

Lake Superior State  
Forest Sustainable  
Forest Management  
Pilot Project

REPORT

10



# Modeling Forest Management on the Lake Superior State Forest

Brian Callaghan

J a n u a r y 2 6 , 1 9 9 9

## Table of Contents

|                                |    |
|--------------------------------|----|
| 1. Introduction .....          | 1  |
| 2. Landbase .....              | 1  |
| 3. Forest Dynamics .....       | 2  |
| 4. Silvicultural Options.....  | 5  |
| 5. Management Objectives ..... | 8  |
| 6. Model Execution .....       | 9  |
| 7. Model Outputs.....          | 10 |
| 8. Conclusions.....            | 14 |
| References.....                | 15 |

## List of Tables

|  |    |
|--|----|
| Table 1. Forecast age-class distribution for the Lake Superior State Forest..... | 11 |
|--|----|

## List of Figures

|  |    |
|--|----|
| Figure 1. Sample temporal succession pathways.....   | 3  |
| Figure 2. Sample catastrophic succession pathways.....   | 4  |
| Figure 3. Sample yield curve (current jack pine stands) .....  | 4  |
| Figure 4. Forest age operability limits.....   | 6  |
| Figure 5. Sample renewal costs and seedling requirements.....  | 7  |
| Figure 6. Sample post-renewal forest succession specification.....                                     | 7  |
| Figure 7. Sample tending specifications.....   | 8  |
| Figure 8. Forecast age-class distribution for the Lake Superior State Forest .....                     | 10 |
| Figure 9. Forecast forest area by forest type for the Lake Superior State Forest. ....                 | 12 |
| Figure 10. Forecast forest growing stock for the Lake Superior State Forest.....                       | 13 |
| Figure 11. Forecast average annual harvest area by forest type for the Lake Superior State Forest..... | 13 |
| Figure 12. Forecast average annual harvest volumes for the Lake Superior State Forest.....             | 14 |



## 1. Introduction

A model was constructed to forecast forest development in response to management actions in the Lake Superior State Forest (LSSF). The platform used to develop the model was the Strategic Forest Management Model (SFMM) (Davis, 1998), an optimization model developed by the Ontario Ministry of Natural Resources for use in analysis and planning.

This report describes the components of the model, some of the parameters used, and the outputs which the model creates.

A workshop was held with forest managers of the LSSF in June of 1998 to introduce to them to forest-level modeling with a tool such as SFMM. In the one-day workshop the contents, function and outputs of the model were covered.

The model of the LSSF has four primary components:

1. Landbase
2. Forest Dynamics
3. Silvicultural Operations
4. Management Objectives.

## 2. Landbase

The land area of the LSSF was summarized on the basis of the most recent operations inventory (OI) data. The LSSF is over 1 million acres in size. Of this total, 291,524 acres (28%) are classified as non-forested (includes upland and lowland brush, treed bogs, bog/muskeg, marsh, rock, sand dunes, grass, local use, water, other). The forested portion of the LSSF is 755,662 acres (72% of LSSF). The operable forest landbase is estimated to be 566,978 acres (75% of the forested portion of the LSSF, 54% of the LSSF). The remaining 188,684 acres have been excluded from timber production, and include 104,683 acres in deer yards as well as other influence zones.

The estimate of the operable landbase is somewhat conservative as it is based on the assumption that only commercial forests within the general forest influence zone will be available for timber production. One of the key decisions within the context of forest planning and in the determination of

allowable harvest rates is the area of timberlands that are available for management over the long-term. The management plan will have to define this area explicitly.

Forests were aggregated into 11 forest types for the purposes of modeling. (In practice these groupings would be the same as those planned for within the management plan.) They are:

| <b>Forest Type</b>               | <b>Silviculture System</b> |
|----------------------------------|----------------------------|
| White Pine (PW)                  | - Four-cut shelterwood     |
| Red Pine (PR)                    | - Clearcut                 |
| Jack Pine (PJ)                   | - Clearcut                 |
| Spruce/Fir/OC (SOC)              | - Clearcut                 |
| Mixed Swamp Conifer (MSW)        | - Clearcut                 |
| Aspen (ASP)                      | - Clearcut                 |
| Other Intolerant Hardwoods (OIH) | - Clearcut                 |
| Lowland hardwoods (LHW)          | - Clearcut                 |
| Northern Hardwoods (NHWs)        | - Selection                |
| Northern Hardwoods (NHWe)        | - Two-cut shelterwood      |

These forest types are the primary building blocks for the forest management model. Associated with each forest type are a range of silvicultural “prescriptions” that define the timing of harvest, renewal options, tending options, and treatment costs.

### 3. Forest Dynamics

The model constructed for the LSSF contains three types of forest succession: temporal, catastrophic and post-renewal.

Temporal succession pathways identify how a forest type will succeed in the absence of management actions or catastrophic disturbance. These pathways identify when stands change or succeed from one forest type to another (Figure 1). Temporal succession was applied to the three most shade-intolerant (pioneer) forest types (jack pine, aspen and other intolerant hardwoods). The rules used represent the type of succession found in neighboring jurisdictions.

```

Parameter: NaturSuccn(mu,fn,an,rn,ff,af,rf) /

! Sub- --- Current Class --- --- Future Class --- Average
! unit Forest Age Silv Forest Age Silv Proportn
! . Unit . Class . Inten . Unit . Class . Inten

! Natural succession from clearcut forest units EUPF

LSSF .PJ . 115 . Prsnt . SOC . 25 . Prsnt 0.15
LSSF .PJ . 115 . Prsnt . OIH . 15 . Prsnt 0.15
LSSF .PJ . 115 . Prsnt . PW . 15 . Prsnt 0.05
LSSF .PJ . 135 . Prsnt . SOC . 35 . Prsnt 0.20
LSSF .PJ . 135 . Prsnt . ASP . 15 . Prsnt 0.10
LSSF .PJ . 135 . Prsnt . OIH . 15 . Prsnt 0.10
LSSF .PJ . 135 . Prsnt . PW . 15 . Prsnt 0.05
LSSF .PJ . 155 . Prsnt . SOC . 35 . Prsnt 0.45
LSSF .PJ . 155 . Prsnt . ASP . 35 . Prsnt 0.20
LSSF .PJ . 155 . Prsnt . OIH . 15 . Prsnt 0.20
LSSF .PJ . 155 . Prsnt . PW . 35 . Prsnt 0.05

```

'Forest unit' is the term used within the Strategic Forest Management Model, It is equivalent to forest type.

### Figure 1. Sample temporal succession pathways.

In many forest types, catastrophic disturbances are a major force in directing/influencing future forest conditions. Catastrophic succession pathways, which illustrate what results after the forest type is destroyed by fires or wind, were defined for all forest types. In Figure 2, the preliminary catastrophic pathways are presented. Along the left-hand side are the present forest types, while across the top are the post-disturbance forest types (rows must add up to one). Along with the specification of the pathway for each forest unit, an annual average rate of occurrence that defines the cycle time for such occurrences is specified. In the example below, cycle rates are estimates reflecting an efficient forest fire control program that serves to lengthen cycle times.

To benchmark forest development in the absence of forest management, "natural" rates of fire occurrence can be used. If this is done and all active management is precluded (i.e., temporal and catastrophic succession are the only factors affecting forest change), the forest can be projected forward to approximate the type of forest nature would create (and when) from that which exists today. (This projection is based on the model's successional assumptions.)

| Forest Type | Cycle | Annual rate | Avg. Annu. Acres | Pr  | Pj  | SOC | Cdr | MSC | Asp  | OIH | NHWs | LHW | Pw   | NHWe |
|-------------|-------|-------------|------------------|-----|-----|-----|-----|-----|------|-----|------|-----|------|------|
| Pr          | 420   | 0.002       | 146              | 0.8 | 0.1 | 0   | 0   | 0   | 0    | 0   | 0    | 0   | 0.1  | 0    |
| Pj          | 420   | 0.002       | 223              | 0   | 0.9 | 0   | 0   | 0   | 0.05 | 0   | 0    | 0   | 0.05 | 0    |
| SOC         | 420   | 0.002       | 114              | 0   | 0.3 | 0.5 | 0   | 0   | 0.1  | 0.1 | 0    | 0   | 0    | 0    |
| Cdr         | 1042  | 0.001       | 41               | 0   | 0   | 0   | 1   | 0   | 0    | 0   | 0    | 0   | 0    | 0    |
| MSC         | 1042  | 0.001       | 51               | 0   | 0   | 0   | 0   | 1   | 0    | 0   | 0    | 0   | 0    | 0    |
| Asp         | 420   | 0.002       | 225              | 0   | 0.2 | 0   | 0   | 0   | 0.3  | 0.4 | 0    | 0   | 0.1  | 0    |
| OIH         | 420   | 0.002       | 79               | 0   | 0.2 | 0   | 0   | 0   | 0.3  | 0.4 | 0    | 0   | 0.1  | 0    |
| NHWs        | 1042  | 0.001       | 87               | 0   | 0   | 0   | 0   | 0   | 0    | 0   | 1    | 0   | 0    | 0    |
| LHW         | 1042  | 0.001       | 11               | 0   | 0   | 0   | 0   | 0   | 0    | 0   | 0    | 1   | 0    | 0    |
| Pw          | 1042  | 0.001       | 24               | 0   | 0   | 0   | 0   | 0   | 0    | 0   | 0    | 0   | 1    | 0    |
| NHWe        | 1042  | 0.001       | 12               | 0   | 0   | 0   | 0   | 0   | 0    | 0   | 0    | 0   | 0    | 1    |
| 1014        |       |             |                  |     |     |     |     |     |      |     |      |     |      |      |

Figure 2. Sample catastrophic succession pathways.

Timber volume is used as the measure of forest growth and yield. Initially, yield curves were derived from the OI data. Unfortunately, the volume data within the OI are weak and could not produce the required yield data. Yield curves were constructed from two separate sources that produced similar results. Yield data were taken directly from the FORSOM models formulated for the Escanaba River State Forest plan. Normal (empirical) yield curves from Ontario (OMNR, 1974, Normal Yield Tables [metric]) were combined with the OI data to produce a set of yield curves. Figure 3 presents the yield curve used for the current jack pine forest type.

|     | Soft-wood | Intol. Hard-wood | Tol. Hard-wood | Pine | Total |
|-----|-----------|------------------|----------------|------|-------|
| 5   | 0         | 0                | 0              | 1    | 1     |
| 15  | 0         | 0                | 0              | 4    | 4     |
| 25  | 0         | 0                | 0              | 8    | 8     |
| 35  | 0         | 0                | 0              | 12   | 12    |
| 45  | 0         | 0                | 0              | 15   | 15    |
| 55  | 1         | 1                | 0              | 17   | 19    |
| 65  | 1         | 0                | 0              | 20   | 21    |
| 75  | 2         | 0                | 0              | 21   | 23    |
| 85  | 2         | 0                | 0              | 22   | 24    |
| 95  | 4         | 0                | 0              | 20   | 24    |
| 105 | 2         | 0                | 0              | 20   | 22    |
| 115 | 4         | 0                | 0              | 16   | 20    |
| 125 | 3         | 1                | 0              | 12   | 16    |
| 135 | 3         | 1                | 0              | 12   | 16    |
| 145 | 3         | 2                | 0              | 11   | 16    |
| 155 | 4         | 2                | 0              | 9    | 15    |
| 165 | 0         | 0                | 0              | 0    | 0     |
| 175 | 0         | 0                | 0              | 0    | 0     |
| 185 | 0         | 0                | 0              | 0    | 0     |
| 195 | 0         | 0                | 0              | 0    | 0     |
| 205 | 0         | 0                | 0              | 0    | 0     |

Figure 3. Sample yield curve (current jack pine stands).

Strategic Forest Management Models have the facility to incorporate wildlife habitat suitability for a variety of species. *Wildlife Habitat Projections for 15 species in the Lake Superior State Forest* (Clark 1999), a companion to the present document, describes how a habitat matrix for the LSSF has been incorporated to facilitate integrated planning. The companion document indicates a need for a more rigorous link between forest type and habitat types.

#### 4. Silvicultural Options

The third component of the model constructed includes initial assumptions and specifications for silvicultural operations. Three broad classes of operations were included in the models: harvest, renewal and tending. Each forest unit has separate specifications.

Harvest age limits are set for each forest unit. These limits identify the age range during which a stand will be available for harvest. The model uses this information to net down the available areas for operations. Lower limits can be set to the chosen rotation age: they are often set to 10 years less than rotation so that all stands that will reach rotation in the planning term will be available. Other criteria, such as stand merchantability, can be used. The upper operability range represents the maximum age at which a stand within the forest unit is considered operable. In many forest types, the stand volumes begin to decline as the stand begins to break up and succeed to another forest type. Figure 4 displays the operability parameters for the 11 forest units used in the model. Ages are specified in years. An entry of "inf" means infinite. As an upper age it means the forest type is forever operable; as a minimum it excludes the forest type from clear-cut harvesting. An entry of "na" means that that forest type will not exist.

For clear-cut forest types, upper and lower ages are specified for the present forest and the available future forest types. ("Extensive" is the default and generally represents natural renewal.) For the jack pine forest type (PJ), the current forest will be available for harvest from age 60 to age 110. Stands that grow beyond 110 years will change only in response to temporal and catastrophic succession.

Forest types managed through selection management (NHWs) have no ages specified. They are harvested (in this model) through a series of selection cuts specified as a tending operation.

| Forest Types       | Present |       | Extensive             |       | Basic                |       | Intensive             |       |
|--------------------|---------|-------|-----------------------|-------|----------------------|-------|-----------------------|-------|
|                    | lower   | upper | lower                 | upper | lower                | upper | lower                 | upper |
| PR                 | 90      | inf   | 90                    | inf   | na                   | na    | 70                    | inf   |
| PJ                 | 60      | 110   | 70                    | 110   | 60                   | inf   | 50                    | inf   |
| SOC                | 80      | inf   | 90                    | inf   | 80                   | inf   | 70                    | inf   |
| CDR                | 100     | inf   | 100                   | inf   | na                   | na    | na                    | na    |
| MSC                | 100     | inf   | 100                   | inf   | na                   | na    | na                    | na    |
| ASP                | 50      | inf   | 50                    | inf   | inf                  | inf   | na                    | na    |
| OIH                | 70      | inf   | 70                    | inf   | inf                  | inf   | na                    | na    |
| NHWs               | inf     | inf   | inf                   | inf   | inf                  | inf   | inf                   | inf   |
| LHW                | 100     | inf   | 100                   | inf   | na                   | na    | na                    | na    |
| Shelter-wood Types |         |       | timing on second pass |       | timing on third pass |       | timing on fourth pass |       |
|                    | lower   | upper | min                   | max   | min                  | max   | min                   | max   |
| PW                 | 60      | 95    | 20                    | 50    | 20                   | 50    | 20                    | 50    |
| NHWe               | 80      | 110   | 20                    | 50    | na                   | na    | na                    | na    |

Figure 4. Forest age operability limits.

Shelterwood forest types (PW, NHWe) have a different form of specification. For the present forest, the operability limits set the first cut in the cycle. Subsequent specifications identify the minimum and maximum delays between cuts. PW is a four-cut uniform shelterwood, so the timing of the four passes is specified. NHWe is a two-cut shelterwood and has only one subsequent pass timing specified.

For each forest type, the treatment costs for various renewal intensities are provided in dollars per acre (Figure 5). For planting treatments, the average seedling requirements are specified in trees per acre. In the model constructed for this study, three broad treatment types were defined:

- Extensive Renewal** - Low-cost natural renewal.
- Basic Renewal** - Medium-cost renewal treatments such as aerial seeding with site preparation.
- Intensive Renewal** - High-cost renewal including site preparation followed by planting and a release treatment.

|     | \$/acre   |       |           | trees/acre |       |           |
|-----|-----------|-------|-----------|------------|-------|-----------|
|     | Extensive | Basic | Intensive | Extensive  | Basic | Intensive |
| PR  | \$15      | \$0   | \$350     | 0          | 0     | 700       |
| PJ  | \$15      | \$100 | \$350     | 0          | 0     | 700       |
| SOC | \$15      | \$240 | \$350     | 0          | 240   | 700       |

**Figure 5. Sample renewal costs and seedling requirements.**

For each forest type the post-renewal succession is defined in the percentage of the area moving into a specified forest type. Figure 6 shows the post-renewal succession pathways specified for two of the forest types on the LSSF. For jack pine the figure shows that 80% (0.8) of intensively renewed jack pine return to the jack pine forest type, 10% are converted to spruce (SOC) and 10% regenerate as aspen forest.

| Cur. FT | Renewal   | Future Forest Type |     |     |     |     |     |     |      |     |    |      |
|---------|-----------|--------------------|-----|-----|-----|-----|-----|-----|------|-----|----|------|
|         |           | PR                 | PJ  | SOC | CDR | MSC | ASP | OIH | NHWs | LHW | PW | NHWe |
| PR      | intensive | 0.8                | 0   | 0   | 0   | 0   | 0.1 | 0.1 | 0    | 0   | 0  | 0    |
|         | basic     | 0                  | 0   | 0   | 0   | 0   | 0   | 0   | 0    | 0   | 0  | 0    |
|         | extensive | 1                  | 0   | 0   | 0   | 0   | 0   | 0   | 0    | 0   | 0  | 0    |
| PJ      | intensive | 0                  | 0.8 | 0.1 | 0   | 0   | 0.1 | 0   | 0    | 0   | 0  | 0    |
|         | basic     | 0                  | 0.9 | 0   | 0   | 0   | 0.1 | 0   | 0    | 0   | 0  | 0    |
|         | extensive | 0                  | 1   | 0   | 0   | 0   | 0   | 0   | 0    | 0   | 0  | 0    |

**Figure 6. Sample post-renewal forest succession specification.**

Tending treatments in the model are specified as shown in Figure 7. In the case of thinning treatments, a complementary table identifies the proportion of stand volume harvested.

```

! Sub- --- Current Class --- Tendg --- Future Class --- Treatmt
! unit Forest Age Silv Treat Forest Age Silv Cost
! . Unit . Class . Inten . . Unit . Class . Inten ($/ha)

LSSF . PR . 25 . Inten . CmThin. PR . 25 . Inten 100
LSSF . PR . 45 . Inten . CmThin. PR . 55 . Inten 100

LSSF . PJ . 25 . Inten . CmThin. PJ . 35 . Inten 100

LSSF . NHWs . 55 . Prsnt . Sel . NHWs . 45 . Exten 15
LSSF . NHWs . 55 . Exten . Sel . NHWs . 45 . Basic 15
LSSF . NHWs . 55 . Basic . Sel . NHWs . 45 . Inten 15
LSSF . NHWs . 55 . Inten . Sel . NHWs . 45 . Inten 15
LSSF . NHWs . 65 . Prsnt . Sel . NHWs . 45 . Exten 15
LSSF . NHWs . 65 . Exten . Sel . NHWs . 45 . Basic 15
LSSF . NHWs . 65 . Basic . Sel . NHWs . 45 . Inten 15
LSSF . NHWs . 65 . Inten . Sel . NHWs . 45 . Inten 15
LSSF . NHWs . 75 . Prsnt . Sel . NHWs . 45 . Exten 15

```

**Figure 7. Sample tending specifications.**

The model also contains treatment types that allow for the afforestation of non-forest lands which were not applied in this preliminary model.

The transfer of lands from operable to reserves can be expressed as a percentage of the harvest area. For example, in the spruce and other conifer (SOC) forest type, it may be that 4% of the gross area allocated for harvest is set aside in travel corridors for moose.

## 5. Management Objectives

The model has four major management objective areas:

1. Financial resources
2. Future forest condition
3. Wood supply
4. Silvicultural operations.

The model can then use the various parameters in these areas to develop a number of management alternatives.

The model allows for the specification of budget levels used for forest operations. It provides the option of linking renewal expenditures to

stumpage (timber sales) revenue. The user can also set a discount rate to be applied when calculating net present value.

A future forest condition can be specified through a number of targets or constraints. The user can specify future required levels of forest growing stock and/or the composition of forest area by forest type and age class. Alternatively, percentage limits can be placed on elements of forest change and/or composition. The user can specify the percentage of area required in a certain type and/or condition (e.g., white pine, old-growth, old growth white pine). Forest managers can use this same approach when considering wildlife habitat needs. Further, the user can control the change in the area of an entire forest type (e.g., limit the change in the PJ forest type to  $\pm 10\%$ ).

Wood supply objectives can be specified in terms of specific volumes. The flow of volume can be regulated (e.g., even-flow, non-declining).

A variety of parameters can be set on silvicultural operations. Harvest area can be controlled through flow constraints (e.g., even-flow, non-declining) or through the direct specification of areas to be harvested. These targets can range from broad forest-type targets to specific age-class targets. Renewal can be targeted through area or percentage limits on the type of renewal to be undertaken for each forest type. Tending targets can be similarly specified.

## **6. Model Execution**

The model allows for a number of execution options. It can simulate forest development with no silvicultural operations. When the model is run with silvicultural operations, five separate objective functions are available:

1. Greatest value of the timber harvest
2. Greatest net present value
3. Least silvicultural cost
4. Least harvest area
5. Greatest value of timber during the period with the lowest available volume.

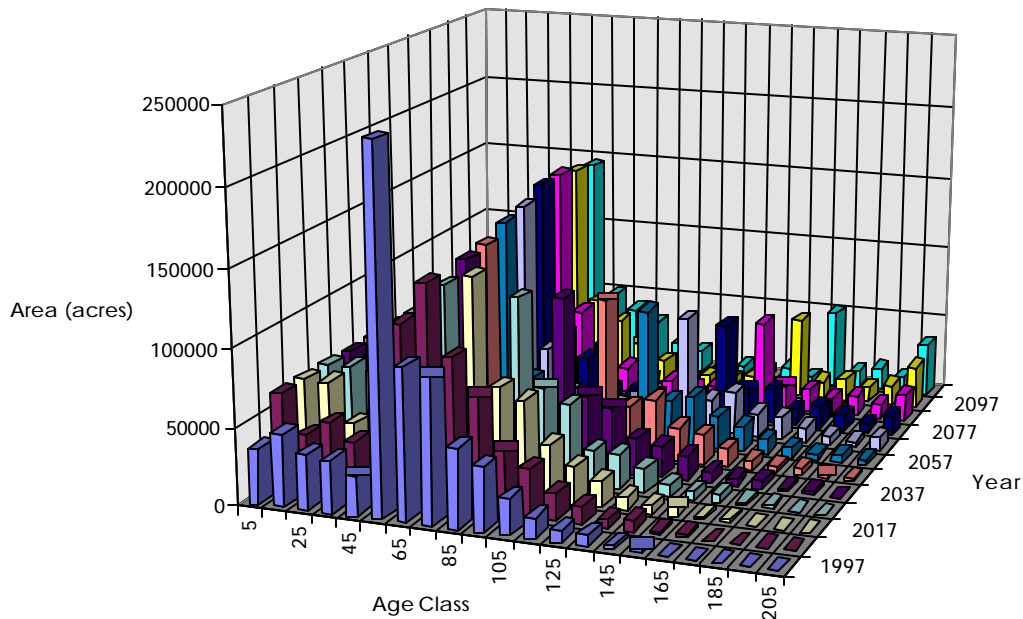
## 7. Model Outputs

A great variety of information is available from the model. Model results are provided at length for seven aspects of each management alternative:

1. Forest area
2. Forest dynamics
3. Areas treated
4. Volumes harvested
5. Finances
6. Wildlife habitat
7. Forest diversity.

Many of the indicators required for forest planning can be generated from such forest management models.

The model produces a diverse array of area reports that are based on the disposition of the forest (i.e., total, operable, reserved) and level of detail (e.g., forest type, age class). Figure 8 and Table 1 show the age-class distribution for the entire LSSF as forecast in the preliminary model. The figure shows how the distribution changes over the modeling horizon.



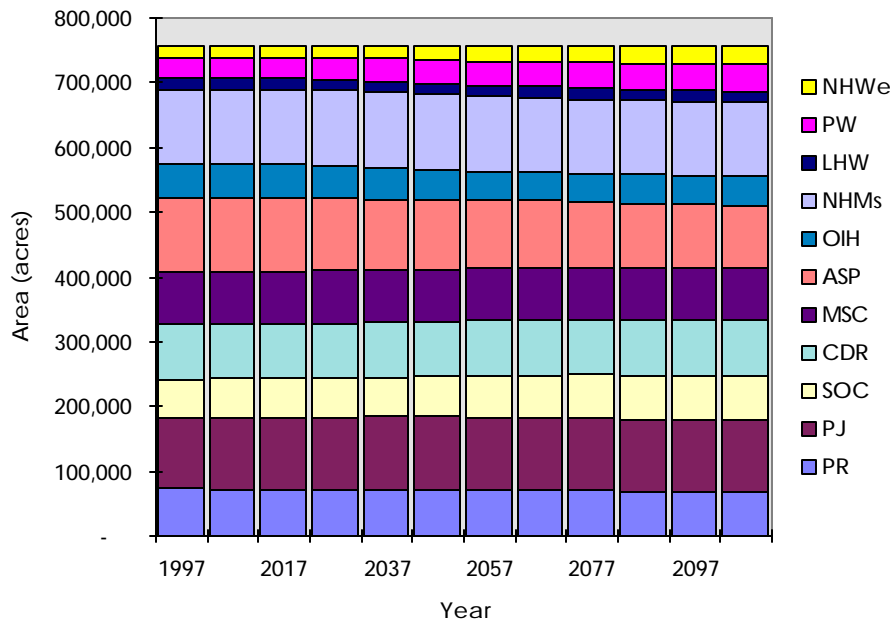
**Figure 8. Forecast age-class distribution for the Lake Superior State Forest.**

**Table 1. Forecast age-class distribution for the Lake Superior State Forest.**

| Age | Year    |         |         |         |         |         |         |         |         |         |         | (acres) |
|-----|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
|     | 1997    | 2007    | 2017    | 2027    | 2037    | 2047    | 2057    | 2067    | 2077    | 2087    | 2097    | 2107    |
| 5   | 35,472  | 61,880  | 61,872  | 61,861  | 61,839  | 61,797  | 61,756  | 61,717  | 61,687  | 61,660  | 61,641  | 61,616  |
| 15  | 46,715  | 36,254  | 60,914  | 61,807  | 61,366  | 61,735  | 62,954  | 63,977  | 62,760  | 63,019  | 63,198  | 61,822  |
| 25  | 35,928  | 46,177  | 35,750  | 60,420  | 62,885  | 63,422  | 63,669  | 63,405  | 64,223  | 62,669  | 64,009  | 63,136  |
| 35  | 34,089  | 35,403  | 45,475  | 35,461  | 47,762  | 51,300  | 52,253  | 51,229  | 50,533  | 50,748  | 49,421  | 50,332  |
| 45  | 25,421  | 33,330  | 34,629  | 44,472  | 47,665  | 59,835  | 63,366  | 71,377  | 71,551  | 67,817  | 64,614  | 62,661  |
| 55  | 234,825 | 114,801 | 121,661 | 122,095 | 130,868 | 133,119 | 140,513 | 143,992 | 151,912 | 152,096 | 148,400 | 145,242 |
| 65  | 98,352  | 141,661 | 24,329  | 31,699  | 23,897  | 28,590  | 34,774  | 45,609  | 48,269  | 55,345  | 54,846  | 50,914  |
| 75  | 93,714  | 96,407  | 139,343 | 20,618  | 23,811  | 12,075  | 14,954  | 17,482  | 31,611  | 34,668  | 41,573  | 41,374  |
| 85  | 51,328  | 73,729  | 69,550  | 118,292 | 14,337  | 20,977  | 11,849  | 13,722  | 11,769  | 17,545  | 24,921  | 32,534  |
| 95  | 41,842  | 40,814  | 63,354  | 61,279  | 111,196 | 14,044  | 17,915  | 11,627  | 11,480  | 10,222  | 14,921  | 18,796  |
| 105 | 23,876  | 31,760  | 36,234  | 52,629  | 48,655  | 102,909 | 12,388  | 17,217  | 9,105   | 11,271  | 7,433   | 14,730  |
| 115 | 13,943  | 17,745  | 24,305  | 24,482  | 42,148  | 33,541  | 88,948  | 7,559   | 12,027  | 7,958   | 7,303   | 5,144   |
| 125 | 8,293   | 11,443  | 16,910  | 23,689  | 23,906  | 40,149  | 29,683  | 76,551  | 6,450   | 11,601  | 6,401   | 6,917   |
| 135 | 6,642   | 4,908   | 8,340   | 16,297  | 20,025  | 22,562  | 34,128  | 22,280  | 64,856  | 5,496   | 9,856   | 4,982   |
| 145 | 2,991   | 6,571   | 4,849   | 8,229   | 16,090  | 19,774  | 21,778  | 29,185  | 21,240  | 59,283  | 4,560   | 8,839   |
| 155 | 2,231   | 2,220   | 5,767   | 4,792   | 7,484   | 12,127  | 16,872  | 16,306  | 23,070  | 16,604  | 54,438  | 4,076   |
| 165 | -       | 2,057   | 2,009   | 5,284   | 4,323   | 6,134   | 10,364  | 14,869  | 11,159  | 15,485  | 11,483  | 52,163  |
| 175 | -       | -       | 2,037   | 1,989   | 5,233   | 4,277   | 6,071   | 10,258  | 14,704  | 10,671  | 15,291  | 11,319  |
| 185 | -       | -       | -       | 2,017   | 1,970   | 5,182   | 4,232   | 6,009   | 10,153  | 14,542  | 10,543  | 15,100  |
| 195 | -       | -       | -       | -       | 1,996   | 1,951   | 5,132   | 4,187   | 5,948   | 10,049  | 14,140  | 10,416  |
| 205 | -       | -       | -       | -       | -       | 1,977   | 3,888   | 8,933   | 12,988  | 18,745  | 28,504  | 35,382  |

Within the model, uneven-aged forest types (NHWs) are arbitrarily maintained in the 45-yr and 65-yr age classes and this bulge is maintained throughout the forecast. The current distribution lacks young (early succession) forests over time and, through active management, younger forests will expand. The middle-aged bulge will be reduced and older forests (mostly in the reserved category) will develop.

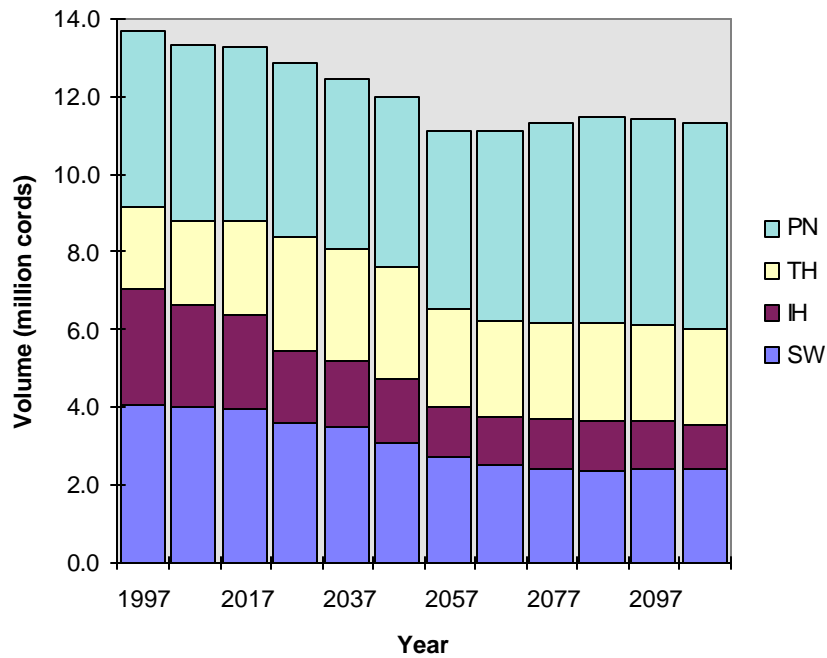
The model tracks and presents a great deal of detail on the areas of forest by type, age, and disposition. Figure 9 shows the gross area in each forest type displayed for each planning term in the modeling horizon. From this figure it can be seen that the total forest area remains constant. The composition of the forest changes somewhat, with the jack pine (PJ), white pine (PW), and spruce and other conifer (SOC) forest types increasing in size, while the area in the red pine (PR), aspen (ASP) and other intolerant hardwood (OIH) forest types declines.



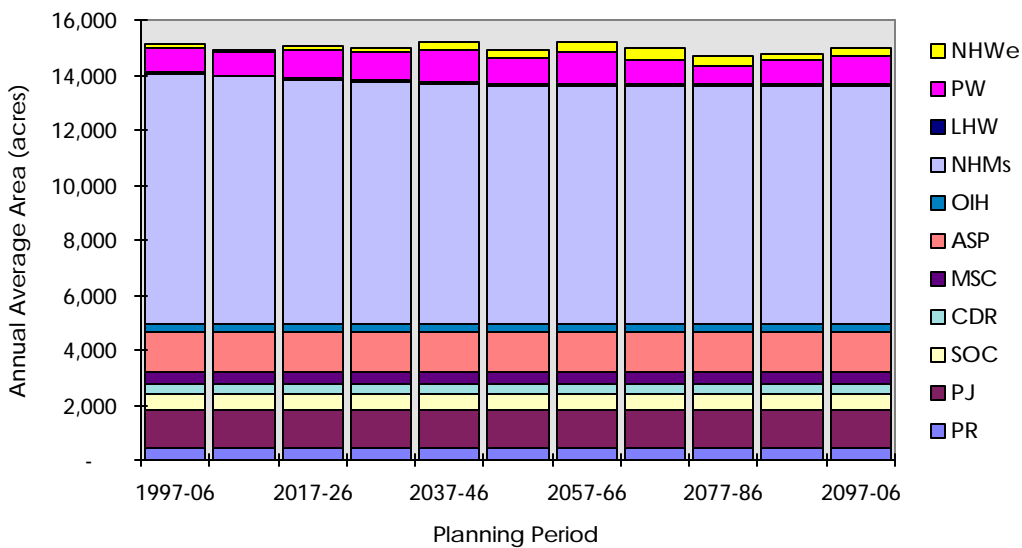
**Figure 9. Forecast forest area by forest type for the Lake Superior State Forest.**

Forest development information is available from the model in great detail, tracking forest changes back to the cause (operations, catastrophic depletion, temporal succession) for each forest type. Broader measures of forest dynamic and development, such as growing stock inventory levels (Figure 10), are available. In this alternative, forest growing stocks decline.

Figure 11 presents the forecast average annual areas to be harvested by forest type and planning period. In this preliminary alternative, the model allocates 15,000 acres per year for harvest. Selection-managed northern hardwoods account for 60% of the area harvested (approximately 9,000 acres per year). Aspen (ASP) and jack pine (PJ) account for the next largest portions of the harvest at approximately 1400 acres per year each. In this alternative, area-control constraints were applied to achieve an even-flow of harvest areas for the clear-cut forest types. Harvest areas in shelterwood and selection forest types were permitted to fluctuate by 10 percent between planning periods.

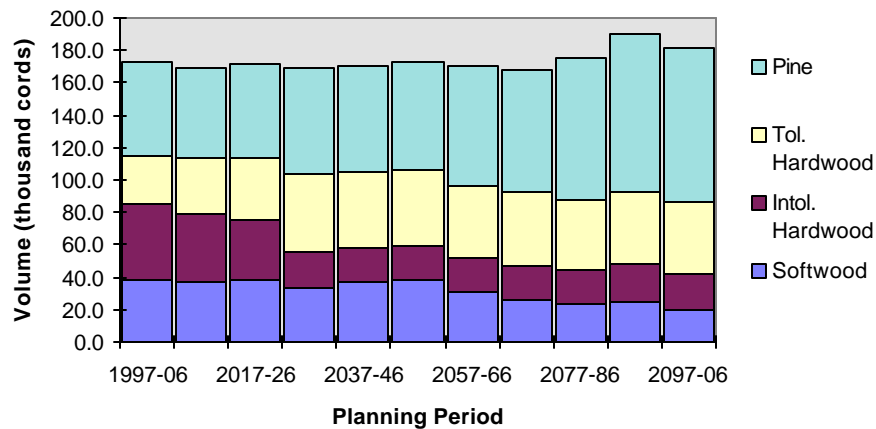


**Figure 10. Forecast forest growing stock for the Lake Superior State Forest.**



**Figure 11. Forecast average annual harvest area by forest type for the Lake Superior State Forest.**

Figure 12 presents the initial forecast of harvest volumes from a preliminary formulation of the model for the LSSF. From this it can be seen that harvest levels in the range of 170,000 cords per year can be maintained. In this alternative, volumes were permitted to fluctuate by 10 percent between each planning period. Volumes fluctuate much less than permitted as the area-control constraints limit the harvest to a greater degree than the volume-flow constraints in this example.



**Figure 12. Forecast average annual harvest volumes for the Lake Superior State Forest.**

## 8. Conclusions

The scenario presented is preliminary. The operable landbase does not include over 100,000 acres of deer yards, which would normally be available for forest operations. The model has not taken into account habitat requirements or the long-term availability of wildlife habitat.

The forest management model developed and tested on the LSSF will require further refinement and confirmation before it can be used in a

forest management planning process. All the variables will have to be confirmed by the planning team.

When this model was tested in the workshop, participants suggested a few refinements:

1. Add a wildlife habitat matrix for selected species (in preparation).
2. Confirm yields against timber sales data and other sources.
3. Compile the model using the forest areas as a basic subdivision (working circles) of the LSSF.
4. Refine successional assumptions.

Decision support tools such as the SFFM are very useful in planning forest management. They allow forest managers and the public to investigate and compare a range of management alternatives in order to plan the future management of the forest. The use of such a tool can help the forest manager assess the effect of forest operations in terms of both forest condition and wildlife habitat suitability.

## References Cited

Clark, T. 1999. Wildlife Habitat Projections for 15 Species in the Lake Superior State Forest. Report #11 from the Lake Superior State Forest Sustainable Forest Management Pilot Project. 10 p.

This report was completed as part of the requirements for a project funded by the Great Lakes Environmental Protection Fund. The objective of the project was to develop a new forest management planning system for the Lake Superior State Forest that meets sustainable forest management standards, specifically those of the Canadian Standards Association and the Forest Stewardship Council.

### **Project Partners:**

Michigan Department of Natural Resources

Mater Engineering, Ltd.

Smartwood

BioForest Technologies Inc.

Craig Howard

Anne Hayes

Brian Callaghan (Callaghan & Associates Inc.)

Tom Clark (CMC Consulting)

### **Reports generated by this project include:**

Project Summary: The Lake Superior State Forest Sustainable Forest Management Pilot Project

An Assessment of the Michigan Department of Natural Resources' Commitment to Sustainable Forest Management

The Lake Superior State Forest: A Description

Michigan Department of Natural Resources Operations Inventory: Survey Results

Roles and Responsibilities for Forest Management Planning in the Lake Superior State Forest

Public Participation in Forest Management Planning in the Lake Superior State Forest: Finding the Right Pathway

Establishing Criteria and Indicators for the Lake Superior State Forest

Workshop I Summary: Values and Indicators of the Lake Superior State Forest

Workshop II Summary: Establishing Targets, Practices and Responsibilities for the Indicators of the Lake Superior State Forest

Modeling Forest Management on the Lake Superior State Forest

Wildlife Habitat Projections for 15 Species in the Lake Superior State Forest

Risk Assessment of Forest Management for the Lake Superior State Forest

A Forest Management Planning Guide for the Lake Superior State Forest

Further information on this report or any of the reports listed may be obtained from:



BioForest Technologies Inc.  
105 Bruce Street, Sault Ste. Marie, ON P6A 2X6  
Phone: 705-942-5824 Fax: 705-942-8829  
Email: bforest@soonet.ca