Table of Contents

Introduction
History
Inventory
Policy Statement
Goals and Objectives
Guidelines and Actions
  Land Management Units
  Commercial Forest
  Timber Management Systems
  Timber Harvest Scheduling
  The Harvest Allocation Process
  Harvest Targets and Estimated Yield
  Silviculture Operating Guidelines
  Timber Sale Guidelines
  Regeneration Guidelines
Monitoring
Critical Research Needs
Introduction

According to the Conservation and Natural Resources Act (Act 18 of 1995), one of the purposes for the creation of a state forest system was "... to provide a continuous supply of timber, lumber, wood and other forest products. ..."

Pennsylvania leads the nation in hardwood log production. Forest products from state forest lands are important to regional and state economies. The United States is by far the largest consumer of round wood and paper in the world. Despite the digital age and recycling, the United States' per capita use of paper products has almost doubled in the last ten years. And during the same time frame, the average house has increased in size from 1,600 to 2,200 square feet.

Pennsylvania's state forests contain an abundance of high-quality forest products, an integral part of the materials base of the Commonwealth's $5 billion per year forest products industry, which employs nearly 100,000 people. Both Pennsylvania's consumers and general economy benefit from this regionally important supply of forest products.

Consumption of forest products in the United States and the Commonwealth continues to grow. If the United States and the Commonwealth do not produce forest products to meet consumptive demands, alternate supplies of wood will be sought. In the case of Pennsylvania's hardwoods, tropical hardwoods would most likely fill the gap. Typically forests in these regions are exploited and not properly managed, resulting in extreme environmental damage.

To retain forest productivity, it is essential that forest products be harvested in an environmentally sensitive manner that ensures forest renewal. The Bureau of Forestry accomplishes this through the implementation of best management practices (BMP's) and scientific silvicultural practices. A discussion of BMP's can be found in the Soil Resources Section of this plan. Silviculture is defined as "the art and science of controlling the establishment, growth, composition, health and quality of forests and woodlands to meet the diverse needs and values of landowners on a sustainable basis" (SAF 1998). From this definition it is clear that silviculture is not a goal in itself, but rather a tool for altering the forest condition to attain predefined needs or values. For example, the Bureau of Forestry uses silviculture as a tool for regenerating the forest (leading towards the goal of balancing the age class distribution), securing a sustainable flow of timber products, conserving and perpetuating under represented forest community types and creating specific types of wildlife habitat.

Pennsylvania's state forest system has undergone a careful review by an independent third party to determine if our management practices are compatible with maintaining forest sustainability. The result of this evaluation, conducted by Scientific Certification Systems as part of the International Forest Stewardship Council program, was that the Bureau of Forestry has become "green certified," establishing the bureau as one of the first, and by far the largest governmental entity to be so designated.
History

At the turn of the 19th century Pennsylvania's native forests lay barren; exploited by industrial logging operations and the ravenous forest fires that often followed. In 1895 nearly all forest land in Pennsylvania was held by private interests. Following the logging and resulting fires, large treeless landscapes were common in Pennsylvania. In 1896, before fire wardens, Pennsylvania lost 280 square miles (179,000 acres) of forests to wildfires. Without any leaf litter and roots to hold the rain and soils back, rain storms caused huge floods in downstream cities. Heavy erosion and continued fires slowed the reestablishment of new trees on these barren lands. High real estate taxes and low land values caused many landowners to abandon their land.

In 1895, the Commonwealth, through the newly established Forestry Commission, began purchasing large parcels of land from owners directly and through county tax sales. Tough new fire laws were passed and the new Division of Forestry was tasked with enforcing them and suppressing fires to allow the new forest to develop. An excellent historical account of this period is more fully described in the The Legacy of Penn's Woods: A History of the Pennsylvania Bureau of Forestry (Adobe PDF - 883 Kb).

In 1899 the Forestry Commission began planting trees in areas where fires had so completely destroyed the landscape that no natural seed sources were available. By 1909 silvicultural operations to aid in establishment of the new forest had grown into a large program. In that year 5.8 million tree seedlings were grown in newly established Department of Forestry nurseries and planted on state forest lands.

World War I was a temporary set back for the tree planting program as labor and resources were shifted to the war effort. By 1923, 34.9 million tree seedlings were again being grown in state nurseries and planted mostly on state forest land.

In 1933, with the Great Depression and the start of Roosevelt's Civilian Conservation Core (CCC) there was a great influx of labor and funding into forestry projects. By 1936 the Department of Forestry had four large nurseries and was producing 179 million tree seedlings per year, many of which were planted on state forest lands. The CCC conducted forest improvement treatments on countless acres of young forest stands as well as developed most of the state forest road system that is still used today. Again, with the start of World War II, labor and resources were diverted away from forestry work into the war effort.

The start of World War II marked the first significant timber removals from state forest land since the reserves were established 50 years before. The Pennsylvania Timber Production War Project was initiated to coordinate the harvesting, which was simply diameter-limit cutting, because few foresters were available to supervise more complex treatments. In fact, there was a shortage of labor for harvesting as well. The U.S. Army placed 1,750 prisoners of war into old CCC camps and hired them to industry to do the harvesting. Despite these problems and much of the forest being immature, from 1942 to 1945, state forest land yielded more than 100 million board feet of timber for the war effort. After 1945, timber production slowed as prisoners were released and the urgency declined, although some diameter limit cutting continued to support post war rebuilding efforts. No comprehensive figures are available for volume removed or acres harvested for that period.

As Pennsylvania's forests developed, it became clear that a plan for its management would be necessary. In 1953 and 1954, timber stands where delineated in the field on aerial photographs and timber stand maps were drafted for the state forest. An inventory was made of timber volumes and growth. Using these maps and inventory as a base, the first set of Forest District 15-year timber management plans was written.

This 1955 plan was based on single-tree selection silviculture and the establishment of an uneven-age management system. Following much debate and the poor regeneration results that often followed selection harvesting, management plans were amended on January 1, 1965 to include even-age management systems (clearcutting, seed tree and shelterwood harvests).
In 1968 and 1969, the state forest was again flown and aerial photographs taken for the ground delineation of forest stands. Foresters prepared new timber stand maps for the state forest. Inventory plots were re-measured and/or established to collect data on volume, growth and mortality. Using the combination of forest type maps and an updated inventory, new 15-year Forest District resource plans were written for the years 1970 through 1984.

The 1970 plan recognized both even-age and uneven-age silvicultural treatments. Also, Wild Areas were established where timber harvesting was limited to sanitation, salvage, and wildlife habitat improvement treatments only. Aesthetic consideration was applied to areas zoned for uneven-age management, and the selection method of silviculture, either single-tree or small group, was used. Two types of silvicultural treatments were applied under even-age management, intermediate and reproduction harvests. Intermediate harvests were used to improve tree quality, species composition, and spacing. Reproduction harvests were used primarily to establish reproduction on forest stands killed or severely damaged by insects, since much of the forest was still immature.

In the early 1970's many forest stands in the central Pennsylvania oak region were severely defoliated by the oak leaf roller. The resulting forest mortality led to heavy salvage harvests. An even more destructive pest, the Gypsy Moth, devastated hundreds of thousands of acres in the oak region from the mid-1970's to late 1980's. On many state forests in the oak region, harvest operations were confined almost exclusively to salvage operations during those years. Even so, many acres remained unsalvaged, and as a result were partially regenerated to red maple. These two-age stands today are challenging to manage, particularly when red maple is not a desirable tree species on many of the sites. In 1983 the state forest was again flown and photographed. Foresters delineated forest stands in the field and new management maps were drafted. In 1985 a new resource plan was developed based on the multiple resource management of water, recreation, fauna and flora, timber and minerals.

Following decades of high deer populations in some areas of Pennsylvania, the forest understory became dominated by shrubs, ferns and other herbaceous vegetation, thus preventing the establishment of young tree seedlings. In areas where young trees have managed to become established, the Bureau of Forestry is successful at regenerating the forest. However, due to a multitude of factors, including deer browsing, in most areas of Pennsylvania it has become increasingly difficult to establish young seedlings. As a result, to aid in the bureau's regeneration efforts, in 1996 the legislature established the Forest Regeneration Restricted Revenue Account commonly referred to as the regeneration fund. This funding allowed the Bureau of Forestry to use 10% of its revenues generated through the timber sale program to be reinvested in projects to establish new forests. The Bureau now spends over $3 million annually from this fund on regeneration projects, which make up a large part of the workload in many districts. Many foresters agree that these extraordinary measures are only temporary-until deer numbers are reduced and solutions to other regeneration-related problems are found.

Regenerating the forest has been, and will continue to challenge the Bureau of Forestry. Numerous ecological problems such as Gypsy Moth, Hemlock Wooly Adelgid, Beech Bark Disease, Chestnut Blight, acid precipitation, competing vegetation, and invasive species are making regeneration difficult. However, forest managers generally agree that the overpopulated deer herd has the greatest impact on forest ecosystems. To address deer and regeneration issues, the Bureau of Forestry will continue its regeneration programs, support and engage in regeneration-related research, and continue to work with other state agencies, such as the Game Commission, on cooperative programs to work toward solutions.

The 1985 state forest resource plan was significantly amended in 1996. Planned timber harvest levels were not being achieved for a number of reasons as outlined in Timber Harvesting on Pennsylvania's State Forests, Dr. James Grace, 1996. However, it was decided that more timber could be harvested than was currently being harvested. Through a plan called the "Timber Initiative", a number of additional foresters were hired. With new foresters and funds available to regenerate stands, there was a 15% increase in harvests acres from 1996 to 1999 as compared to the previous four-year period. Sawtimber harvest volumes and timber revenues increased 33% and 100% respectively for the same period.
Silviculture Inventory

Resource Inventories

Conducting and maintaining accurate and current forest resource inventories is critical to implementing ecosystem management and achieving sustainable forestry. As part of its resource planning and management strategy, the Bureau of Forestry conducts and maintains many inventories that provide information on various levels, including statewide, eco-region, individual state forest, landscape, and finally, forest stand level. See the Overview section of this plan for details on inventories and resource summaries. In addition to these inventories, districts conduct detailed forest stand level analysis to aid in developing, proposing and conducting land management activities.

Timber Harvests

The Bureau of Forestry harvested an estimated 643,537,000 bdft. of timber and 773,177 hundred cubic feet of pulpwood on 224,636 acres from 1985 to 1999. Shown in the chart below and listed in the table on the next page is a complete record of timber harvest operations since records where first started in 1955 (the data shown before 1955 is incomplete).

Chart: Past Silvicultural treatments 1955 to 1999

Table: Summary of Area Harvested and Timber Sold
<table>
<thead>
<tr>
<th>Year</th>
<th>Even-age Reproduction Harvests</th>
<th>Improvement Harvests</th>
<th>Uneven-age/Two-age Harvests</th>
<th>Salvage &amp; Other Harvests</th>
<th>Timber Sold</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Thousand Board Feet (MBF)</td>
<td>Hundred Cubic Feet (HCF)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1945</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1946</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1947</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1948</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1949</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1950</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1951</td>
<td>0</td>
<td>0</td>
<td>735</td>
<td>0</td>
<td>1,728</td>
</tr>
<tr>
<td>1952</td>
<td>0</td>
<td>0</td>
<td>1,190</td>
<td>0</td>
<td>3,743</td>
</tr>
<tr>
<td>1953</td>
<td>0</td>
<td>0</td>
<td>408</td>
<td>0</td>
<td>556</td>
</tr>
<tr>
<td>1954</td>
<td>0</td>
<td>0</td>
<td>667</td>
<td>0</td>
<td>1,864</td>
</tr>
<tr>
<td>1955</td>
<td>0</td>
<td>0</td>
<td>2,491</td>
<td>3,645</td>
<td>11,397</td>
</tr>
<tr>
<td>1956</td>
<td>0</td>
<td>0</td>
<td>5,381</td>
<td>4,151</td>
<td>17,453</td>
</tr>
<tr>
<td>1957</td>
<td>0</td>
<td>0</td>
<td>8,005</td>
<td>4,061</td>
<td>26,489</td>
</tr>
<tr>
<td>1958</td>
<td>0</td>
<td>0</td>
<td>7,914</td>
<td>2,967</td>
<td>21,139</td>
</tr>
<tr>
<td>1959</td>
<td>0</td>
<td>0</td>
<td>6,875</td>
<td>7,343</td>
<td>22,098</td>
</tr>
<tr>
<td>1960</td>
<td>50</td>
<td>0</td>
<td>5,974</td>
<td>3,816</td>
<td>22,892</td>
</tr>
<tr>
<td>1961</td>
<td>0</td>
<td>0</td>
<td>7,878</td>
<td>5,116</td>
<td>33,531</td>
</tr>
<tr>
<td>1962</td>
<td>0</td>
<td>0</td>
<td>9,216</td>
<td>5,623</td>
<td>42,276</td>
</tr>
<tr>
<td>1963</td>
<td>22</td>
<td>0</td>
<td>11,001</td>
<td>7,479</td>
<td>51,353</td>
</tr>
<tr>
<td>1964</td>
<td>0</td>
<td>0</td>
<td>12,229</td>
<td>11,727</td>
<td>49,931</td>
</tr>
<tr>
<td>1965</td>
<td>1,782</td>
<td>0</td>
<td>16,296</td>
<td>6,512</td>
<td>49,086</td>
</tr>
<tr>
<td>1966</td>
<td>4,773</td>
<td>0</td>
<td>9,343</td>
<td>3,738</td>
<td>41,385</td>
</tr>
<tr>
<td>1967</td>
<td>4,406</td>
<td>0</td>
<td>9,557</td>
<td>2,637</td>
<td>36,374</td>
</tr>
<tr>
<td>1968</td>
<td>5,316</td>
<td>0</td>
<td>4,787</td>
<td>2,274</td>
<td>33,075</td>
</tr>
<tr>
<td>1969</td>
<td>3,449</td>
<td>0</td>
<td>6,825</td>
<td>1,722</td>
<td>28,401</td>
</tr>
<tr>
<td>1970</td>
<td>4,121</td>
<td>0</td>
<td>10,122</td>
<td>13</td>
<td>20,516</td>
</tr>
<tr>
<td>1971</td>
<td>4,551</td>
<td>0</td>
<td>5,456</td>
<td>594</td>
<td>23,430</td>
</tr>
<tr>
<td>1972</td>
<td>4,333</td>
<td>0</td>
<td>6,653</td>
<td>467</td>
<td>19,453</td>
</tr>
<tr>
<td>1973</td>
<td>6,243</td>
<td>0</td>
<td>6,344</td>
<td>1,015</td>
<td>30,408</td>
</tr>
<tr>
<td>1974</td>
<td>6,612</td>
<td>0</td>
<td>5,236</td>
<td>1,798</td>
<td>31,203</td>
</tr>
<tr>
<td>1975</td>
<td>5,150</td>
<td>0</td>
<td>7,036</td>
<td>858</td>
<td>25,513</td>
</tr>
<tr>
<td>1976</td>
<td>5,475</td>
<td>0</td>
<td>9,482</td>
<td>1,657</td>
<td>32,298</td>
</tr>
<tr>
<td>1977</td>
<td>4,008</td>
<td>0</td>
<td>4,993</td>
<td>2,134</td>
<td>21,573</td>
</tr>
<tr>
<td>1978</td>
<td>5,951</td>
<td>0</td>
<td>5,268</td>
<td>1,574</td>
<td>23,568</td>
</tr>
<tr>
<td>1979</td>
<td>7,820</td>
<td>0</td>
<td>7,765</td>
<td>1,699</td>
<td>39,545</td>
</tr>
<tr>
<td>1980</td>
<td>6,545</td>
<td>0</td>
<td>5,423</td>
<td>3,081</td>
<td>31,227</td>
</tr>
<tr>
<td>1981</td>
<td>6,421</td>
<td>0</td>
<td>7,404</td>
<td>2,134</td>
<td>32,148</td>
</tr>
<tr>
<td>1982</td>
<td>6,010</td>
<td>0</td>
<td>7,113</td>
<td>2,273</td>
<td>36,064</td>
</tr>
<tr>
<td>1983</td>
<td>6,849</td>
<td>0</td>
<td>7,001</td>
<td>1,872</td>
<td>37,810</td>
</tr>
<tr>
<td>1984</td>
<td>5,177</td>
<td>0</td>
<td>13,081</td>
<td>1,695</td>
<td>60,972</td>
</tr>
<tr>
<td>1985</td>
<td>5,393</td>
<td>0</td>
<td>3,746</td>
<td>271</td>
<td>55,913</td>
</tr>
<tr>
<td>1986</td>
<td>7,547</td>
<td>0</td>
<td>5,521</td>
<td>723</td>
<td>61,784</td>
</tr>
<tr>
<td>1987</td>
<td>4,928</td>
<td>0</td>
<td>6,595</td>
<td>1,310</td>
<td>44,274</td>
</tr>
<tr>
<td>1988</td>
<td>6,168</td>
<td>0</td>
<td>5,523</td>
<td>1,771</td>
<td>51,001</td>
</tr>
<tr>
<td>1989</td>
<td>5,763</td>
<td>0</td>
<td>5,713</td>
<td>1,688</td>
<td>45,929</td>
</tr>
<tr>
<td>1990</td>
<td>4,911</td>
<td>0</td>
<td>4,947</td>
<td>1,141</td>
<td>34,886</td>
</tr>
<tr>
<td>1991</td>
<td>5,033</td>
<td>0</td>
<td>4,373</td>
<td>1,796</td>
<td>30,658</td>
</tr>
<tr>
<td>1992</td>
<td>3,121</td>
<td>0</td>
<td>4,557</td>
<td>1,294</td>
<td>28,248</td>
</tr>
<tr>
<td>1993</td>
<td>3,134</td>
<td>0</td>
<td>4,051</td>
<td>1,559</td>
<td>30,524</td>
</tr>
<tr>
<td>1994</td>
<td>3,220</td>
<td>0</td>
<td>4,527</td>
<td>948</td>
<td>37,303</td>
</tr>
<tr>
<td>1995</td>
<td>3,220</td>
<td>0</td>
<td>4,527</td>
<td>948</td>
<td>37,303</td>
</tr>
<tr>
<td>1996</td>
<td>4,752</td>
<td>0</td>
<td>4,889</td>
<td>1,499</td>
<td>36,671</td>
</tr>
<tr>
<td>1997</td>
<td>5,091</td>
<td>0</td>
<td>6,342</td>
<td>1,514</td>
<td>48,776</td>
</tr>
<tr>
<td>1998</td>
<td>7,679</td>
<td>0</td>
<td>5,697</td>
<td>1,379</td>
<td>48,609</td>
</tr>
<tr>
<td>1999</td>
<td>6,264</td>
<td>0</td>
<td>5,416</td>
<td>1,590</td>
<td>40,353</td>
</tr>
</tbody>
</table>

Totals: 183,900 | 369,454 | 118,396 | 52,155 | 1,642,623 | 2,450,937
Harvest Revenues

In calendar year 2002 the Commonwealth of Pennsylvania received timber sale bids totaling $38,006,458 as a result of the Bureau of Forestry's silvicultural operations. Revenues have been increasing steadily due to a number of factors. The harvest from state forest land has increased in recent years and thus increased bids. Even more so, the value of high quality sawlogs has increased, particularly black cherry and to a lesser degree many of the oak species. The age of the forest is requiring more regeneration harvests and these harvests yield greater volumes of sawtimber than other silvicultural treatments. All of these factors combined have led to increased revenue in recent years. Below is a chart showing timber sale revenues to the Commonwealth from 1985 to 1999.

Chart: State Forest Timber Sale Bids 1985-1999

Growing Stock Volumes

Approximately 1,198,600 acres of the 2.1 million acres of state forest are in the commercial forest land base. Sawtimber growing stock on the commercial forest within the multiple resource and aesthetic/buffer zones is estimated at 8.4 billion boardfeet net with an additional 5.0 billion boardfeet equivalents in pulpwood volume. The distribution of commercial sawtimber volumes within each of seven forest community groups is shown in the chart below. These estimates are based on sample data from 788 inventory plots. However, sample data was collected on only the most common community types within the commercial state forest. Some community types did not contain sufficient acres to be adequately sampled. Because of the large number of new community types added to this planning period, these unsampled or poorly sampled areas represent almost 45% of the state forest. The number of plots will be doubled to approximately 1500 for the next inventory to more accurately sample the forest. For the purpose of estimating total commercial growing stock volume some approximations were made to cover the lack of complete sampling data. Similar forest types, for which data was collected, were used to make estimations of the unsampled types.

A systematic inventory of Wild and Natural Area zones has been started. However no complete data is presently available on these areas or the limited resource zone. Therefore only a very rough approximation can be made at this time of sawtimber growing stock on all state forest lands. This figure would likely be around 15 billion boardfeet net.

Chart: Distribution of Commercial Boardfoot volumes by forest community groups.
Policy Statement

State forest lands will be managed to provide a sustained yield of high quality timber and other wood products. The successful and timely regeneration of diverse forest communities will be promoted on state forest lands. The management of state forest lands will demonstrate and promote silvicultural practices that sustain ecological and economic forest values.

Goals and Objectives

Goal 1: To promote and maintain desired landscape conditions.

Objectives:

- Promote balanced age class and tree diameter distributions.
- Promote a mix of native forest communities.
- Create a mix of patch sizes to promote a variety of forest successional stages.
- Use silvicultural operations to create disturbances that mimic natural patterns and promote natural regeneration.
- Incorporate landscape-level concerns, including forest habitat diversification and connectivity.
- Meet or exceed established best management practices to protect soil and water quality.
- Maintain or improve native species diversity, genetic diversity and structural diversity, including desirable commercial species.
- Maintain nutrient, water and energy cycles in accordance with the best available
knowledge.
- Design timber harvests making effective use of existing access and minimizing the impacts of forest roads.

**Goal 2: To maintain and develop naturally reproducing forest communities.**

**Objectives:**

- Conduct regeneration harvests only when natural forest regeneration is present or is likely to follow.
- Use dedicated Forest Regeneration Funds to ensure forest regeneration in harvest or critical areas affected by inhibiting factors.
- Encourage research to identify factors inhibiting regeneration.
- Encourage research to document the extent of deer impacts on native forest communities.
- Work with the Pennsylvania Game Commission and other stakeholders to maintain deer population levels that are proportionate with healthy forest ecosystems.
- Develop and implement a system for predicting and evaluating regeneration success on state forest lands.
- Establish forest cover in areas that failed to regenerate following disturbance.
- Use artificial regeneration when natural regeneration is not feasible or when necessary to maintain or restore desired tree species.

**Goal 3: To provide economic and social benefits through a sustained yield of forest products.**

**Objectives:**

- Ensure timber harvests are financially advantageous to the Commonwealth.
- Promote growth of high quality trees.
- Harvest the planned acreage to aid local, regional and state economies.
- Utilize rotation ranges that are compatible with the biology of forest communities and are economically feasible.
- Salvage dead commercial timber only when economically and ecologically appropriate.
- Ensure silvicultural operations are compatible with the protection, use and development of the other forest resources.

**Goal 4: To determine appropriate, sustainable timber harvest levels.**

**Objectives:**

- Consider socially acceptable timber harvest levels in the development of planned harvests.
- Develop scientific feedback mechanisms to ensure timber harvests are sustainable.
- Continuously inventory and monitor landscape conditions, and adjust timber harvest levels based on scientific feedback mechanisms.

**Goal 5: To demonstrate and promote silvicultural practices that sustain ecological and economic forest values.**

**Objectives:**

- Promote the use of state forest management activities to demonstrate sustainable practices.
- Promote scientific study of sustainable forestry within the context of forest operations on state forest land.
- Participate, as appropriate, in international, national and regional assessments of sustainability.
• Practice and demonstrate active adaptive management.

Management Guidelines and Actions

Land Management Units

The state forest is divided into 20 forest districts and each is considered as its own management unit for the purposes of silvicultural operations and harvest regulation. Forest districts are further divided into landscapes that average between 2,000 and 4,000 acres each. Landscapes are defined by topographic features such as uplands (e.g., mountains, hill, plateaus) and valleys. Typically a forester is assigned to manage and coordinate activities in a number of these landscapes within a forest district. A landscape may contain 100 or more forest stands. These forest stands are the bureau's primary land management unit for silvicultural activities. Bureau foresters schedule landscape examinations and make management recommendations. Each landscape is scheduled for an exam once every 10 years. The schedule can be modified due to changes in forest condition; however, no landscape should go more than 15 years without an exam. Details of this landscape exam and management are explained in the overview section of this plan and the Landscape Exam Manual (Adobe PDF - 45 Kb).

Commercial Forest

Commercial forest stand classification was defined during initial forest stand typing and is described in the Typing Manual (Adobe PDF - 527 Kb). The commercial forest is defined as those forest stands that have an availability classification code of C and are within a multiple resource or aesthetic/buffer zone. These two zones are where most harvesting activities currently occur. Other zones that have commercial forest stand classifications are not included in the commercial land base for planning purposes. These commercially typed forest stands may occur in the limited resource, special resource and wild area zones. These areas are not typically harvested and will be grouped with the non-commercial forest land base.

Commercial availability areas will change as markets and technology change. The ability to market a forest stand is determined by many complex factors that readily change over time. The amount of commercial acreage is a snapshot in time that should accurately reflect current markets and technology. It is not a permanent designation. Therefore, forest stands designated non-commercial may at some time be harvested if they become marketable and vice-a-versa.

The commercial forest is primarily divided into two management zones; the multiple resource zone and the aesthetic/buffer zone. Smaller amounts of the commercial forest exist in other management zones. The vegetation in each commercial forest zone will be managed to meet the objectives established for that zone. A full explanation of management zones and objectives is included in the overview section of this plan. All management efforts applied to a given area must be in accordance with the management zoning indicated on the map or digital files. Requests for variation from the management zoning as designated on the map/digital files must be submitted in writing to the Director, Bureau of Forestry, Department of Conservation and Natural Resources. It is the policy of the Bureau to zone all state forest lands according to its primary land use and to apply management practices that will protect and enhance the values for which the land was zoned.

Timber Management Systems
The following forest stand treatment definitions are aligned with silviculture terminology described by "The Dictionary of Forestry" and the "Forestry Handbook" second edition. The Society of American Foresters publishes both books. In addition, some definitions were further changed to align to those in a report entitled "Silviculture Terminology with Appendix of Draft Ecosystem Management Terms" prepared by the Silviculture Instructors Sub-Group of the Society of American Foresters.

Among the main changes from previous practices are the following:

1. A stand treatment will describe a harvest of individual trees that has been planned by a forester or a harvest that is a combination of both a forester's prescription and the salvage of trees affected by natural events. The salvage of widely scattered individual trees that do not significantly impact a stand will not be considered a silvicultural treatment.
2. The word "salvage" may be attached to any of the stand treatments (i.e. salvage-overstory removal, salvage clear-cut, salvage-improvement, etc.) when the treatment is better described by indicating that dead or dying trees are the main value component of the harvest (generally > 50% of the sale value should be in dead or dying trees).
3. A stage of the shelterwood will describe most of the stand treatments currently being proposed on state forest land.
4. The difficulty with sustaining uneven-age conditions is recognized and the application of any uneven-age system should be done with caution if the main goal is sustained timber production.
5. An intermediate treatment that is creating natural tree regeneration is not an improvement type treatment. It is better described as some form or stage of shelterwood treatment.

Listed below are more complete definitions of silvicultural terms to be used in describing harvests:

**Regeneration Harvests**

**Even-aged silvicultural system**

The forest stand consists of trees of the same or nearly the same age. Arbitrarily, a forest stand is even-aged if the range of tree age does not exceed 20% of the rotation length. Forest stand age is usually measured from the time the trees are first open to nearly full sunlight and thus able to grow in height without restriction.

**Shelterwood**

The establishment of a new, essentially even-aged, forest stand from the partial removal of the overstory. Each harvest if done in a series is a shelterwood treatment. The essential characteristic is that the new forest stand is being established naturally or artificially before the overstory trees from the original forest stand are removed. Any of the regeneration techniques described in Appendix C may also be used. The shelterwood method can be used to describe any of a series of harvest treatments that are of the following types:

1. A preparatory treatment designed to foster the potential seed producers, with additional trees retained to meet the Bureau's reservation guidelines (Link).
2. A seed treatment aimed at getting the new seedlings established, with additional trees retained to meet the bureau's reservation guidelines.
3. A final harvest in a shelterwood series or the overstory removal with residuals which will release established regeneration from competition with the existing overstory. In the case of established regeneration from natural causes or regeneration fund activities (fences, herbicide, etc.), the one time release harvest
is also the final treatment and is termed the overstory removal harvest. The residual trees left to meet the bureau's reservation guidelines are the only remnants of the old forest stand not harvested.

**Clearcut**

The establishment of a new even-aged forest stand from the development of new trees after removal in a single harvest of all trees in the previous forest stand, except trees reserved as part of the bureau's reservation guidelines. Regeneration is established after the harvest from one or more of the following: natural seeding, direct seeding, planted seedlings, or coppice regeneration. Fences, herbicide, or fertilizer are options to protect or enhance established regeneration for any of the areas having significant deer browsing or other inhibiting vegetation problems.

**Seed-Tree**

Basically, the application of the overstory removal method addressed above, except for an additional small number of otherwise commercial trees left singly, in small groups, or narrow strips, as an added source of seed for supplemental regeneration. Individual seed trees will often also function as part of the bureau's reservation guideline trees and would not be potentially harvested until the next rotation.

**Seed-Tree Removal**

The removal of seed-trees after any potential use as seed-trees is past. This method is recommended as a treatment only when the seed-trees are not a component of the reservation guidelines, the regeneration lost during harvest will not have significant impact on the next forest stand, and the seed-trees are not needed for visual concerns.

**Two-aged Silvicultural system**

A system designed to maintain and regenerate a forest stand with two age classes. The goal or condition is for each age class to be separated in age by more than 20% of rotation. The desired age class spread would be to approach 50% of rotation to lessen visual impact and extend the period of time between entries to the forest stand. A two-aged system is different than a shelterwood or seed-tree system in the purpose of the reserved trees, the number of the reserved or residual trees, and the goal of a difference in age class of 50% of rotation. Any of the regeneration techniques described in the Regeneration Guidelines section of the Silviculture Manual may be used for areas having significant deer browsing or other inhibiting vegetation problems.

**Uneven-aged Silvicultural system**

Forest stands created or existing that include three or more distinctly different age classes, including regeneration (forest stands with two age classes are associated with or managed in ways that duplicate even-age methods). Attempts to convert an even-age forest stand to uneven-age are difficult. Caution must be taken to avoid treatments that effectively become "high-grades" and are not sustainable. Several entries to the forest stand are required to maintain the age class structure and this could be functionally impossible and also create undesirable site disturbance conditions. Any of the regeneration techniques described in may be used, but the impact of deer and interfering plants may be more difficult to control in large landscapes managed under this system.

**Group Selection**

A method of regenerating uneven-aged forest stands in which trees are removed, and new age classes are established in small groups. The maximum width of groups is
approximately twice the height of the mature trees, with small openings providing microenvironments suitable for tolerant regeneration and larger openings providing conditions suitable for more intolerant regeneration. The forest stand in which regeneration, growth, and yield are regulated consists of a landscape containing an aggregation of groups.

**Single Tree Selection**

A method of creating new age classes in uneven-age forest stands in which individual trees of all size classes are removed more-or-less uniformly throughout the forest stand to achieve desired forest stand structural characteristics and regenerate shade-tolerant species.

**Intermediate Treatments**

**Improvement Treatments**

An intermediate treatment (after establishment of the new forest stand and prior to final harvest) is conducted to remove trees that will improve residual forest stand composition and improve residual tree quality. This is a non-reproductive treatment and the forest stand's residual basal area should be at least B level stocking or greater. Improvement treatments in pole size forest stands may be the most beneficial for the forest stand, but are often marginally commercial and difficult to predict success. Improvement treatments in forest stands less than 15 years from rotation are usually less productive in the long run than proceeding directly to a shelterwood method aimed at creating regeneration or reducing inhibiting factors for regeneration. The term "T.S.I." or "timber stand improvement" refers to a totally non-commercial application of this treatment.

**Plantation thinning**

A cultural treatment made to plantations to reduce forest stand density of trees primarily to improve growth, enhance plantation health, or recover potential mortality.

**Timber Harvest Scheduling**

In previous forest resource plans the district timber harvest goals were based on the total number of acres in a state forest's commercial land base and a statewide 100-year rotation length. With the focus on ecological principles in this plan, bureau managers recognize that forest communities mature at varied rates. The bureau is committed to scheduling harvests over a range of rotation ages rather than adhering to one set rotation length. Additionally, the current forest has a large inventory of trees in later successional stages. This current forest structure is not sustainable for the long term. The focus of this plan is to begin balancing the age class distribution of the forest by regenerating forested stands leading to a sustainable forest structure, capture a range of rotation ages, and promote and ensure areas of forest that are managed on long rotations.

The Bureau of Forestry formed a partnership with the Pennsylvania State University's School of Forest Resources (PSU) in 1999 to develop a harvest scheduling model for planning harvests on each of the 20 forest districts. The model has provided the bureau with a tool to develop harvest schedules that consider the long-term sustainable flow of forest products and lead toward a desirable and sustainable forest structure in the future. The model schedules acres of state forest to receive timber harvests and will aid the bureau in achieving its silviculture and timber management goals. The goals specifically addressed by the model include:
1. To promote and maintain desired landscape conditions; including balancing the age class distribution of the multiple resource, commercial land base.
2. To ensure and maintain areas of older forest.
3. To provide economic and social benefits through a sustained yield of forest products.
4. To determine sustainable long-term timber harvest levels.
5. To promote silvicultural practices that sustain ecological and economic forest values.
6. To develop feasible timber management plans considering forest regeneration issues and resources available to the Bureau of Forestry.

This forest modeling approach will help the bureau achieve these goals by developing feasible, district-specific, timber management plans that consider:

- Planning on a large scale-10,000's to 100,000's of acres of forestland
- Creating and maintaining diverse forests composed of many forest community types with varying site quality, ages, and stocking levels
- Long-range planning horizons (140-years or more)
- Specific short-term harvest goals (10 years)
- Bureau of Forestry policy issues
- Forest resource limitations

This process will help the bureau find more efficient ways to accomplish its goals; identify the true costs of operational and resource constraints; evaluate trade-offs among goals; and anticipate and avoid problems in the future.

The Harvest Allocation Process

The development of individual district harvest allocations consisted of gathering district specific considerations, developing preliminary allocations and discussing them at district meetings, and then refining the allocation based on these discussions. District specific considerations include the calculation of the commercial land base, determining the appropriate yield tables, and identifying the resource and operational constraints of the district. Based on this information, several preliminary allocations were developed and presented to the districts and key central office personnel. Following the meetings, refinements were made to the allocations presented and a final allocation was developed.

The harvest allocation for each district consists of shelterwood and overstory removal treatments, aesthetic buffer treatments, and intermediate treatments. The shelterwood and overstory removal treatments were scheduled explicitly through the harvest allocation model. Aesthetic buffer and intermediate treatments were scheduled outside of the model. The following is a brief description of the data and techniques used to develop each district's harvest allocation.

Land Base

The land base considered for the timber allocation model includes only those acres designated as multiple resource and commercial, per the bureau's Phase One Inventory Manual: Land Classification and Management Zoning. Bureau foresters visited each forest stand and designated 974,904 acres as multiple resource, commercial. To account for circumstances that may lead to over-estimating the multiple resource, commercial land base (e.g., classification errors and areas that are too rocky, too wet, too steep or too small to have been classified as a separate forest stand) an area reduction factor of 10% was applied to reduce the available area. In addition, this reduction factor crudely accounts for constraints that were not explicitly modeled. This reduction resulted in a final multiple resource, commercial land base for the Bureau of Forestry of 876,548 acres.
Timber Yield Data

Yield tables were developed from the bureau's Continuous Forest Inventory (CFI) plots. The oldest plots have been periodically inventoried since 1963. New plots have been established over time, resulting in a total of 788 CFI plots. Using initial plot inventories and periodic re-measurements, this results in a total of 2,289 plot measurements. Individual tree-level records for each plot were used to develop yield estimates by forest type, site class, stocking, and age class for two volume regions: Northwest and Southeast.

To account for differences in species composition within the two volume regions, two species composition regions were delineated for each volume region (Figure 00). For example, the Northwest Volume Region contains two species composition regions: NW and NC. The total volume is exactly the same in the NC and NW species composition regions; however, the volume is distributed across the species differently, based on the estimated species composition developed from the permanent plots in that region.

Forest Types

The 26 terrestrial forest types listed in the Phase One Inventory Manual were aggregated into seven forest types to facilitate the development of the yield tables for the timber allocation model:

1. **Northern hardwoods**: northern hardwoods and sugar maple-basswood types
2. **Allegheny hardwoods**: black cherry-northern hardwoods type
3. **Red maple**: red maple type
4. **Red oak**: red oak-mixed hardwood type
5. **Other oaks**: dry oak-heath and dry oak-mixed hardwood types
6. **Conifers**: hemlock (white pine), dry white pine (hemlock)-oak, hemlock (white pine)-northern hardwood, hemlock (white pine)-red oak-mixed hardwood, hemlock-tuliptree-birch, hemlock-rich mesic hardwood, pine plantation, and spruce plantation types
7. **Other hardwoods** (all other types)

Estimated Age Class Distribution

A goal of the bureau is to balance the age class distribution of the multiple resource and commercial land base of the forest. In order to do this, the current age class distribution must be known. Estimated age class distributions were derived from the statewide permanent plot data, based on the distribution of ages of plots located in each forest type, site, and size/stocking class. Since plots were not located in every forest type, site, and size/stocking class, age was estimated where necessary to fill in the gaps. Figure 00 shows the initial age class distribution of the entire state forest system by aggregated forest type. All areas in the no harvest zones where aggregated into one separate category.
Initial (year 2000) age class distribution of the entire state forest by forest type for the multiple resource, commercial land base, plus all other management zones and forest types grouped together (excluding only areas zoned Buffer and Commercial).

More detailed tables of initial age class distribution by forest type and site/stocking levels can be found in the Forest District Supplements of this plan.

**Economic Information**

To develop the models the following economic information was used:

- **Costs**
  - Statewide average fixed timber sale costs of $97 per acre and regeneration treatment costs of $158 per acre were estimated from Bureau of Forestry records. For some districts these averages were inappropriate. In these districts, cost estimates were based on district records. See the individual Forest District Supplements for more details.

- **Discount Rate**
  - A four percent discount rate was used.

- **Stumpage Prices**
  - Stumpage prices (table below) were estimated using a conservative approach based on averages from the Timber Market Report. Data from the 1st quarter of 1992 through the 3rd quarter of 2001 for each Timber Market Report region was used. The actual numbers used by each district are more fully described in the Forest District Supplements to this plan. For additional information on how the data for the TMR is collected and compiled, visit Penn State's School of Forest Resources website: [http://www.sfr.cas.psu.edu/TMR/TMR.htm](http://www.sfr.cas.psu.edu/TMR/TMR.htm).

<table>
<thead>
<tr>
<th>Product</th>
<th>S/bdf</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red Oaks</td>
<td>0.434</td>
</tr>
<tr>
<td>White Oaks</td>
<td>0.313</td>
</tr>
<tr>
<td>Other Oaks</td>
<td>0.305</td>
</tr>
<tr>
<td>Red Maple</td>
<td>0.163</td>
</tr>
<tr>
<td>Hard Maple</td>
<td>0.256</td>
</tr>
<tr>
<td>Black Cherry</td>
<td>0.388</td>
</tr>
<tr>
<td>Other Hrdwds.</td>
<td>0.242</td>
</tr>
<tr>
<td>Softwoods</td>
<td>0.08</td>
</tr>
</tbody>
</table>
Harvest Allocation Model

The harvest allocation model is a linear programming (LP) model used to develop long-term sustainable timber harvest schedules for the multiple resource and commercial land base. Linear programming is a mathematical method for allocating scarce resources (e.g. time, funding, personnel, trees) to competing activities in an optimal manner. The timber allocation model uses the forest inventory data, economic information, Bureau of Forestry policy requirements and desired ending target forest conditions to develop timber harvest schedules that best meet the bureau's silvicultural and timber management goals.

The harvest allocation model is a non-spatial model and schedules areas for harvest by analysis areas, rather than individual forest stands. Analysis areas are aggregates of similar forest stands. Harvests can therefore be conducted in one forest stand or across multiple forest stands- whatever combination is necessary to meet the regeneration goal for each forest type, site class and stocking level, and age class.

Model Assumptions

It is assumed that harvests will regenerate to the same forest type. For example, red oak stands will regenerate into red oak stands and northern hardwood stands will regenerate into northern hardwood stands. No forest type conversion was modeled.

Stocking levels following harvest were assumed to change based on predefined percentages. In general, it is estimated that 95% of fully stocked forest stands will regenerate to a fully stocked condition and 80% of under-stocked forest stands will regenerate to a fully stocked condition. This estimate does not apply to all districts; see the individual Forest District Supplement to this plan for more details.

A volume reduction factor of 15 percent was applied to account for residual trees following harvest. The yield tables do not account for residual trees left on the site following an overstory removal and may overestimate the projected volume. It is estimated that 15% of the volume remains on the site in residual trees following a timber harvest.

General Model Formulation
Planning Horizon and Planning Periods

The planning horizon for the model is a minimum of 140 years. This planning horizon is divided into 10-year planning periods.

Decision Variables

The model schedules overstory removal and shelterwood treatments, only. Aesthetic buffer and intermediate treatments are allocated outside of the model.

Shelterwood harvests were modeled as a percentage of area, by forest type, which will require a two-stage shelterwood treatment prior to the overstory removal. Appropriate percentages were developed by each district, along with an estimated percentage of volume that is removed in the shelterwood harvest. Additionally, an inventory of area by forest type, site class, and age class was compiled to reflect those areas that are currently in a shelterwood condition awaiting the overstory removal. The model will schedule those areas currently in a shelterwood condition for overstory removal in the first planning period. Areas scheduled for a shelterwood treatment in any given planning period will be automatically scheduled for the overstory removal in the planning period following the shelterwood treatment. See the individual Forest District Supplements for more details.

Model Constraints

Constraints are conditions that the timber allocation model must satisfy to produce a feasible harvest schedule. Constraints represent both natural resource limitations and Bureau of Forestry policy decisions. Regardless of whether the constraints are resource or policy-related, they must be satisfied fully for the model to produce a feasible solution. Modifying the constraints used in each state forest district allowed the model to be customized to fit different issues found in each district.

Minimum Rotation Ages Constraint

Minimum rotation ages were established in each district by forest type and site class. These ages were determined as the youngest age when it is generally acceptable to harvest a forest stand. However, it does not mean that the model will always schedule the final regeneration harvest at the minimum ages, some analysis areas will be scheduled at older ages. As an example, the table below displays the minimum rotation ages by forest type and site class that were used for the Tiadaghton State Forest. The District Supplements to this plan contain specific information on each district.

<table>
<thead>
<tr>
<th>Forest Type</th>
<th>Site Class 1*</th>
<th>Site Class 2*</th>
<th>Site Class 3*</th>
</tr>
</thead>
<tbody>
<tr>
<td>N. Hardwoods</td>
<td>80</td>
<td>80</td>
<td>100</td>
</tr>
<tr>
<td>A. Hardwoods</td>
<td>80</td>
<td>80</td>
<td>100</td>
</tr>
<tr>
<td>Red Oak</td>
<td>80</td>
<td>80</td>
<td>100</td>
</tr>
<tr>
<td>Other Oaks</td>
<td>80</td>
<td>80</td>
<td>100</td>
</tr>
<tr>
<td>Red Maple</td>
<td>70</td>
<td>70</td>
<td>70</td>
</tr>
<tr>
<td>Other Hrdwds.</td>
<td>80</td>
<td>80</td>
<td>100</td>
</tr>
<tr>
<td>Conifers</td>
<td>80</td>
<td>80</td>
<td>100</td>
</tr>
</tbody>
</table>

*Includes both fully- and under-stocked sites.
Desirable rotation ranges (Adobe PDF - 5 Kb) where derived by consulting literature on the subject and with guidance from local forester managers. From this process a set of rotation ranges was developed for the most significant forest communities.

**Volume Fluctuation Constraint**

Allowable fluctuations in net board foot sawtimber volume between adjacent 10-year planning periods were imposed to ensure a sustainable, even flow of volume over time. This steady flow of volume helps identify the long-term sustained yield of the forest and support stable local industries and economies. Fluctuations were developed based on conditions in each district and details can be found in the Forest District Supplements to this plan.

**Harvest Area Fluctuation Constraints**

Similar to volume fluctuation constraints, the Bureau of Forestry constrained harvest area between adjacent 10-year periods. This was accomplished in several ways:

- The total area scheduled for treatment (overstory removals and shelterwood treatments) was permitted to increase or decrease by allowable percentages between adjacent planning periods. This helps ensure a stable workload for the district over time.
- The total area scheduled by site class was permitted to increase or decrease by allowable percentages between adjacent planning periods. This helps ensure a stable flow of volume quality over time and prevents the model from scheduling all of the best sites in early planning periods and leaving the poorer site classes for harvest in later planning periods.
- The total area scheduled by forest type was permitted to increase or decrease by allowable percentages between adjacent planning periods. This helps ensure a balance in the age class distribution within forest types as well as preventing the model from scheduling all of the best forest types in early periods and leaving the lesser forest types for harvest in later planning periods.
- The area scheduled for shelterwood harvests was permitted to increase or decrease by allowable percentages between adjacent planning periods.

The inclusion, type and percentages assigned for these constraints are different and specific to each forest district. Please see the Forest District Supplement to this plan for more details.

**Extended Rotation Area Constraints**

To address ecological, aesthetic, recreational and high-quality sawlog production concerns where older forests are desirable, the Bureau of Forestry established extended rotation area constraints to ensure that some areas of the multiple resource, commercial land base will be managed on rotations longer than the minimum rotation length. These extended rotation ranges (Adobe PDF - 5 Kb) were developed by a careful review of literature and through input from the forestry staff. The actual percentages of each forest community type maintained in older ages varied for each district and are more fully described in the Forest District Supplements to this plan. The table displays an example from the Tiadaghton Forest District of the approximate percentages of each forest type that will be managed as extended rotation acres.
It is important to note that these areas only applied to the fully stocked site classes that when the percentage was applied, exceeded 50 acres.

**Ending Forest Condition Constraint**

Ending forest condition constraints were imposed to ensure a desirable forest age structure at the end of the planning horizon. The ending forest condition constraint ensures that the minimum average ending age of each forest type and site class (excluding areas assigned to meet the extended rotation requirements) is at least one-half of the specified minimum rotation age.

**Objective Function**

The objective function of the harvest allocation model is to maximize the discounted net present value (NPV) of the modeled land base plus the discounted residual value of the forest. This does not mean that the Bureau of Forestry's objective for state forest land management is to maximize NPV, but rather to schedule treatments to meet the stated goals and objectives in a rational and economically efficient manner. The model must first satisfy all the constraints imposed by the Bureau of Forestry, then, only after all the constraints have been fully satisfied, is the model permitted to maximize net present value. With this technique, the constraints such as policy decisions and resource limitations take precedence and must be satisfied prior to optimizing the objective function.

<table>
<thead>
<tr>
<th>Table: Approximate percentages of forest types managed as extended rotation acres in the Tiadaghton District.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern Hardwoods</td>
</tr>
<tr>
<td>25% &gt; 80 yrs old</td>
</tr>
<tr>
<td>12% &gt; 110 yrs old</td>
</tr>
<tr>
<td>5% &gt; 130 yrs old</td>
</tr>
<tr>
<td>Allegheny Hardwoods</td>
</tr>
<tr>
<td>25% &gt; 80 yrs old</td>
</tr>
<tr>
<td>12% &gt; 100 yrs old</td>
</tr>
<tr>
<td>5% &gt; 120 yrs old</td>
</tr>
<tr>
<td>Red Oak</td>
</tr>
<tr>
<td>25% &gt; 80 yrs old</td>
</tr>
<tr>
<td>12% &gt; 120 yrs old</td>
</tr>
<tr>
<td>5% &gt; 150 yrs old</td>
</tr>
<tr>
<td>Red Maple</td>
</tr>
<tr>
<td>25% &gt; 80 yrs old</td>
</tr>
</tbody>
</table>
**Method of Scheduling Buffer Harvests**

Buffer treatments were scheduled outside of the Harvest Allocation Model according to the following methods:

- Within each district the number of acres of Commercial Buffer was determined.
- It was assumed that two-aged management with a 160-year rotation age would be the primary management technique in these areas. It is understood that in reality some areas may also be managed by uneven-aged systems.
- 1/80th of Commercial Buffer acreage scheduled for treatment annually.
- Each district's ideal total was then adjusted to more closely reflect realistic harvest levels when compared to historical harvests from these zones. This was necessary since many stream and trail buffers do not permit harvesting or are too narrow to schedule harvesting at planned intervals. They are only accessed normally when an adjoining multiple resource zone forest stand is harvested.
- Volumes derived from this type of harvest varied by district.

**Method of Scheduling Intermediate Harvests**

Intermediate treatments were scheduled outside of the Harvest Allocation Model. The forest types, site classes, age of entry and amount of area differed by district. However, in general, most intermediate treatments are scheduled to occur in site classes one and two Allegheny hardwoods, northern hardwoods and oak types between the ages of 50 to 70. Volumes derived from this type of harvest varied by district.

**Harvest Targets and Estimated Yield**

The yield projections are an estimate of the annual yield that can be expected through implementation of the plan. The plan was developed using 10-year planning periods. The table below shows the harvest targets and projected volumes for the first 10-year period of the plan on an annualized basis. More detailed plans by forest community and site class guidelines are found in the State Forest District Supplements.

More detailed district specific goals by forest type, site class, and age class are in each of the Forest District Supplements. Although the harvest schedule above is planned for the next 10 years, the Bureau of Forestry will re-examine the allocations every five years to account for changes in the land base, natural disturbances, and other data that might become available. The Bureau of Forestry will also re-examine the allocations to account for changes in Bureau policies and advances in modeling capabilities.

The timber allocation model is a simplification of reality. It will be used as a guide to district staff along with their field expertise and professional judgment to plan harvests.

**Future Harvest and Volume Projections**

The charts below display the projected trends for acres treated, volume harvested and revenues generated during each ten-year planning period over the 140-year planning horizon.
Projected Age Class Distribution by Forest Type

An objective of the Bureau of Forestry is to begin balancing the age class distribution of the multiple resource, commercial land base. The following charts show the age class distributions of state forest land as it is projected to change over time. These projections are based on strict implementation of the harvest schedules for each district for the next 140 years. Note the projected ending target forest condition at the end of the 140-year planning horizon. There is a balance of acreage in age classes up to 100 years old. These age classes contain the majority of the multiple resource, commercial land. There is a "tail" of acres in the 100- to 180-year old age classes. These are acres of the multiple resource, commercial land base that are being managed in extended rotations. The acres in the 180- to 280-year old age classes are areas that are mostly part of the limited resource, natural area, wild area, and other zones that are not traditionally managed as part of the multiple resource, commercial or aesthetic/buffer, commercial designations. This is the portion of the state forest system that, without active management, will just continue to get older over time.
**Silviculture Operating Guidelines**

**Project Review**

On initiation of any silvicultural project, e.g., timber sale, TSI, regeneration project, etc., the Project Review Checklist must be reviewed and completed by the administering forester and important issues must be addressed in the silvicultural proposal.

**Landscape Examinations**

The Landscape Examination Schedule provides for the orderly examination of all state forest land. Potential areas for silviculture treatments are determined during these exams. Procedures for conducting landscape examinations are found in the [Landscape Examination Manual](#) (Adobe PDF - 45 Kb)
**Annual Operating Plan**

The Annual Operating Plan (FRP-T-1) constitutes a schedule for all silvicultural and timber management activities. It is a work plan for the coming year, a record of the prescribed silvicultural treatment for each forest stand examined, a record of future treatment where needed and an assignment of priority. It will be filed in Supplement No.1 of the Timber Management Section of the Forest District Plans for each year of the management period, and a copy must be filed in the Landscape folder.

**Records and Maps**

**Records**

Proper execution of this plan requires that accurate records be kept of areas treated, volume removed, and silviculture applied. The following records will be maintained as part of the Forest Resource Plan, Silviculture/Timber Section.

1. Landscape File. See the Landscape Examination Manual (Adobe PDF - 45 Kb) for details
2. Annual Operating Plan FRP-T-1. This form will coincide with the time period between October 1 of the preceding year and June 30 of the current year. It will be filed in the landscape folder.
3. An annual harvest report form with acres treated by forest type, site/stocking, size and sale numbers. This form will be used to help the forest district track progress towards the attainment of harvest goals. It will be reviewed and updated by foresters at the time of sale proposal. Each prescription will contain information about progress towards the harvest goals by forest type, site class and size/stocking. This will provide feedback to the Silviculture and Resource Planning and Information Sections on progress and obstacles foresters are facing in attaining goals.

**Maps**

Each forest district will maintain at least the following, most recent, GIS coverages:

- Vegetation type
- Roads
- Trails
- Streams
- Landscape boundaries
- All Silvicultural Activities
- State Forest Boundary lines

These layers constitute the approved zoning for all silvicultural operations and provide resource data on land use. The data must be entered in a compatible format with statewide data sets. The Resource Planning and Information Division will assist and coordinate these efforts. Annually, a hard copy set of these layers should be printed for use in the forest district office.

**Timber Sale Guidelines**

The timber sale program within the Bureau of Forestry is administered through guidelines described in the Timber Management Manual. At the time of plan writing the "Timber Management Manual", 1983 is being significantly revised and renamed to the Silviculture Manual to reflect its broader scope. The new manual will be revised periodically to conform to changes in laws, rules and regulations, and to reflect advances in scientific knowledge and technology. Some of the more important silvicultural guidelines are listed here in the plan as well as in the Silviculture Manual.

**Reservation Guidelines**
The Bureau of Forestry supports the concept of conserving biological diversity in forest ecosystems. For purposes of this document, we are concerned with the effects of silvicultural operations on forest stand or site level bio-diversity. These effects focus on three components of bio-diversity; genetic, species and structural.

Although all components of bio-diversity are linked, a simplistic definition of each component is helpful for discussion purposes.

- **Genetic diversity** - The starting point of bio-diversity issues and can be defined as the variety of genes within a particular species, variety or breed.
- **Species diversity** - The number and variety of species found in a given area, in this case, the treatment area.
- **Structural diversity** - Pertains to the spatial arrangement of physical units. At the forest stand or site level. Structural diversity can be characterized as the number of strata or canopy layers within an area.

The Bureau of Forestry uses a number of silvicultural treatments to ensure the sustainability of the forest resource on state forest land. Silvicultural treatments of forest stands involve the removal of trees to accomplish prescribed objectives. Generally, silvicultural treatments strive to improve the merchantable quality of residual trees and/or provide conditions favorable for natural or artificial regeneration.

Removal of trees for any purpose inherently results in impacts to a site. Depending on one's perspective, the impacts can be viewed either positively or negatively, depending on forest stand marking and harvesting techniques. Un-harvested trees on an area act to mollify both real and perceived impacts to the site. Based on bio-diversity considerations and the above-mentioned site impacts, the bureau has implemented these reservation guidelines.

The purpose of reservation guidelines is somewhat divergent from fiber-oriented silvicultural objectives. Reserving trees in silvicultural treatments serves many purposes including the retention of biological or site integrity and diversity, and reducing aesthetic impacts. Retention of specific cohorts of trees on a site will retain or promote genetic, species and structural diversity in the residual and future forest stand, as well as protect other site values. Live crown ratio and tree vigor should be considered when selecting reserve trees.

Reservation guidelines are not intended to usurp silviculture but rather are designed to assist foresters with bio-diversity and aesthetic considerations when planning and implementing silvicultural practices. These considerations must be taken into account in all phases of silviculture, from planning to final harvest. Reservation guidelines will be considered and implemented for all silvicultural treatments.

Efforts should be made not to reduce species diversity in the forest stand. Retain a variety of tree species so that the reserved trees represent all existing species. Selection of residual trees should be based on retention or promotion of either genetic, species or structural diversity. Efforts should be made not to reduce species diversity in the forest stand. All crown classes should be represented and tree spacing must not represent a grid-like pattern. Leave small groups of trees as they occur naturally and consider future harvests when selecting trees to be reserved. Selection of reserve trees should be based on the following values and conditions:

- Genetic diversity
- Species diversity
- Structural diversity
- Live crown ratio
- Tree Vigor

When the even-aged silvicultural system is used, retain an average basal area between 10-20 square feet over the entire treatment area and a minimum of 5 trees per acre in the dominant, codominate and/or intermediate class on each acre. When using the two-aged system and doing intermediate treatments, a portion of the overstory should contain residual trees that satisfy these guidelines.
Whole Tree Removal

Whole tree removal (branches, etc.) is permitted only on sites approved in advance by the Resource Planning and Information Division and Silviculture Section.

Timber Salvage

Salvage sale operations will follow normal silvicultural procedures where possible. Where this is not possible, only the damaged material will be marked or designated for removal.

Coordination of Timber Management With Other Uses

It will be the responsibility of the district forester to see that timber management activities are coordinated with the uses and consistent with the policies and goals outlined in the State Forest Resource Management Plan.
Any management applied to any given area must be in accordance with the land use zoning. Requests for variation from the designated land use must be fully justified in writing to the State Forester.

If federal or state listed fauna or flora species, or habitat critical to their survival, either presently known or subsequently identified, occur within or adjacent to a proposed timber management project area, the Bureau Wildlife Biologists or Botanists will be notified prior to commencement of additional work on the project. The Wildlife Biologists or Botanists will determine what, if any, changes to the project are necessary to protect the species or habitat.

If archeological sites, either presently known or subsequently identified, occur within a proposed timber management project area, the Resource Planning and Information Section will be notified prior to commencement of any additional work on the project. The Section will coordinate assessment of the site and needed protection measures with the State Historical and Museum Commission.

Regeneration Guidelines

Deer Exclosures
Browsing by white-tailed deer can cause the failure of hardwood forest stands to successfully reproduce. Deer exclosures have been widely used and are effective in increasing biodiversity and reducing regeneration failures caused by deer browsing. Two types of exclosures are currently used on state forest land: woven wire and high-tensile electric. Complete guidelines on deer fences may be found in "Regeneration Project Options, Procedures & Guidelines", Pa. Bureau of Forestry, July, 1997.

Herbicide
Herbicide application is used when fern, grasses and undesirable shrub and tree species are competing with the establishment and growth of more desirable tree seedlings. Guidelines on herbicide application are found in "Regeneration Project Options, Procedures & Guidelines", Pa. Bureau of Forestry, July, 1997.

Fertilization
Aerial and ground application of fertilizer is used to establish black cherry regeneration in Allegheny hardwood stands following overstory removals. Fertilization has proven to be effective when there is adequate regeneration present, but deer browsing prevents it from developing. Fertilizer applied at the appropriate time and rate stimulates black cherry seedlings to rapidly grow out of the reach of deer, usually within one or two years. Herbaceous plants also respond vigorously producing large quantities of palatable browse that is more than deer can consume. This can effectively dilute the browsing pressure on the emerging forest stand. This is very cost effective since it eliminates the need for a deer fence.

Actions:

1. Continue to study the effects of fertilization and liming of forest stands on both trees and the ecology of forest communities.

Tree Planting Guidelines

Tree planting is sometimes done to supplement natural regeneration, increase species diversity, and improve wildlife habitat. On some highly disturbed sites it may be the only means available to reestablish forests. Artificial regeneration will be considered on state forest land when natural regeneration is not feasible or when necessary to maintain or restore desired tree species. However, the low cost and practicality of natural reproduction make it the most favored technique for reproducing state forest land.

Wildlife habitat improvement, supplementing natural regeneration and forest restoration are acceptable state forest management activities where artificial regeneration can be considered. Natural catastrophic events (i.e., insect infestations, frost events, wind fall and wild fires) that are followed by natural reproduction failures and periodic silvicultural treatments that have failed to naturally regenerate adequately may be candidates for restoration. In these instances of natural and anthropogenic regeneration failures, often the establishment of preferred regeneration can only be accomplished in a timely fashion with artificial regeneration.

Complete guidelines on tree planting (artificial regeneration) may be found in "Regeneration Project Options, Procedures & Guidelines", Pa Bureau of Forestry, July, 1997. Additional ecological considerations on tree planting are found in the Ecological section of this plan.

Actions:

1. Update tree-planting guidelines to better incorporate ecological guidelines.

Prescribed Fire

Prescribed fire is a powerful tool land managers are increasingly using in an attempt to restore certain ecosystems. Many of Pennsylvania's forests originated during a period in time when burning was much more frequent than it is today. Many plant and animal communities are dependent on a regular occurrence of fire for a healthy existence. Fire can favor certain plant communities, provide better forage for wildlife, return nutrients to the soil, and reduce hazardous fuel buildups. Currently on state forest lands, prescribed fire is used on a very limited basis for fuel reduction, silviculture and ecological purposes.

Prescribed fire can be as effective as a silvicultural treatment to promote regeneration of tree seedlings and other plants. It can be an efficient and cost effective tool to control inhibiting vegetation that competes with fire tolerant species. The Silviculture Section will consider proposals for prescribed fire for silvicultural purposes when other available options are not feasible to obtain the silvicultural or ecological objectives for a site. Prescribed fire is considered one of several treatments to a site to develop and maintain adequate desirable regeneration. The district forester must submit project proposals to the Silviculture Section for approval. The silvicultural proposal will be reviewed by the Division of Forest Fire Protection and the Silviculture Section.
Prescribed fire is a fire carefully set under very stringent weather and fuel conditions that allow it to be controlled to achieve specific objectives. Before burning, a burn plan must be prepared by a resource professional and the district forest fire specialist supervisor. This plan must then be reviewed and approved by the district forester. A copy must be sent to the Division of Forest Fire Protection for notification and documentation of the fire. Pennsylvania has a number of very strict laws pertaining to those who set fires that escape onto the lands of another or endanger the property or lives of others. It is difficult to overemphasize the importance of careful and thorough planning for any prescribed burn.


**Actions:**

1. Additional prescribed burning guidelines must be developed by the Division of Forest Fire Protection, the Silviculture Section and Ecological Services to better define responsible procedures, practices and qualifications for prescribed fire on state forest lands.
2. A standardized burn plan should be adopted to encourage the thorough and careful consideration of objectives and to facilitate more consistent documentation.
3. Provide opportunities for additional training to qualify personnel involved with planning and conducting prescribed burning according to National Wildfire Coordinating Group (NWCG) standards.

**Monitoring**

- Area of forest land and net area of forest land available for timber production.
- Total growing stock volume of both merchantable and non-merchantable tree species on forest land available for timber production.
- Annual removal of wood products compared to the volume determined to be sustainable.
- Value of investment, including forest regeneration.
- Level of expenditure on research and development.
- Level of expenditure on education.

**Critical Research Needs**

- Develop guidelines for evaluating adequacy of advanced oak regeneration and stump sprouts under Pennsylvania conditions.
- Develop silvicultural treatments for the establishment and development of large advanced oak regeneration.
- Develop guidelines for identifying threshold levels of competing vegetation that negatively influence oak regeneration.
- Develop methods for economical treatment of large woody competition (both oak and northern hardwoods).