitive sites;
> - 10 percent on moderately sensitive sites; and
> - 20 percent on sites with low sensitivity.

The analysis of significant harvest unit impacts under the high scenario indicates they were most frequent on the well-drained medium-textured soils, which are the most common soils in the state, and the poorly-drained medium and poorly-drained fine soils which have the lowest strength.

Harvesting

The following figures are the cumulative results for the 50-year study period assuming the high level harvesting scenario and the seasonal distribution of harvesting activities outlined in the Silvicultural Systems background paper (Jaakko Pöyry Consulting, Inc. 1992m). Approximately 7 million acres of timberlands on mineral soils would be harvested statewide during the study period. The significance criteria would be exceeded on harvesting units representing an area of just in excess of 1,240,000 acres. The area devoted to haul roads in order to extract the timber means an additional 90,000 acres would be significantly impacted.

The impact assessment indicated that increased levels of timber harvesting will invariably lead to increased amounts of compaction and related disturbance. The significance criteria were exceeded by both mechanical and hand-felling operations on moderately and highly sensitive sites. It was estimated that about 25 percent of the area within moderate sensitive sites would be negatively affected by equipment trafficking for both harvesting configurations. The portion of highly sensitive sites that are negatively impacted could increase to about 30 percent for hand-felling operations and 55 percent for mechanical felling operations.

These results reflect the seasonal harvesting distribution on all soil types within each ecoregion. Limiting timber harvesting to specific seasons on individual soils or sites could greatly affect the impact assessment. The MNDNR and some counties are starting to implement these practices on upland sites in addition to the long standing use of these practices on organic soils.

Soil Erosion

An impact is considered significant if the rate of soil loss is projected to exceed the limits prescribed by the U.S. Soil Conservation Service expressed as:

$$\text{rate} > T$$

where T varies between 1-5 (tons/ac/yr)

Surface erosion rates exceeded T values on less than 1 percent of the area harvested, and this significant impact was predominantly limited to well-drained soils which exist on steeper slopes.

These results represent the total area impacted over the 50-year planning period. The analyses indicated that significance criteria would be exceeded only in moderately and heavily trafficked areas (skid trails) within harvest units and on haul roads. Also, significant impacts were concentrated in well-drained mineral soils which is to be expected since they are the soils with steepest slopes.

Under the high level of harvest, about 45,000 acres within harvest units would develop erosion rates that exceed T values. Accelerated erosion caused by skidding and felling activities would exceed T values on less than 1 percent of the total area harvested during the 50-year period.

The greatest erosion rates were estimated to occur in ecoregion 6. This ecoregion has the steepest slopes (averaging 45 percent in many areas). The southern portion of the state also has the highest rainfall intensity. It was estimated that initial erosion rates could exceed 14 ton/ac/yr in some areas in ecoregion 6. Initial rates rarely exceeded 5 ton/ac/yr in other ecoregions.

If an area equal to 1 percent of the harvest area were utilized for haul roads on mineral soils, T values would be exceeded on an additional 10,000 acres under the high level of harvest. These totals indicate that erosion rates would be exceeded on about 8 percent of the haul road area.

Erosion associated with haul roads would occur at faster rates than erosion within harvest units. This is a function of the more complete removal of surface protection and smoothing of the ground surface in haul roads. The analyses indicated that maximum initial erosion rates in haul roads could approach 100 ton/ac/yr in some areas.

As stated in section 5.6.6, the effects of timber harvesting and forest management activities on mass movements were not quantified. The greatest potential for mass movements would occur in areas with steep slopes such as the Coulee region of southeastern Minnesota (in ecoregion 6) and areas with shallow soils over bedrock (ecoregions 2 and 3). However, there is currently no evidence suggesting that mass movements are currently a major problem in forested portions of Minnesota.

7.6.3
Water Resources and Aquatic Ecosystems

These criteria were applied to identify significant impacts affecting water resources and aquatic ecosystems.

Lakes, rivers, streams, and wetlands - level of sedimentation/nutrient loading.

An impact is considered significant if timber harvesting and associated management activities are projected to cause changes in the level of sedimentation and/or nutrient loading of waterbodies such that more than 25 percent of monitoring observations following harvest exceed the 85th percentile of preharvest or reference conditions.

Lakes, rivers, streams, and wetlands - runoff.

An impact is considered significant if projected timber harvesting and associated management activities cause changes that result in greater than 60 percent of a *Minor Watershed*[1] to be in a *disturbed condition*[2] at any time.

[1]Minor watersheds as defined in MNDNR 1979 Watershed Map.

[2]Disturbed condition is defined as cleared land or regenerated forest younger than age 15 years.

Lakes, rivers, streams, and wetlands/peatlands - aquatic ecosystems.

> An impact is considered significant if timber harvesting and forest management activities are projected to result in changes to one or more aquatic ecosystem variables such that:
>
> a. more than 25 percent of observations exceed the 85th percentile of preharvest or reference conditions for the following variables:
>   - sediment levels,
>   - water nutrient levels; or
>
> b. peak streamflows more than double or if minimum flows fall below the *7Q10*[3] level; or
>
> c. more than 25 percent of observations exceed the 85th percentile or fall below the 15th percentile of preharvest or reference conditions for
>   - *aquatic community structure, community function, or fish populations*[4].

Application of the above criteria to the water resource impacts projected to occur at the high scenario indicates that the effects of timber harvest at the ecoregion level will not cause impacts that will exceed the thresholds specified in the criteria.

However, there will be a series of changes in the landscape and in the water resource. Most of those changes will be relatively local and relatively short-term in scale. Timber harvest which is accomplished in compliance with Minnesota BMPs will have significantly fewer local water resource impacts than will timber harvest in the absence of BMPs. Therefore, the increased harvesting under the high scenario is likely to increase the number of sites affected, but will not change the types of impacts that were projected to occur under the base scenario.

7.6.4 Wildlife Populations

These criteria were used to determine the significance of impacts of projected changes in wildlife populations.

[3] The 7Q10 designation is a measure of the lowest flow for any 7-day period within any 10-year interval, and is widely used to protect water quality. Other methods for which significance criteria could be developed (e.g., wetted perimeter, Tennant's method, Instream Flow Incremental Methodology) would be more appropriate in representing fish habitat values.

[4] Specific variables to be measured might include kinds and numbers of organisms, rates at which the community processes energy or nutrients or the populations of fishes. The specific variables to be measured will be chosen by scientists assessing any given timber harvest operation(s).

Forest dependent wildlife - habitats.

An impact is considered significant if the available habitat of a species is projected to be changed by 25 percent in any ecoregion.

Table 7.16 summarizes the wildlife species showing significant negative impacts by this criteria and the next one involving species of special concern, threatened, or endangered or their habitat. Ninety-one species, about 53 percent of all wildlife species included in the analysis, were significantly impacted over the 50-year study period under the high scenario. Most species impacted significantly under this scenario were also impacted under the base and medium scenarios; for some of these the number of ecoregions in which the impacts occurred was higher under the high as compared to the base and medium scenarios.

No large mammals would be significantly impacted under the medium scenario. Eight small mammal species would be impacted under the high scenario. Species impacted included northern flying squirrel; gray, fox, and red squirrels; lynx; porcupine; pine marten; and fisher. The number of bird species impacted by the high scenario increased to 78, which is up from the 69 under the medium scenario and 39 under the based scenario. Species projected to be adversely impacted include all owl species, most woodpecker species and many warbler species.

Small mammals: The eight small mammals adversely impacted include gray and fox squirrels which are associated with mature oak forests. The northern flying squirrel requires large tracts of forest to maintain stable populations and may be adversely affected by forest fragmentation. Beaver are projected to be impacted for one decade in two ecoregions. However, the projected decline in this species must be viewed against a trend of population increases elsewhere. The remaining species showing negative impacts, lynx, porcupine, pine marten, and fisher, occupy a variety of covertypes and impacts on these species may reflect an overall reduction in the area of mature forests in these covertypes.

Birds: Impacts on riparian species were projected to be the same under the high as for the base and medium scenarios. Ten conifer dependent species were projected to declining populations under the high scenario, up from two under the medium scenario. Sixteen hardwood dependent species under the high scenario compared with six under the medium scenario.

Several times as many interior and mature forest bird species are projected to be negatively impacted under the high scenario as under the medium scenario. In addition, Spruce Grouse would be negatively impacted statewide and in ecoregions 1, 2, and 4 compared with a negative impact on ecoregion 4 only under the medium scenario.

Table 7.16. Species significantly negatively impacted on all forest lands under the base, medium, and high levels of harvest using criterion 8 (≥5 percent statewide decline for a species listed as endangered, threatened, or special concern) and criterion 11 (≥25 percent decline in any ecoregion). Numbers in parentheses indicate ecoregions with a projected decline ≥25 percent. Double x (xx) shows those species with a ≥25 percent decline statewide, plus all species affected by criteria 8.

Species	Species Significantly Impacted		
	Base	Medium	High
Small- and medium-sized mammals:			
Beaver	x (2,6)	x (2,7)	
Northern flying squirrel	x (5)	x (3,5)	xx (3,4,5)
Porcupine			xx (3,4,5)
Pine marten			xx (1,3,4)
Fisher			x (3,4,5)
Gray squirrel	x (4,7)	xx (4,6)	xx (1,4)
Fox squirrel	x (4,7)	xx (4)	xx (4,5,6)
Red squirrel			x (3,4)
Bobcat	x (3)	x (3)	
Lynx	x (3)	x (3)	x (3,4)
Birds			
Spruce Grouse		x (4)	xx (1,2,4,)
Green-backed Heron	x (3,6)	x (6)	x (6)
Sharp-shinned Hawk		x (3)	xx (3,4)
Cooper's Hawk	x (4)	x (1,4)	xx (1,4)
Northern Goshawk	x (4)	x (4)	xx (1,3,4)
Red-shouldered Hawk	xx (4,5,6)	xx (4,5,6)	xx (4,5,6)
Broad-winged Hawk		x (4)	xx (1,3,4)
Merlin		x (4)	xx (3,4)
Eastern Screech-owl	x (4)	x (4)	x (4)
Great Horned Owl		x (4)	x (1,3,4)
Barred Owl		x (6)	xx (1,3,4,5,6)
Great Gray Owl	x (3)	x (3)	x (3,4)
Long-eared Owl		x (3,4)	xx (3,4)
Boreal Owl		x (3,4)	xx (3,4)
Northern Saw-whet Owl		x (3)	xx (3,4)
Whip-poor-will	x (7)	x (7)	x (7)
Red-headed Woodpecker		x (3,4)	x (1,3,4)
Red-bellied Woodpecker			x (4)
Yellow-bellied Sapsucker		x (4)	xx (1,3,4)
Hairy Woodpecker	x (6)	x (3,6)	x (3,6)
Black-backed Woodpecker		x (3,4)	x (3,4)

Table 7.16. (continued)

Species	Species Significantly Impacted		
	Base	Medium	High
Northern Flicker	x (2)	x(2)	
Pileated Woodpecker	x (6)	x (1,6)	xx (1,3,4,5,6)
Olive-sided Flycatcher			x (3)
Eastern Wood Pewee	x (4)	x (4)	xx (1,3,4)
Yellow-bellied Flycatcher			x (3,4)
Acadian Flycatcher	x (6)	x (6)	xx (5,6)
Least Flycatcher			xx (1,3,4)
Eastern Phoebe	x (2)	x (2)	x (2)
Great Crested Flycatcher			xx (1,3,4)
Gray Jay	x (3)	x (3)	x (3,4)
Blue Jay		x (4)	xx (3,4)
American Crow			xx (1,3,4)
Common Raven		x (4)	xx (3,4)
Black-capped Chickadee			xx (1,3,4)
Boreal Chickadee	x (3)	x (3)	x (3,4)
Red-breasted Nuthatch			x (1,3,4)
White-breasted Nuthatch		x (4)	xx (1,3,4)
Brown Creeper		x (4)	xx (2,3,4)
Golden-crowned Kinglet		x (3)	xx (3,4)
Ruby-crowned Kinglet		x (3)	x (3,4)
Blue-gray Gnatcatcher		x (4)	xx (4)
Eastern Bluebird	x (2)	x (2)	
Veery			x (1)
Swainson's Thrush	x (3)	x (3)	x (3,4)
Hermit Thrush			xx (3,4)
Wood Thrush		xx (4)	xx (3,4)
Gray Catbird	x (2)	x (2)	
Brown Thrasher	x (2)	x (2)	
Solitary Vireo		x (3,4)	xx (3,4)
Yellow-throated Vireo	xx (4,6)	xx (1,4,5,6)	xx (1,4,5,6)
Red-eyed Vireo		x (6)	xx (1,3,4)
Tennessee Warbler			x (3,4)
Nashville Warbler			x (3)
Northern Parula			xx (3,4)
Yellow Warbler	x (2)	x (2)	
Magnolia Warbler	x (3)	x (3)	x (3)

Table 7.16. (continued)

	Species Significantly Impacted

Species	Base	Medium	High
Cape May Warbler		x (3)	x (3,4)
Black-throated Blue Warbler			xx (3)
Black-throated Green Warbler		x (4)	xx (2,3,4)
Blackburman Warbler			xx (3,4)
Pine Warbler		x (1,3)	xx (1,3,4)
Bay-breasted Warbler		x (3)	x (3)
Cerulean Warbler	x (6)	xx (6)	xx (5,6)
Black-and-white Warbler			x (5)
American Redstart			x (1)
Ovenbird	x (6)	x (4,6)	xx (1,3,4)
Louisiana Waterthrush	x (7)	x (7)	x (7)
Connecticut Warbler	x (3)	x (3)	x (3,4)
Common Yellowthroat	x (2)	x (2)	
Hooded Warbler	xx (6)	xx (6)	xx (5,6)
Wilson's Warbler	xx (2)	xx (2)	
Yellow-rumped Warbler	x (3)	x (3)	x (3,4)
Northern Cardinal		x (4)	x (4)
Indigo Bunting			x (1)
Scarlet Tanager	x (6)	x (4,6)	xx (1,3,4,5,6)
Chipping Sparrow			x (3)
Song Sparrow	x (2)	x (2)	
Lincoln's Sparrow	xx (1,2,3,4)	xx (1,2,3,4)	xx (1,2,4)
Dark-eyed Junco	x (3,4)	x (3)	x (3)
Common Grackle	x (2)	x (2)	
Northern Oriole	x (4)	xx (4)	xx (1,3,4)
Purple Finch	x (3)	x (3,4)	x (3,4)
Red Crossbill		x (3)	x (3,4)
White-winged Crossbill		x (3)	x (3,4)
Pine Siskin	x (5)	x (1,3,4,5)	xx (1,3,4,5)
American Goldfinch	x (2)	x (2)	
Evening Grosbeak		x (3)	xx (3,4)

Table 7.16. (continued)

Species	Species Significantly Impacted		
	Base	Medium	High
Amphibians and Reptiles:			
Ringneck snake	x (1)	xx (1,3,4)	xx (1,3,4)
Eastern newt			x (1,4)
Red-backed salamander			x 91)
Wood frog			x (3)
Spring peeper			x (3,4)

Source: Jaakko Pöyry Consulting, Inc. (1992f).

Herps: The ringneck snake was the only species showing adverse impacts statewide under the medium and high scenarios. However, five species show significant adverse impacts in at least one ecoregion, compared with one under the base and medium scenarios.

The changes for some species also translate into 25 percent or more declines on a statewide basis. These are summarized in table 7.13 in section 7.4.1. Statewide, 48 species would decline by 25 percent or more; that is more than four times the number adversely affected under the medium scenario. The statewide declines include three species that are of special concern, endangered, or threatened (Red-shouldered Hawk, Louisiana Waterthrush, and pine marten).

Federal- or state-listed wildlife species of special concern, threatened, or endangered or their habitats.

> An impact is considered significant if any harvest or forest management activity is projected to diminish the habitat and disturb a species listed as of special concern, threatened, or endangered (either federal or state).

For analysis, a decrease of 5 percent or more in habitat or population index statewide was interpreted to be a significant impact.

The same significant impacts are projected to occur for the Red-shouldered Hawk and Louisiana Waterthrush under the high scenario as occurred under the base and medium scenarios. Additionally, the pine marten is significantly impacted under this criterion.

In addition to the direct assessments of population change assessed above, two other criteria were used to identify impacts on key habitat factors for some species. These criteria and the assessments of significance are discussed below.

Forest dependent wildlife - habitats (lowland conifers).

An impact is considered significant if, by ecoregion, net loss of patches of mature lowland conifer between 10 and 200 acres is projected to exceed 25 percent of total patches over the 50-year study period.

In regions where great expanses of lowland conifers, particularly black spruce, predominate on the landscape, protection of this covertype is not as critical to wildlife as where the type occurs as isolated patches. The increased demand for black spruce under the high scenario will likely increase pressure on this covertype.

Forest dependent wildlife - food species.

An impact is considered significant if, by ecoregion, the projected rate of removal of tree species that provide vital food for wildlife, (oaks, hickories, and mountain ash), exceeds their projected rate of replacement.

A number of species such as the grey and fox squirrels projected to have significant declines under the high level harvest rely on mature oak forests for food and cavity resources. Three factors that were part of the output will provide some guidance as to landscape scale changes to some of these species. The covertype area and age variables allow an interpretation of very broad change in the availability of these resources. In addition, the number of trees by species on timberlands was also projected.

The projected area changes in the oak-hickory covertype (table 7.8 section 7.2.1) shows that the area of this covertype is projected to increase slightly over the 50-year period, probably reflecting projected increases in the area of forest in the southern ecoregions. The average age of this covertype is projected to decline slightly from the present 69 years to 63 years under the high scenario (table 7.9 section 7.2.2). This is 15 years less than that projected under the base scenario.

The projected numbers for food tree species (from table 7.13, section 7.2.3) show increases under the high scenario compared to the base scenario. It should be stressed, however, that the numbers include all trees larger than 1-inch dbh. Trees this small would not provide food resources, hence these figures should only be used to gauge broad trends. Species showing increases over current levels include mountain ash, bitternut hickory, black oak, white oak, swamp white oak, and butternut. Those showing stable or slight increases/decreases included black walnut, bur oak, and northern pin oak. Northern red oak was projected to show a decline of approximately 15 percent for all three scenarios.

Forest species - genetic variability.

An impact is considered significant if there is projected to be a loss of genetic variability in forest plant or animal species as measured by:
1. a reduction or isolation of habitat or communities supporting a species, or
2. a reduction of geographic ecotypes such that a species now present as a viable population disappears or is approaching extirpation from any ecoregion.

As discussed previously, fragmentation is likely to increase as a consequence of increased harvesting projected to occur under the high scenario. The range of species previously listed under the base scenario are likely to be more affected under this level of harvesting than was the case under the base level. The importance attached to change affecting individual species can be assessed by weighing several factors including the overall size of the population, the distances involved, and particularly the mobility of the animal. Thus, birds would probably be least affected and herps would be most vulnerable, particularly those that are not likely to disperse along major streams and rivers. Some species show genetic variability over their range whereas others have a more homogeneous genetic makeup. Information on this is essentially lacking, so this discussion must be confined to generalities. This issue is fully discussed with regard to plants in the Biodiversity technical paper.

In general, when fragmented populations at or near the boundaries of a species range are in jeopardy, it suggests that genetic loss is much more likely than where the same amount of local loss occurs well inside the geographic range of a species. Minnesota, with its great diversity of forest and climatic types, includes the distributional limits of many wildlife species—including cases of northern, southern, eastern, and western edges of species' distributions. Thus, among midwestern states, Minnesota has an unusual number of cases where the edges of a species' genetic variability might be jeopardized. Species with significant predicted impacts from timber harvesting that reach the edge of their range in the state include: black bear, fisher, pine marten, northern flying squirrel, fox squirrel, red squirrel, woodland jumping mouse, lynx, Great Gray Owl, Boreal Owl, and red-backed salamander.

7.6.5
Recreation and Aesthetics

Changes to Minnesota forests - Patterns of forest cover in predominately forested areas-forest roads

An impact is considered significant if there is projected to be development of permanent forest roads in areas meeting the criteria for either of the following Recreation Opportunity Spectrum (ROS) categories: • unroaded primitive areas. • semiprimitive nonmotorized areas.

The two ROS classes used in the criterion are defined as:

Primitive.—An area three or more miles from all maintained roads or railroads and which has an unmodified natural environment. There can be evidence of foot trails, or recreational use. Structures in use are rare. Contact with humans is rare and chances of seeing wildlife are good. Example: BWCAW. Approximately 3 percent of total forest land and 0.4 percent of timberland in Minnesota meet these criteria.

Semiprimitive nonmotorized.—An area one-half to three miles from all maintained roads or railroads, but which can be close to primitive roads or trails used only occasionally. Modifications to the environment are evident, such as old stumps from logging, but are not apparent to the casual observer. Structures in use are rare. Human contact is low and chances of seeing wildlife are good. Example: Recently undisturbed state lands. Approximately 9 percent of total forest land and 7.2 percent of timberland meet these criteria.

A permanent forest road is defined as a formed road that is graveled or paved and is maintained in a trafficable condition (as distinct from being allowed to revegetate). The criterion is intended to identify changes in the pattern of disturbance to the least disturbed areas of the unreserved forest lands. The ROS criteria assess levels of disturbance, particularly roads. The criterion was applied to northern counties that are predominantly forested (see table 7.17).

Harvesting and the development of roads needed to access timber from forests within these categories of lands is indicative of an increased level of disturbance. Improved access provides opportunities for additional use by people who depend on motorized access. This will likely displace a proportion of existing users and will impact animals that are adversely affected when the level of human contact increases.

Table 7.17. Distribution of FIA timberland plots and percent of plots projected to be harvested in primitive and semiprimitive nonmotorized ROS classes, by physiographic class under the base, medium and high scenarios.

ROS Class	Total number of plots	Percent of timberland plots harvested by scenario and ownership*											
		Base Scenario				Medium Scenario				High Scenario			
		State/federal lands		Other lands		State/federal lands		Other lands		State/federal lands		Other lands	
		dry	wet	dry	wet	dry	wet	dry	wet	dry	wet	dry	wet
Primitive	53	11.3	3.8	20.7	7.6	13.2	5.6	21.5	6.8	17.0	5.6	26.4	17.0
Semiprimitive nonmotorized	876	10.8	6.3	15.3	3.9	12.1	12.0	17.3	5.6	17.4	18.7	17.8	7.0

* See table 5.19 for total number of plots harvested by scenario.

According to the criterion used, only plots harvested on dry sites constitute significant impacts to primitive and semiprimitive nonmotorized recreation opportunities. The criterion specified for use in assessing impacts on primitive class lands further requires identification of those areas designated unroaded *primitive* lands and *semiprimitive nonmotorized* lands, where construction of permanent forest roads is projected.

Under the high scenario, 43.4 percent of the 53 timberland plots designated as primitive and dry are projected to be harvested and therefore significantly impacted. Additionally, 35.2 percent of the 876 timberland plots designated as semiprimitive nonmotorized are projected to be significantly impacted. These impacted plots correspond to 5.4 and 23.6 percent of all forested plots in the primitive and semiprimitive nonmotorized ROS classes, respectively. Based on the criterion, no significant impacts occur when plots in the "wet" physiographic classes are projected to be harvested. These plots would be accessed when the ground is frozen and therefore are assumed not to require permanent roads.

Forest Recreation and Aesthetics

An impact is considered significant if VMGs are not used in the planning and execution of projected timber sales for visually sensitive areas.

The criterion refers to VMGs, which are planning tools used by the federal and state ownerships to reduce visual impacts. Significant impacts can be avoided where visual planning is used to identify *where* and *how* harvesting and associated forest operations should take place, i.e., road location and design, use of buffers, size and shape of cut, and slash and debris disposal practices.

Harvesting can reduce the aesthetic experience for subsequent users, therefore limiting the recreation value of harvested areas and the adjacent unharvested areas. However, harvest operations and associated roading can also create additional recreation opportunities of a more developed type.
Visually sensitive forested areas recognized in this criterion can include such areas as those adjacent (within one-fourth mile) to water (lakes and rivers), important tourist and recreation areas, and along recognized tourist access routes. The criterion assumes that significant impacts occur where harvesting operations take place in visually sensitive areas on lands where owners do not practice formalized visual management planning. For example, the USDA Forest Service has had formalized VMSs in place for a long time. Other ownerships, including MNDNR Management Region 2 and Beltrami County, are in the process of developing and applying guidelines.

Typically, other ownerships do not have formalized systems in place. Hence, while in some cases efforts are made to reduce visual impacts on a site by site basis, impacts can still occur when viewed from a wider context.

The certainty of the impact is dependent on the degree to which visual planning is used in timber sale layout and BMPs are adhered to in the execution of the harvesting and postharvest closure of the site. Impacts can extend into the medium-term depending on the circumstances.

Based on the interpretation of the significant impact criterion, significant visual impacts occur when timber harvesting and forest management activities do not follow VMGs. Analysis found that 74.1 percent of the timberland plots harvested under the high scenario would not be treated according to VMGs and these are therefore judged to be significantly impacted.

7.6.6
Unique Cultural and Historical Resources

> An impact is considered significant if heritage resources including cultural landscapes, structural remains, archaeological remains, Native American traditional use sites are destroyed; or cemeteries are disturbed.

The following maximum levels of significant impacts are predicted for each type of heritage resource, based on the interpretation of *destroyed* and the types of impacts discussed in section 5.5.3, and estimated likelihood of impacts under the high scenario in section 7.5.3. There is insufficient data to assess, even qualitatively, the extent that these sites will be impacted. Significant impacts are likely to occur and the relative number of impacts will increase as the level of harvesting increases.

Archaeological and Cemetery Sites
Based on the analysis presented in section 5.5.3, the predicted *maximum* number of sites to be destroyed is shown in table 7.18.

The actual numbers of sites affected can be confidently predicted to be less than these totals. However, because of the nature of the assumptions used to generate these estimates, it is not possible to quantitatively assess the effect of most of these assumptions. The only data that can be quantified are the projected acres that are harvested on national forest. Preharvest surveys detect most sites on these lands and therefore it is valid to assume that no impacts occur. The figures in table 7.18 reflect this reduction. However, it is not possible to set a lower bound on these estimates.

Table 7.18. Predicted maximum number of archaeological and cemetery sites to be destroyed in ecoregions 1 to 6 under the base, medium, and high harvesting scenarios.

Harvest Scenario	Number of Sites Destroyed	
	Number	Percent of Total Predicted Sites Affected*
Base	100,000	52
Medium	116,000	61
High	142,000	75

Source: Jaakko Pöyry Consulting, Inc. (1992g).
*The total number of sites predicted in ecoregions 1 to 6 (see section 2.3) is approximately 190,000.
Note: excludes impacts on USDA Forest Service lands.

Traditional Use Sites

As discussed in section 5.5.3, traditional use sites will be impacted. However, the extent cannot be quantified, as these sites have not been inventoried. Thus, significant impacts on these sites are likely to increase with the level of harvesting.

7.6.7 Economics

Regional economics - changes in economic parameters.

An impact is considered significant if there is projected, for each region (north, south, and metro), a change in the following economic parameters by economic sector over 50 years:
• output - ± 5 percent
• employment - ± 5 percent
• income (wages and salaries) - ± 5 percent

Section 6.6.7 describes the methodology used to estimate economic impacts. The significance criterion outlined above assesses the significance of the economic impacts projected to as a consequence of the high level of harvesting. The factors assessed include employment, employee compensation, and TIO. Applying this criterion to the economic impacts generated by the high scenario indicated that significant positive impacts are projected to occur in all of the top twenty economic sectors in the northern region of Minnesota and in five sectors in the state as a whole. In the southeast region, only two sectors are projected to have significant positive economic impacts. No significant impacts are projected to occur in the metro and southwest regions, because no forest industry expansion was projected to take place in these regions.

Significant Economic Impacts in the North Region

The expansion of the timber industry under the high scenario was projected to occur in the pulp and paper industry and in sawmills. This level of harvesting was projected to have significant positive economic impacts in terms of employment, employee compensation, and TIO within the northern region.

Nearly all of the north region's economic sectors showed significant increases in economic activity and employment (5 percent or more) as the result of high scenario expansion.

All but one of the top twenty sectors and eight of ten selected forest products and forestry sectors showed significant increases in employee compensation in the north region. Overall, the projected increase in employee compensation for all sectors of the north region was significant.

All of the top twenty sectors showed significant increases in TIO, with the Paper Mills (sector 188), Logging (sector 160), and Forestry Products (sector 24) sectors showing the largest percentage gains. Overall, the top twenty sectors together showed a significant 42 percent gain in TIO. Six of the forest products and forestry sectors showed a significant gain in TIO. When all economic sectors in the north region are considered, the projected increase in TIO was significant.

Expansion of the Paper Mills sector (188) resulted in a significant 195 percent gain in TIO. It generated a 34 percent increase in employment and employee compensation. These employment and employee compensation increases were easily significant under the criteria established for this analysis.

Significant Economic Impacts in the Southeast Region

Expansion of the sawmill industry was projected for the southeast region under the high scenario. This expansion caused significant increases in the sawmills and logging sectors. However, the overall employment, compensation and TIO increases for the region were not significant.

Significant Economic Impacts for the State of Minnesota

The projected expansion of the timber industry would result in significant increases in employment, employee compensation, and TIO for many sectors in the north region, especially under the high scenario. However, the increases for the state as a whole were less significant. At the high level of timber harvest, only five of the top twenty sectors contributing most to employment gains in Minnesota had projected increases that were significant (5 percent or greater), and three of these were sectors related to forestry or forest products. Only three of the top ten forest products and forestry sectors (22-Forest Products) indicated a significant increase in employment statewide. Among the top twenty sectors contributing most to employee compensation, four showed a significant increase. Only three of the selected forest products and forestry sectors showed significant gains in employee compensation. Table 7.19 shows those sectors of Minnesota's economy with significant (5 percent or greater) increases in employment, employee compensation, and TIO resulting from the medium and high scenarios.

Overall, total output in the state's economy increases by about a billion dollars under the medium scenario and by over five billion dollars under the high scenario. In each case, about 60 percent of the total increase occurs in the paper sector. Almost all of the direct impacts occur in the paper sector. The output of the paper sector increases by 39 percent under the medium scenario and by 195 percent under the high scenario. The logging sector increases output by 24 percent under the medium scenario and doubles under the high scenario. Impacts are measured relative to the base scenario; therefore, there are no impacts resulting from the base scenario.

Impacts on Forest Management Activities

The changes to management agencies caused by an increase in the level of harvest will not trigger the significance criterion as this was developed to assess impacts by sector at a regional scale. Precise estimates are not available for the additional funding and personnel that might be required by federal, state, and county land management agencies to meet future increase in timber harvests. However, additional resources will need to be committed by state government and the counties to implement the harvest level and mitigations recommendations.

Impacts on Recreation and Tourism

It was not possible to directly link increased timber harvesting with changes in recreation activities. In addition, it was not possible to develop linkages between the level of harvesting and the levels of tourism activities or expenditure patterns. As a consequence, it has not been possible to quantitatively assess how the increased timber harvesting levels considered would economically impact the sectors identified in the FSD. In the absence of quantitative assessments it is not possible to trigger the significance criterion.

7.6.8
Summary of Significant Impacts

The high scenario significant impacts identified in sections 7.6.1 to 7.6.7 are the same as those listed in section 5.6.8 as explained in section 6.6.8. The difference between scenarios is in the degree or scale of impacts rather than in the type of impact. The high scenario in most cases showed more significant impacts in terms of acreage and/or species impacted than the base

Table 7.19. Economic sectors in Minnesota with significant increases in employment, employee compensation, and TIO due to increased levels of timber harvesting under the medium and high scenarios. (Direct, indirect, and total impacts, in employment [jobs] and in millions of dollars.)

IMPLAN Sector	Baseline TIO	Medium Scenario				High Scenario			
		Direct Effect	Indirect Effect	Total* Effect	Percent of Base	Direct Effect	Indirect Effect	Total* Effect	Percent of Base
Sectors with significant increases in employment (jobs)[a]									
160 Logging Camps and Logging	2,016		488	489	24		2,007	2,008	100
188 Paper Mills, Except Building	8,252	352	0	352	4	2,812	0	2,812	34
456 Electric Services	12,116		173	192	2		873	976	8
446 Railroads and Related	8,732		135	138	2		684	698	8
24 Forestry Products	1,386		131	132	10		551	559	40
22 Forest Products	75		6	6	7		24	24	32
161 Sawmills and Planing Mills	941		10	10	1	247	56	316	34
170 Wood Pallets and skids	193		4	4	2		19	19	10
Total, all sectors in Minnesota	2,085,517	352	3,788	6,752	0	3,059	18,424	35,094	2
Sectors with significant increases in employee compensation ($ millions)[b]									
188 Paper Mills, Except Building	380.22	16.19	0.01	16.20	4	129.35	0.06	129.41	34
456 Electric Services	455.54		6.49	7.23	2		32.82	36.68	8
446 Railroads and Related	384.95		5.86	6.04	2		29.73	30.64	8
160 Logging Camps and Logging	23.13		5.60	5.61	24		23.03	23.05	100
521 Other State and Local	180.14		1.35	1.75	1		6.82	8.92	5**
24 Forestry Products	1.89		0.18	0.18	10		0.75	0.76	40
161 Sawmills and Planing Mills	9.64		0.16	0.16	2	3.85	0.86	4.73	49
170 Wood Pallets and Skids	2.34		0.05	0.06	3		0.27	0.28	12
Total, all sectors in Minnesota	43,230.86	16.19	84.42	146.38	0	133.20	418.87	790.41	2
Sectors with significant increases in TIO (any scenario) ($ millions)[c]									
188 Paper Mills, Except Building	1,568.1	611.2	0.3	611.4	39	3,062.1	1.3	3,063.4	195
456 Electric Services	2,814.1		40.1	44.7	2		202.8	226.6	8
160 Logging Camps and Logging	126.9		30.7	30.8	24		126.3	126.4	100
457 Gas Production and Distribution	885.0		13.5	15.2	2		68.2	76.9	9
235 Petroleum Refining	1,038.0		11.4	13.1	1		57.3	66.0	6
446 Railroads and Related	758.6		11.6	11.9	2		58.6	60.4	8
24 Forestry Products	65.7		8.7	8.8	13		31.1	31.5	48
521 Other State and Local	550.1		4.4	5.6	1		22.0	28.8	5
161 Sawmills and Planing Mills	47.8		0.9	0.9	2	21.9	4.9	26.9	56
22 Forest Products	4.7		0.3	0.4	7		1.4	1.5	32
170 Wood Pallets and Skids	8.6		0.2	0.2	2		1.0	1.2	13
Total, all sectors in Minnesota	140,462.7	611.2	297.0	1,059.5	1	3,084.0	1,451.2	5,324.1	4

Source: Jaakko Pöyry Consulting, Inc. (1992h).
[a]Sectors 160, 446, 464, 27, 161, 172, and 23 adjusted to reflect IMPLAN revisions in the north region. Units are number of jobs above baseline employment.
[b]Sectors 188, 160, 521, 27, 161, 170, and 172 adjusted to reflect IMPLAN revisions in the north region. Units are employee compensation above baseline compensation ($ millions).
[c]Sectors 188, 160, 24, 521, 464, 27, 161, 170, and 172 adjusted to reflect IMPLAN revisions in the north region. Units are increase in TIO above baseline ($ millions).
* Total effect in industry output includes direct, indirect, and induced (not shown) increases.
** Less than 5.0 percent, but rounded up to 5 percent.

and medium scenarios. In some cases, for example soil nutrient losses, the effect was closely related to the acreage harvested. However, in other cases, notably wildlife impacts, there was a large increase in the number of significant impacts.

7.7 Recommended Mitigation Strategies

The strategies developed to mitigate significant impacts projected to occur at the high level of harvest (7.0 million cords per year) will include those developed to mitigate the significant impacts identified at the base (4 million cord) and medium (4.9 million cord) levels of harvest. For most covertypes, the difference among the three scenarios is related to the intensity of harvesting activity at the landscape level. *The types of site level impacts will be unchanged and, therefore, the same mitigations will be required; although, mitigations would typically need to be applied to more area than under the base scenario*. For example, the area of harvest units expected to be significantly impacted by compaction was approximately 840,000 acres under the base scenario, 1,050,000 acres under the medium scenario and 1,240,000 under the high scenario. Therefore, the same mitigation strategies would have to be applied to an additional 190,000 acres to mitigate significant impacts under the high scenario as compared to the medium scenario.

In addition, the same mitigations applied because of significant impacts identified at the base and medium levels may also mitigate other impacts projected to occur at the high level of harvest. For example, the intensity of harvesting in a covertype projected under the base level may have resulted in projections of significant impacts on a single squirrel species; while under the medium scenario, the more intensive harvesting in the same covertype may have resulted in significant impacts on two additional squirrel species and two bird species. The same mitigation strategy, e.g., retain cavity and mast trees may mitigate all impacts.

Similarly, more intensive harvesting at the landscape level will not change the types of impacts; however, the *need* for mitigations will likely increase with increasing intensity of harvest. Hence, the strategy to develop a connected landscape, and the principles guiding development of that strategy remain the same at all three levels of harvest; however, the need for this mitigation increases as the level of harvest increases and the degree of human induced change in the landscape increases.

The rate of harvest over the 50-year study period will also affect the level of impacts. This is particularly the case with mitigations that depend on information being gathered. Information on the locations and ecology of plant species classified as endangered, threatened, and special concern is a good example. Stands harvested without that information increase the likelihood of impacts. Therefore, the more stands harvested before the information becomes available, the greater the impacts.

Therefore, the strategies presented in section 5 for the base scenario will apply to the mitigations required under the high scenario. However, these mitigations will often need to be applied to more areas or there is greater urgency to them.

7.7.1 Recommended Strategies Development

The criteria and process for developing recommended mitigation strategies was described in section 5.7.1.

7.7.2 Recommended Strategies

This section identifies the strategies developed to mitigate significant impacts projected to occur at the high level of harvest (7.0 million cords per year). These strategies, many of which reflect the mitigation measures developed in the technical papers, have been combined and modified where required in order to achieve multiple objectives and resource protection goals. Mitigation strategies that would improve the standard of forest practice in Minnesota but do not directly mitigate significant impacts are also presented.

The strategies recommended to address significant impacts at the high level of harvesting are presented under three categories which reflect their main focus:

1. site-level responses;
2. landscape-level responses; and
3. forest resources research.

The actual mitigations recommended for each of these categories were listed in section 5.7.2.

7.7.3 Effectiveness at Mitigating Significant Impacts

The following section discusses the relative effectiveness of the proposed strategies as mitigations for the significant impacts projected to occur under the high scenario.

1 Impact
Projected significant loss of forest area in ecoregions 1, 3, and 4
Reduce the area of forest converted to nonforest land uses: The process of land use conversion is independent of the level of harvesting. The proposed strategy seeks to influence NIPF ownership to maintain forested land under forest cover, irrespective of their management objectives for the land. The effectiveness and feasibility of this mitigation strategy was discussed in section 5.7.3 and those findings apply as well to the high harvest scenario.

2 Impact
Projected harvesting affecting patterns of forest cover in areas of mixed land use
These impacts would affect species that depend on the features of mature forest and forest interior species. The following strategies will mitigate these impacts.

Maintain patches of forest intact in areas of mixed land use: By reducing use of clearcutting silvicultural systems, linking patches, and augmenting existing patches of forest.

Mitigations to maintain populations of forest interior species and the Red-Shouldered Hawk will need to maintain forest interior conditions in remnant patches. Large (>300 acre) blocks of mature forest will likely have to be retained with only periodic disturbance to maintain the most sensitive species.
Effectiveness: If applied at a regional scale this mitigation strategy will likely be effective at mitigating impacts by maintaining these important habitats. The increased level of harvest is projected to be mainly within northern ecoregions which are not the focus of the mitigation strategy.

Feasibility: As discussed in section 5.7.3, the feasibility of this strategy is heavily dependent on NIPF owners adopting the constraints on management of their forests.

Retention of large blocks of forest with constraints on the amount of disturbance is less likely to be successful because this aspect of the strategy will likely require cooperation of more than one NIPF landowner. As more landowners become involved the likelihood of **all** owners cooperating will decrease. Purchase of these blocks for inclusion in the state's reserve system is likely the most effective means to achieve this mitigation.

3 Impact
Projected changes to tree species mix
Projected changes to tree species mixes in the state's forests are likely to result from changes in the age class distributions of covertypes as well as

from direct impacts on minor tree species. The strategy depends on several distinct elements which are discussed below.

Monitor the age class structure and covertype structure of the state's forests and their patterns across the landscape: This mitigation would not mitigate impacts directly but would contribute information that would allow informed decisions to be made concerning other mitigations.

Complete the MNDNR county biodiversity inventory: This mitigation would not mitigate impacts directly but would contribute information that would allow informed decisions to be made concerning other mitigations.

Conduct an inventory of old growth forests across all ownerships: This would not mitigate impacts directly, but would contribute information to assist decisions on other mitigations. Specific guidelines for managing the identified sites would have to be developed for USDA Forest Service, MNDNR, and county-managed lands.

Maintain desired age class distributions for each covertype: Offers the prospect of modifying the tree species mix by insuring that there are adequate numbers of stands present in the state that are likely to provide suitable conditions for the full range of species.

Maintain desired covertype distribution: This provides for maintenance of tree species mix by management to achieve acreage goals by covertype. The available tools include harvesting and a range of silvicultural practices that favor certain species and covertypes. In some areas, restoration of forest cover by planting or enrichment may be appropriate. In other situations minimal disturbance might be effective to allow natural succession.

Effectiveness: The mitigation strategy would likely be only moderately effective and would require long periods to achieve even detectable change. Because harvesting is the only practical tool available for these landscape scale manipulations there are inherent constraints on the range of covertypes that will likely be manipulated. Typically changes will be focussed on covertypes dominated by the more commercial species. The projected increases in demand for some species such as black spruce and balsam fir will assist in efforts to balance age classes. Stands of other noncommercial covertypes and those within reserved forests will likely continue the trend towards older age classes. Use of other tools such as fire and special silvicultural systems would likely be very expensive and confined to important stands.

Feasibility: The mitigation is moderately feasible as the major public ownerships have policies to maintain biodiversity. The other ownerships typically have no clear management objectives in this area and are less likely to direct their management to achieve these goals. Therefore, the mitigation would be focussed on the major public owned forests

4 Impact
Projected changes in the age class structure of paper birch
This was the only covertype projected to have significant changes to the age class distribution. The following elements comprise the mitigation strategy for this covertype.

Monitor age class and covertype structure of the state's forests and their patterns across the landscape: This would not mitigate impacts directly but would contribute information that would allow informed decisions to be made concerning other mitigations.

Conversion of older stands to young stands to balance the age class structure: Would require that old stands be harvested and new stands regenerated.

Effectiveness: If a proportion of older stands could be replaced by younger stands the mitigation would be effective.

Feasibility: The mitigation is only moderately feasible because the covertype is not a sought after commercial species and is difficult to regenerate once stands become too old to reliably stump sprout. The major public ownerships will likely undertake limited regeneration programs but these will likely be inadequate to balance the age class distribution.

5 Impact
Projected harvesting affecting genetic variability of plant or animal species
Harvesting is projected to lead to further fragmentation of the forest and to impact outlier populations of some species and some plant communities. The following elements make up the mitigation strategy to mitigate these impacts.

Complete the MNDNR county biodiversity inventory: This would not mitigate impacts directly but would contribute information that would allow informed decisions to be made concerning other mitigations.

Develop blocks of ERF: Would promote additional diversity of covertype condition and would provide habitat for species dependent on mature/older forest. ERF policies are likely to be confined to the major public ownerships.

ERF and riparian corridors would maintain many opportunities for transfer of genetic materials between separated populations of forest plants and animals. In the northern ecoregions where public ownerships dominate ownership patterns, remnant old growth is preserved and ERF policies are being implemented. In the southern part of the state, the riparian zones will be the most important vectors for genetic transfer.

Modified silvicultural systems: Such as use of uneven-aged and thinning for harvesting and retention of key habitat requirements would likely maintain conditions that are suitable for many of the species likely to be significantly adversely impacted.

Effectiveness: Combinations of these mitigations will likely be effective at reducing significant impacts by providing a range of age classes in each covertype and linkages for transfer of genetic material.

Feasibility: The major public ownerships have mandates to manage for biodiversity. However, application of these mitigations within forests managed by ownerships other than the major public landowners is likely to be mixed and will depend on owners' objectives. Consequently, the mitigation is rated at low to moderate feasibility. It will likely be more feasible in the north and less feasible in the south of the state.

6 Impact

Projected harvesting affecting federal- or state-listed species of special concern, threatened or endangered or their habitats

Impacts affecting populations of these species of plants and the communities that contain them are interpreted to occur as a consequence of harvesting because little is known of their locations. The significant impact criterion threshold was set at any diminution or disturbance of habitat or populations of these species. Projected increases in levels of harvesting, particularly in ecoregions 3 and 4, will increase the risk that such impacts will occur, especially under the high scenario.

The mitigation strategy directed towards maintaining genetic variability discussed previously will likely mitigate these significant impacts.

Complete the MNDNR county biological survey: There is a strong likelihood that populations of these species and the communities which support them will be disturbed and diminished under circumstances where the occurrences of these species remains unknown. Therefore, significant impacts are likely to be higher in areas that have not been surveyed by the MNDNR county biological survey.

Concern for completion of an old growth inventory, as noted in section 5, increases with the level of harvesting.

Effectiveness: The effectiveness of the strategy is highly dependent on access to information on the occurrences of these species and the communities that support them. Consequently, the rate at which harvesting occurs is an important factor. The increased level of harvesting under the high scenario means that during any given period, approximately 21 percent more timberland will be harvested than under the medium scenario. Therefore, to maintain the risk of impacting these species it will be necessary as a minimum to greatly increase the rate at which the survey is done. Planning based on information available from this program would enable the locations of these populations to be noted and harvesting redirected. The effectiveness of the strategy relies largely on increasing the funding and staffing allocated to the MNDNR county survey.

Feasibility: The strategy is likely to be moderately feasible subject to adequate funding being provided to complete the biodiversity survey.

7 Impact

Changes in the susceptibility and vulnerability of covertypes to forest health risks

Impacts were interpreted based on projected changes to age class distributions and circumstances where multiple-entry harvesting systems were to be used. The changes in forest health projected to occur primarily reflect the increasing age of stands in the noncommercial covertypes on timberlands and all covertypes within reserved lands. The mitigation strategy is aimed at developing statewide plans to handle pest outbreaks and to modify the equipment and techniques used in multiple-entry harvests. The following outlines the elements of this strategy.

IPM strategies: Will assist to mitigate impacts associated with major outbreaks such as gypsy moth. Planning such as advocated under this mitigation will allow a more rapid response and therefore will likely reduce the level of impact experienced.

Modify equipment and practices for use in multiple entry harvesting operations: Will likely reduce the incidence of damage to residual stems and will therefore reduce the incidence of pests and diseases that are associated with wounds. This will have particular application in the south of the state.

Maintain desired age class distributions for each covertype: Will allow the prospect of reducing the proportion of susceptible and vulnerable covertypes on ownerships with wood production objectives.

Effectiveness: The mitigation strategy is likely to be moderately effective at providing the basis for reducing the scale of damage caused by major outbreaks of pests, particularly pests such as gypsy moth. The localized impacts caused by damage to retained stems would likely be reduced if the mitigations to equipment and practices were introduced.

Feasibility: The strategy is likely to be moderately feasible subject to participation by the major stakeholders in the process of developing IPM strategies. Adoption of new harvesting equipment and techniques will likely be of moderate feasibility subject to provision of assistance to undertake trials and subsequently, to loggers willingness to make the investments needed to replace equipment.

8 Impact

Projected harvesting affecting site nutrient capital

Nutrient losses above estimated levels of replenishment were projected to occur for several combinations of covertype/soil type/harvesting practices. The increased harvesting projected to occur under the high scenario will increase the requirement for this mitigation by increasing the area of timberland projected to be significantly impacted. These significant impacts can be mitigated by changing the length of rotations and the harvesting methods used. The following strategy has been developed to mitigate these impacts.

Retain or redistribute slash within the cutover: Will maintain the nutrients contained in the leaves (needles) and branches within the cutover. This can be achieved either by favoring use of equipment that retains slash at the site where the tree was felled; or, slash from landings can be redistributed using existing equipment. Development of systems that could undertake partial or full bark removal in the cutover would also greatly aid nutrient retention.

Manage a proportion of stands under ERF guidelines: Would extend the period for nutrient replenishment prior to the next harvesting operation.

Effectiveness: The mitigation of retaining or returning slash and (if feasible) bark within the cutover is likely to be a very effective strategy for reducing nutrient loss. Longer rotations are also effective by allowing natural processes to replenish the nutrients lost in harvest or in site preparation. The duration is long-term, but effectiveness is reduced with time as species reach advanced ages and become less vigorous and more susceptible to forest health problems.

Feasibility: In some cases the strategy can be implemented relatively easily. However, overall feasibility will depend upon operational and technical constraints, particularly on the harvesting technique, the equipment available, and to some extent the season of harvesting as it facilitates removal of bark. Equipment to remove branches and bark at the stump is currently operational overseas. In the long-term, feasibility should be high. Return of slash to a site from a landing or elsewhere would also be similarly effective and long-term. Its feasibility would be affected by the added cost of another pass of equipment over the site and the potential compaction and puddling associated with such an activity. Returning material in winter would minimize the latter effect. The duration of the effect is long-term.

The feasibility of applying longer rotations is problematic for short-lived species and benefits diminish with time as nutrient levels return to preharvest levels. Under the high scenario, substantial acreage would need to be under short rotation.

9 Impact

Projected harvesting affecting soil physical structure

Compaction and puddling is projected to most frequently impact well-drained medium-textured soils (the most common soil in the state) and poorly-drained medium- and fine-textured soils. The likelihood of impacts is affected by the extent of roading, type of equipment, and the season of harvest. The following describes the mitigations that comprise this strategy.

Develop landscape-based road and trail plans: This strategy would involve planning and coordination between ownerships to develop landscape-based road and trail plans. The plans would cover development of new roads, long-term access needs and closure policies.

Modify times of equipment operation to minimize compaction: Is intended to reduce the occurrence of compaction by identifying susceptible sites and limiting operations on those sites to periods when the risk of compaction is lowest.

Effectiveness: If fully implemented, the strategy would likely be moderately effective at mitigating the significant impacts.

Feasibility: Development of landscape-based plans would require a leadership role to initiate the process and to coordinate responses from other ownerships. The MNDNR is the agency best placed to undertake this role. This strategy is feasible given the existing MNDNR responsibilities to produce an inventory of state forest roads under the MFRMA of 1982. In addition, the number of ownerships likely to be developing new roads in the more remote areas is limited. The cost of adopting this mitigation would center on the additional planning that some ownerships would have to undertake to participate in the process. Additional costs would also be incurred by the MNDNR in coordinating and compiling inputs from others.

Constraints on equipment operation during susceptible periods will require assessments of site susceptibility at an operational scale if preventative measures are to be effective. In most areas, soil maps and other tools are *not* available at the stand or harvest unit scale. Confirmation of site susceptibility will require on-the-ground inspection by natural resource professionals. This will likely require additional training and staffing of forest management organizations. The MNDNR, USDA Forest Service, and possibly the larger counties and forest industries are best equipped to undertake this mitigation. It is unlikely that planning and assessments on NIPF lands would reach this level of sophistication and consequently this mitigation is unlikely to be feasible on these lands.

The feasibility of imposing seasonal restrictions on harvesting on some soil types or delaying operations that are already underway would likely be constrained by the financial hardship to loggers that would likely happen as a consequence of these actions. In addition, these restrictions may interfere with the continuity of supply to some mills. The feasibility will therefore also be constrained by the flexibility of forest industries delivery schedules.

10 Impact
Projected harvesting causing accelerated erosion from forest roads
Forest roads are the primary sources of accelerated erosion from harvested areas. The mitigation strategy aimed at reducing compaction will also mitigate erosion impacts.

The key elements of the above strategy that will mitigate accelerated erosion impacts include adherence to BMPs: consistent road closure policies; and reducing the length of road constructed while improving the standard of design, construction, and maintenance.

Effectiveness: These mitigations will reduce the amount of poor standard forest roads that are likely to cause erosion. If applied throughout the state this strategy would provide moderately effective mitigation of the impact.

Feasibility: The main erosion problems in the state occur in the southeast where there is less likelihood that these measures will be adopted because of the predominance of NIPF lands in this region.

11 Impact
Projected changes in the populations of forest dependent wildlife
Projected changes to wildlife populations were based on changes in the amount and quality of likely habitat within the known ranges of each species or group of species. The mitigation strategy is intended to:

- identify and protect important habitats;
- provide a range of age classes within each covertype in particular to maintain habitat features of old and old growth forests;
- maintain patches of forest in areas of mixed land use;
- provide a landscape with connections necessary for movement of animals among separated populations;

- modifications to harvesting practices to maintain within cutovers some of the key habitat needs for animals dependent on features of mature forests; and
- distribute logging slash to provide cover for small animals in clearcuts.

The following discusses each element of the proposed mitigation strategy and assesses the overall effectiveness and feasibility of the strategy.

Complete the MNDNR county biological survey: The information from the survey is essential to identify important habitats for forest dependent species. Earlier comments on the importance of the rate of harvesting and its relation to the speed of the survey also apply here.

Conduct an inventory of old growth forests across all ownerships: This information is important to identify habitat for species dependent on old growth forests.

Develop blocks of ERF: Would promote additional diversity of covertype condition and would provide habitat for species dependent on mature/older forest. ERF policies are likely to be confined to the major public ownerships. ERF and riparian corridors would maintain many opportunities for movement of animals between separated populations.

Maintain patches of forest intact in areas of mixed land use: By reducing use of clearcutting silvicultural systems, linking patches, and augmenting existing patches of forest. This mitigation strategy incorporates aspects of mitigations including management of riparian corridors and use of uneven-aged silvicultural systems in those patches that are harvested. Large (>300 acre) blocks of mature forest will likely have to be retained with limited disturbance to maintain populations of the most sensitive species, especially the Red-Shouldered Hawk.

Modify silvicultural systems to maintain key habitat components: Such as use of uneven-aged and thinning systems as substitutes for clearcutting where appropriate, i.e., in certain covertypes that can be managed using these systems.

Redistribute slash across the cutover: Would maintain cover for small mammals in cutovers following clearcutting.

Effectiveness: Maintenance of key habitat requirements and slash spreading would likely be moderately effective at maintaining habitat for adversely impacted species in those covertypes harvested using clearcutting systems. Mitigations that substitute uneven-aged silvicultural systems for clearcutting will likely be effective at maintaining suitable habitat conditions for species dependent on elements of mature forests, but would likely provide moderate to low levels of mitigation for species dependent on forest interior conditions and limited disturbance.

ERF, old growth, and connected landscapes would provide habitat for species dependent on old forest and forest interior species. The focus of these mitigations is likely to be in the northern half of the state because of the pattern of ownership. These mitigations are less likely in the south because of predominantly NIPF ownership. Maintenance of large patches of unharvested forest in these areas will likely be moderately effective at maintaining populations of forest interior species present in the south.

Feasibility: Modifications to maintain key habitat features are widely practiced on lands by the major public ownerships and are being introduced by some counties. Introduction of these mitigations to NIPF and industrial lands will likely be dependent on the costs associated with their adoption, the owner's awareness of the need for these mitigations, and the willingness of loggers to implement the mitigations at an operational level.

Replacement of clearcutting with uneven-aged silviculture systems is actively being undertaken by the major public landowners as part of their ERF programs. In addition, these systems are likely to be used on NIPF lands in the south of the state. This is because the covertypes and range of products sought in the south are more suited to these systems.

ERF and old growth are likely to be feasible on public lands in the northern part of the state. These measures are consistent with the mandate given these ownerships. The feasibility of maintaining large blocks of forest in the south is less likely because of the problems associated with coordinating uniform management with more than one owner as were discussed previously.

Similarly, connecting corridors of ERF would be more feasible in the north, where there are large contiguous blocks of public ownership. Given that a sizable portion of the landscape is going to be managed as ERF anyway, the cost of ERF corridors might be modest, since corridors might simply be a different spatial arrangement of ERF—some of it in strips instead of all in blocks. ERF corridors would likely be infeasible in the south, due in large part to the high cost of purchasing easements across private lands in areas that are intensively farmed. As a consequence, riparian corridors will probably always provide the major habitat linkages in the southern part of Minnesota.

The overall strategy is likely to be moderately successful at mitigating impacts on those species projected to be significantly impacted. The need for it increases under the high scenario as compared to the base and medium harvest levels.

12 Impact

Projected harvesting affecting populations of the Red-shouldered Hawk, Louisiana Waterthrush, and pine marten

These are the only animal species listed as a federal or state species of special concern, threatened, or endangered. The Red-shouldered Hawk and pine marten are projected to be significantly impacted because of harvesting in larger patches of forest. The pine marten is found in a variety of mature forest types in the northern part of the state where such habitat exists in large blocks.

The strategies discussed under impact 11 which seek to mitigate impacts on all significantly impacted wildlife populations includes all the elements likely to benefit these species. Developing blocks of ERF, maintaining linkages between patches of remnant forest or old growth via connected landscapes, and maintaining patches of forest intact in areas of mixed land use are the three strategies discussed under impact 11 most likely to benefit the Red-shouldered Hawk and pine marten.

13 Impact

Projected harvesting affecting patterns of mature lowland conifer stands

Patches of mature lowland conifers are important habitat, particularly in those parts of the state where lowland conifers occur as small isolated patches within more extensive upland forests. The strategy is intended to maintain such stands as an ongoing part of the landscape. The substantial increases in the volumes of lowland conifers projected to be harvested under the high scenario will likely increase the need for this mitigation. The following describes the proposed elements of this strategy.

Retention of conifer patches in clearcut stands: Is part of existing federal and state management guidelines. This mitigation would require that these patches be excluded from harvests on other ownerships that are primarily directed at obtaining upland species.

Effectiveness: If applied, the mitigation would maintain these habitat elements within cutovers in predominantly upland stands.

Feasibility: The mitigation is straightforward and could be easily applied at an operational level. The major public ownerships already undertake elements of this mitigation in their current management strategies guidelines, particularly for deer management. It is less likely that NIPF and industrial owners will adhere to these guidelines because the retention of conifers could present a real cost. The level of compliance will likely reflect the value of the species retained.

14 Impact
Projected harvesting affecting the availability of food producing trees
The loss of food producing trees such as oak and hickory were projected to impact species such as the gray and fox squirrels that rely on mature oaks to provide food and shelter (cavities). The following mitigations make up the strategy directed at maintaining these habitat features.

Clearcutting with residuals: Will retain mature food producing trees in those covertypes that include such trees as part of the species mix. This mitigation would favor retention of trees such as oak, hickory, mountain ash, and cherry. Federal and state management guidelines favor retention of these trees on the major public timberlands.

Effectiveness: This mitigation would preferentially maintain these important habitat elements in areas subjected to clearcutting. Retention of these trees would be moderately effective in sustaining populations of animals dependent on food from these trees.

Feasibility: The feasibility of this mitigation is dependent on ownership. The state and federal lands are likely to forgo the revenues possible from sale of these trees (especially oak). In contrast, the mitigation is less likely to be feasible on NIPF and industry owned lands and on many county managed lands as these owners are less likely to forgo the revenues. In addition, operations on these lands are less likely to be planned to maintain these habitat features prior to harvesting.

15 Impact
Projected harvesting in the absence of VMGs on visually sensitive areas
Timber harvesting and forest management activities that occur within the visual catchment of resorts or other outdoor recreation facilities are projected to cause significant impacts on aesthetic values where VMGs are not used. The mitigation strategy is aimed at developing (1) VMGs that can be applied as a minimum standard for all timberlands, and (2) coordinated planning of future road and trail development and closures.

Develop landscape-based road and trail plan: This would provide opportunities for a broad audience to learn about and affect the visual aspects of forest settings.

Development and promotion of VMGs for use on all timberlands**:** This would reduce the level of visual impact likely to occur as a consequence of harvesting related activities on ownerships that do not use VMGs.

Effectiveness**:** This strategy would provide a moderate level of effectiveness at reducing the likelihood of conflicts between the forest products industry and the tourism/recreation resort industry.

Feasibility: There is already some dialogue between resort owners and timber producers regarding timber harvesting, travel corridors, and the visual catchment of resorts. A variety of options are available that range from a cooperative agreement with the landowner to limit logging and/or to use VMGs if logged to purchase of visual easements.

16 Impact
Projected development of permanent roads in primitive and semiprimitive nonmotorized areas
Harvesting is projected to result in the development of permanent roads in primitive and semiprimitive nonmotorized areas. Doing so affects these sites by changing the recreational opportunities present and restoration to the original opportunities is by definition not possible. The problem is intensified by increased harvesting in the high scenario as compared to the base and medium scenarios.

Develop landscape-based road and trail plan: This would improve the chances for minimizing roads and trails that would change recreational opportunities on the more primitive sites and ensure that a variety of recreation opportunities are maintained across ownerships.

Develop guidelines for management road construction: Would provide for protection of recreational values and use in primitive and semiprimitive nonmotorized areas which are managed for timber production.

Effectiveness: In addition to the above noted benefits of road and trail planning for resort operators, such plans would provide the overview needed to develop an understanding of where primitive and semiprimitive nonmotorized recreational opportunities exist and might exist in the future. Coordination between ownerships is important to the success of this planning. Use of nonpermanent roads and VMGs can reduce the degree and period over which impacts persist.

Feasibility: These alternatives are potentially feasible subject to cooperation of the major timberland ownerships. However, this will require leadership by the MNDNR as the most appropriate agency to initiate and oversee the planning and development of nonpermanent road guidelines and their implementation. This planning and the development and implementation of guidelines would have long-term benefits.

17 Impact
Projected harvesting affecting unique cultural and historical resources
Harvesting is projected to significantly impact a range of archaeological, cemetery, and traditional use sites used by contemporary Native Americans.

Provide adequate resources to maintain the state listing of known sites: This would allow the state archaeologist to discharge current responsibilities to maintain an important reference describing the occurrences of sites in the state; and to provide a leadership role in developing a better understanding of the state's heritage resources. This mitigation is not linked to timber harvesting but extends to all land uses that involve soil disturbance.

Increase the proportion of harvests undertaken during winter: Reducing soil compaction by changing the season of harvest for susceptible soil types will likely mitigate some impacts as frozen soil will not experience the levels of compaction that would occur during other seasons.

Development of a landscape-based road and trail plan : This would provide opportunities for traditional users to comment on roading issues during the planning phase. This could help avoid conflicts.

Effectiveness: This strategy would provide a low level of effectiveness at mitigating the significant impacts projected to occur.

Feasibility: The feasibility of these mitigations is likely to be relatively low, due to the low priority given these resources by the majority of ownerships.

7.7.4 Cumulative Unmitigated Significant Impacts

The mitigation strategies described in the previous section will likely mitigate many of the significant impacts projected to occur under the high level of harvesting. This section identifies the cumulative unmitigated impacts that are likely to remain despite implementation of the mitigation strategies.

Loss of Forest Area and Timberlands
There is a strong likelihood that the area of forest in the north of the state will continue to decline. The area of timberlands will continue to decline as a consequence of the loss of forest area and the increased area of forest managed primarily for nontimber values. These reductions will exacerbate constraints on wood supply at the high level of harvesting. Increasing the productivity of the acres that remain available for harvest is achievable and could offset any losses of timberland acreage over the long-term.

Changes to Age Class and Covertype Structure
The levels of harvesting projected to occur under the high level of harvesting will improve the balance in the age class distributions for several of the species and/or covertypes that are currently underutilized from a timber production perspective and were showing marked shifts towards older age class distributions. The shift will be towards younger age classes. However, despite this reversal in the trend to older age classes, the projected age class

distributions at the end of the study period show the acreage of old forest will be similar or greater than what exists today for most covertypes. This is because there are areas that have been excluded from harvest where forests will continue to mature. Also, for some covertypes, the volumes harvested are less than the net increment in volume over the study period.

Changes to the paper birch covertype were assessed as being the only significant impact under the relevant age class criterion. However, there is a projected increase in the aspen covertype acreage at the apparent expense of conifer covertypes. That would be mitigated only by allowing natural succession to conifer covertypes, retention of conifers in harvested stands, and regeneration of harvested aspen stands by planting conifers or other practices that favor conifer establishment on a large-scale. This situation argues for covertype goals and practices to achieve them over the long-term.

Incidence of Pests and Diseases
The likely increase in the vulnerability and susceptibility of some covertypes to impacts from pests and disease is closely linked to the age class changes discussed above. Despite the effectiveness of an IPM plan, some impacts cannot be mitigated for the reasons set out above. The incidence of losses to pests and disease will likely be less under the high scenario as compared to the base or medium scenarios because of the trend to younger and generally less susceptible and vulnerable stands.

Impacts on Biodiversity
The lack of knowledge concerning the distributions and specific populations of endangered, threatened, and special concern species will likely lead to ongoing and increased frequency of localized impacts on these species as a consequence of timber harvesting operations. In the absence of this data, impacts on these categories of plants will continue and likely increase over the levels of impacts under the base and medium scenarios.

Populations of the Red-shouldered Hawk, Louisiana Waterthrush, and pine marten will likely be maintained under the proposed mitigations, although there is some uncertainty due to inadequate knowledge of the precise habitat requirements of these species.

Impacts on Forest Soils
More acres will be affected by losses of nutrient capital under the high as compared to the base and medium scenarios. Similarly, more acres will be compacted and experience accelerated rates of erosion. The projected increase incidence of these impacts increases the importance of mitigation strategies to minimize their occurrence.

Erosion from roads and other compacted areas will likely increase under the high scenario as compared to the base and medium levels of harvesting.

Improved road design, construction, maintenance, and consistent road closure policies will also become more important practices. Increased erosion can have subsequent impacts on water quality, though mitigations can be effective at reducing the risk of these secondary impacts occurring.

Impacts on Archaeological and Cemetery Sites
Uncertainty regarding the locations of these sites and their vulnerability to damage means that impacts will continue except on timberlands owned by the USDA Forest Service, on timberlands not available for harvesting, and on the comparatively high proportion of other lands where operations are conducted when the ground is frozen.

Impacts on Traditional Use Sites
Improved liaison between forest managers and Native American groups regarding future roading plans will likely reduce but not eliminate the incidence of impacts on these uses. The high scenario will greatly increase the importance of this liaison.

Loss of Primitive and Semiprimitive Nonmotorized Recreation Opportunities
Roading in these areas will likely reduce the areas of primitive and semiprimitive nonmotorized recreational experiences that are potentially available in the state. The consequences of this loss cannot be accurately gauged because the amount of use within these areas and the number of users affected is not known. Use of VMGs and the development of a coordinated road and trail plan will become imperative under the high scenario.

Impacts on Motorized Recreational Uses
Harvesting in visually sensitive areas without VMGs will adversely impact existing users of these sites. The maturing of many areas of forest, including formerly harvested areas, will likely provide new or replacement opportunities for these recreational activities. However, population growth and increased harvesting under the high scenario will exacerbate the problems of providing for this use.

Impacts on the Tourism and Travel-based Industries
The inability to quantify the linkages between the level of harvest and its consequences for the tourism industry means the likelihood of unmitigated impacts cannot be ascertained. However, it is likely that more resorts will be more adversely impacted by visually obtrusive harvesting operations within their viewshed or along access routes under the high scenario as compared to the base and medium level of harvesting. Use of VMGs will likely reduce the area adversely impacted and duration of impacts and will become imperative under the high scenario if conflicts over timber harvesting and resource management are to be avoided.

7.8 Conclusions

The harvesting projected to occur at the high level (7.0 million cords) is only marginally feasible over the study period given existing and likely future land management policies and practices. However, this scenario exhibits less margin for error in projection model accuracy and associated assumptions than the base and medium scenarios. In addition, impacts on soil productivity, wildlife habitat, and aesthetic values are more severe than for the base and medium scenarios and thus the effectiveness of mitigations in maintaining these and other characteristics and values is unlikely. The following paragraphs discuss the degree of certainty in these conclusions and implications.

Estimated timberland area changes and assumptions of timberland availability by ownership play a crucial role in the feasibility of this scenario. Loss of timberland acreage as projected or lesser availability of timberland for harvest without compensating investment to improve productivity contribute to making this scenario infeasible. The importance of these assumptions is underscored by the fact that feasibility was only achieved with substantial (25 percent) substitution of other species for aspen and relaxation of ASQs for the two national forests in Minnesota. Further, introduction of these assumptions caused changes to the forest different and beyond those projected to occur under the base and medium scenarios.

As with the base and medium scenarios, localized impacts will continue and increase, despite the introduction of proposed mitigation strategies. These impacts will increase and be most evident on NIPF lands as a consequence of likely lower standards of planning and supervision of field operations compared to large ownerships with professional staffing. However, if fully implemented across all ownerships, the previously identified mitigations would reduce both the likelihood and frequency of significant impacts that might degrade the long-term sustainability of the state's forest resources. The exception is the projected reductions in the nutrient capital of some low productivity sites. As discussed previously, the consequences of these reductions will need to be carefully monitored.

The high level of harvesting is still below the level of sustainable yield as defined from the standpoint of tree and forest growth potential. However, the high scenario harvest level fell over 1.5 million cords per year short of being sustainable over the long-term in a timber production sense given assumptions about ownership constraints, mitigations, etc. In other words, the growth and yield potential needed to achieve the 7.0 million cords per year level over the long-term is only achievable with substantial investment in practices that would improve productivity. Thus, at the current levels of productivity investments, the maximum long-term sustainable harvest level appears to be about 5.5 million cords per year. Also, at this level of harvesting there is little flexibility available to meet timber supply demands while making provision for nontimber values. Importantly, if some of the impacts cannot be effectively mitigated, then the 5.5 million cord level would not be sustainable as described in this study. Further, the increased pressure on the resource to meet these varied demands means that investments to increase productivity of timberlands would become essential if a higher than 5.5 million cord level of harvest were to be achieved. These investments could increase the productivity of stands to meet harvest levels and also allow more area to be used for other activities. However, such investment is a long-term strategy that must consider satisfying nontimber values in execution.

Harvest levels above 5.5 million cords per year appear sustainable only if, in addition to effective mitigation of impacts, (1) the loss of forest land projected in the north was halted, and (2) substantial investments in forest management are made to improve productivity. Such harvest levels would require long-term investments. Additionally, such harvest levels might require the USDA Forest Service allowable sale quantities on the two national forests to be relaxed.

As with the base and medium scenarios, there will be constraints in the supplies of aspen during the middle of the modelled period. The base and medium scenario projections assumed that 25 percent of the demand for this species would be transferred to northern hardwood species. However, that shift cannot be sustained indefinitely. Widening the range of acceptable species to more closely reflect the mixed species stands found in Minnesota increases management flexibility and possibly reduces the area that has to be harvested by reducing the amount of potentially usable wood fiber left on harvested sites.

The proposed mitigations will require a leadership role to oversee their development and application. At present, there is no agency with the authority for such responsibility extending across ownerships to discharge these responsibilities. In addition, the current diverse ownership patterns and associated objectives means that there are no broad-based direction or goals for a future forest condition being set within the state. Direction and goal setting clearly becomes extremely important with the high level harvest scenario.

Future forest industry developments should be directed towards industries that can utilize species that have the capacity to sustain high levels of harvesting. This includes covertypes that continue to show unbalanced age class distributions at the end of the high scenario study period. The assumed timber demand used to prepare the high scenario provides some guidance for possible species mixes for forest industries that could address these age class concerns.

The high scenario level of harvesting seems unlikely to be achieved. The statewide coordination across ownerships required at this level of harvest is doubtful. The considerable negative consequences for production of nontimber values from the forests, the extent of required mitigations, and cost of timber produced means that achieving widely satisfying results would be very difficult.