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Landscape Level Planning: Exploring and Evaluating Management Alternatives for the Dwight B. Demeritt Forest

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LANDSCAPE LEVEL PLANNING: EXPLORING AND EVALUATING MANAGEMENT ALTERNATIVES FOR THE DWIGHT B. DEMERITT FOREST

by

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Abstract

The intent of this project was to use the management planning process to develop and evaluate three alternative management scenarios for the Dwight B. Demeritt Forest in Orono and Old Town, Maine, to determine which scenario best meets the landowner objectives, and to identify and provide recommendations to remediate any concerns.

Software including the Landscape Management System (LMS), Microsoft Access, and Microsoft Excel were used to develop, analyze, and evaluate a no harvest, a more intensive, and a moderate scenario. A score sheet was created to aid in the comparison of each scenario and to help determine which scenario best meets the landowner objectives.

None of the scenarios met all criteria for each objective, and there were benefits and disadvantages to each scenario. The more intensive scenario offered the best alternative to meet the landowner objectives, but it was recommended that the intensive scenario be altered slightly in order to better meet the objectives. Overstory removals should be modified to more vigorously remove the midstory and the amount of clearcut harvests should be increased to create a higher percentage of size class B stands. Furthermore, the substantial area of the forest dominated by large trees should be reduced to lower susceptibility to wind damage, the amount of fir throughout the forest should be decreased to reduce susceptibility to spruce budworm damage, and white pine regeneration and growth should be promoted to maintain the valuable white pine resource. Implementation of these changes will improve the results of the intensive scenario and better meet the landowner objectives.

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Introduction

The Dwight B. Demeritt Forest is located in Orono and Old Town, Maine, within minutes from the University of Maine campus. It is owned by the University of Maine and managed by the School of Forest Resources through the University Forests office. The last management plan developed for the Forest was a stewardship incentive plan written in 2000, under the Community Forest Recovery Program in response to damage by the 1998 ice storm (Simpson 2000). The plan is long outdated, and thus, the management planning process must be initiated once again.

The forest management planning process explores alternative management scenarios and exposes certain tradeoffs in order to find an appropriate balance between landowner objectives. The purpose of this project was to develop and analyze three alternative management scenarios for the Demeritt Forest and to determine which scenario best meets the landowner objectives. Recommendations were made as to how to alter and improve the chosen scenario and remediate any concerns.

This document first discusses the history of the Demeritt Forest, the land base for which the management planning process was completed. The document then explains the importance of the management planning process, gives some background on landscape modeling, and discusses the landowner objectives and criteria used to measure the objectives. The methods section will discuss the steps involved in developing the alternative management scenarios, and will describe how the scenarios were analyzed. Finally, the results, discussion, and conclusions sections will explain the results of each scenario and offer recommendations to address the concerns identified throughout the planning process.

History of the Dwight B. Demeritt Forest

Details of Acquisition

The first forestry courses at the University of Maine were taught in 1903, but the faculty did not consider the forestry department's laboratory facilities sufficient to allow for proper instruction and demonstration of the concepts and methods most important to forestry (Demeritt 1972). Therefore, in the 1920s and 1930s, the University acquired about 15 acres of land which were used for instruction, research, and demonstration of activities related to forestry (Demeritt 1972). In 1934, the forestry department became interested in acquiring more land to be used for educational purposes, which meant that the department could be considered for accreditation by the Society of American Foresters (SAF) (Demeritt 1972). The land that is now the Demeritt Forest was acquired by the government during the depression under the Bankhead-Jones Farm Tenant Act of 1937, which granted the federal government permission to acquire certain pieces of land which would help reduce the cost of maintaining schools, public facilities, and highways (Demeritt 1972). The forestry program was subsequently accredited by SAF in the late 1930s (Demeritt 1972).

The land acquired by the government was leased to the University on June 19, 1939 (Demeritt 1972). The lease for 2,085 acres of land was established for a 50 year time period, and was to be automatically renewed for three successive 15 year periods (Demeritt 1972). Upon signing the lease, it was agreed that the University was to use the land for instruction, research, and demonstration in the School of Forest Resources, and that the forest would also serve as a recreation facility for the surrounding community (Demeritt 1972). In addition, various government employees would be allowed to work on the forest, performing duties such as administrative upkeep and developing programs and activities related to recreation, forestry, and wildlife (Demeritt 1972).

After acquiring the land in 1939, some of the 2,085 acres were transferred by the University to other interested parties, reducing the amount of forest land managed by the University to about 1,748 acres by 1955 (Demeritt 1972). Approximately 325 acres were transferred to the City of Old Town in April 1941 for use as an airport (Demeritt 1972). Because this particular tract of land was not considered valuable forest land, and because it was farthest away and least accessible to the University, it was deemed most appropriate for use as an airport (Demeritt 1972). Furthermore, about 60 acres of the Smith Farm Lot were transferred to the College of Agriculture for use by the department of animal industry (Demeritt 1972). In addition, the fields on the Guarantee Lot were leased to Pinkham Farms for hay and pasture land, and a fielded area of the Smith Farm Lot was used for crop land (Taylor 1985).

On March 4, 1955, a little more than 16 years after the original lease was signed, the federal government terminated the lease and deeded the land as a gift to the University under the restriction that the land continue to be used for public purposes, conservation, and utilization, and that 75% of the land's minerals as well as all fissionable materials be reserved by the United States (Demeritt 1972). The University Forest was named the Dwight B. Demeritt Forest on September 23, 1971 to honor the man most responsible for its acquisition (Demeritt 1972, Taylor 1985).

Today, the Demeritt Forest is comprised of four primary tracts of land located in Orono and Old Town, all less than a 15 minute drive from campus (Griffin 1968). The tracts are further broken into ten compartments, labeled A-J, and total about 1547 acres in size. The Game Pen Lot contains Compartment A, the Sewall Block contains Compartments B-F and I-J, the Smith Farm Lot contains Compartment G, and the Guarantee Lot contains Compartment H (Figure 1) (Demeritt 1972). Woodlands adjacent to the University Forest add approximately 318 acres to the forest, totaling approximately 1865 acres. The Demeritt Forest is one of 45 parcels of land owned by the University of Maine or the University of Maine Foundation and managed by the University Forests office.

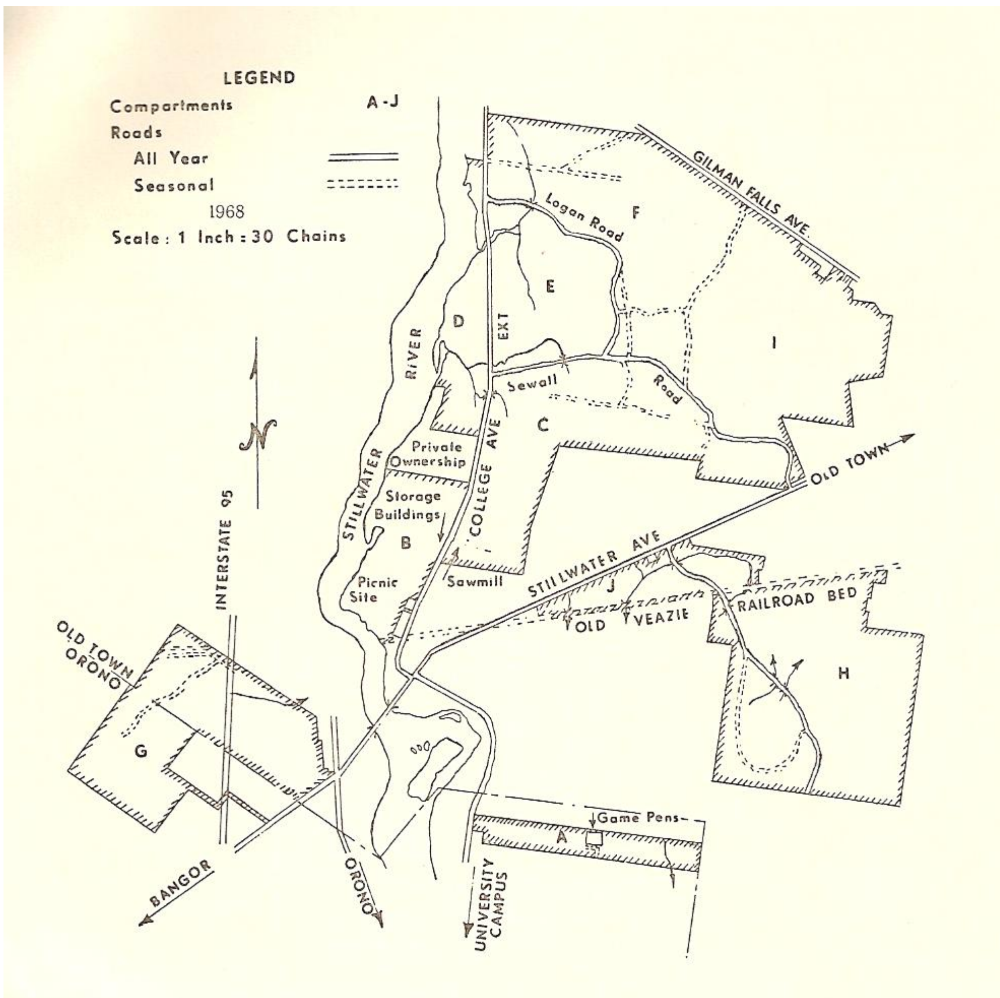


Figure 1: Map of Demeritt Forest, 1968

The recreational trails on the Demeritt Forest were built from old twitch trails between 1986 and 1990 (Chuck Simpson and Al Kimball, Personal Interviews, 2010), and were mapped and marked with signage by the University Forest Office. Campus Recreation is now responsible for maintenance and signage of the trails on the south side of Stillwater Avenue, closest to campus. Management of the trail system has traditionally been shared between the two entities, though there is no formal written agreement (Al Kimball, Personal Interview, 2010). The trails may be used for hiking, biking, cross country skiing, snowshoeing, dog walking, and horseback riding, but motorized recreational use is prohibited. Certain areas of the forest have also been used by Maine Bound, UMaine ROTC, airsoft and paintball clubs, among others, which has occasionally resulted in conflicting interests among user groups (Al Kimball, Personal Interview, 2010).

Changes in Management

The Demeritt Forest has been intensively managed since 1946 (Unknown 1987), though various educational and maintenance activities have been taking place on the forest since its original acquisition in 1939. Jerome Dunphy was the first individual responsible for forestry related activities on the forest from 1939 to 1946 (Taylor 1985). A few students were employed on the forest during this time to assist with activities such as release cuttings, planting, and slash and brush removal, but work was accomplished at a very slow pace since hand tools were the only equipment available at the time (Taylor 1985). As technology improved and more funds were available for employment, more students were hired for work on the forest (Taylor 1985). The first timber cruise of the Demeritt Forest was conducted in 1939-1940 by student Fred Holt (Taylor 1985).

Subsequent inventories were conducted in 1952, 1962 (Griffin 1968), 1986, 1995 (Greenwood 2007), and most recently in 2006 and 2009. These inventories were the basis for management of the forest.

When the land was first acquired, most of the forest stands contained considerable volumes of poor quality, diseased, over mature timber due to high grading and neglect (Taylor 1985). Between 1946 and 1960, however, management of the forest, and consequently, forest condition, improved greatly due to increasing amounts of labor and availability of equipment, all of which allowed for more efficient harvesting (Taylor 1985).

Roger Taylor was assigned to the position of Forest Superintendent in 1946 with the primary responsibility of managing the University Forest (Taylor 1985). Prior to 1946, management of the forest consisted mainly of improvement or release cuttings of hardwood to release the softwoods (Taylor 1985). Most of the entries were single-tree harvests. White pine and spruce were favored over all other species (Taylor 1985). Only about 19 acres of the forest were in a shelterwood system at the time (Al Kimball, Personal Interview, 2010). After 1946, the shelterwood method became the primary silvicultural method implemented in the pine dominated stands, and since 1985 the shelterwood method has been the primary method implemented throughout the entire Demeritt Forest (Al Kimball, Personal Interview, 2010).

Since the forest was acquired in 1939, up until about 1986 (Chuck Simpson, Personal Interview, 2010), trees were harvested primarily using a motor-manual stump-cut system (Al Kimball, Personal Interview, 2010). With this system, trees were cut-to-length, piled at the stump, and then carried to the landing with a bulldozer and trailer (Al

Kimball, Personal Interview, 2010). Thus, the trees were transported off of the ground, offering less impact on soil and regeneration damage. After 1986, a gradual transition was made from the short wood, stump-cut system which used bulldozers and chainsaws, to a tree length method that used mainly skidders and chainsaws (Chuck Simpson, Personal Interview, 2010). Trees were hauled to the landing tree length, which required increased care to reduce the likelihood of soil and regeneration damage, and required a straighter trail network throughout the forest (Al Kimball, Personal Interview, 2010).

Originally, all records of inventory and harvesting activities were kept using stand type as the basic management units (Taylor 1985). However, because stand types don't have permanent boundaries and are constantly changing, problems resulted (Griffin 1968, Taylor 1985). A permanent grid system was later established on the forest to better maintain record keeping and maintenance plans (Taylor 1985). The blocks, each 10 acres in size, were surveyed and established from 1958 to 1959 (Taylor 1985). The grid lines were spaced at 10 chain intervals and were run N8°E and S82°E in all compartments except compartment G, where the gridlines ran N53°W and N37°E (Griffin 1968). The lines were blazed, painted orange, and cleared of brush, and each block corner and road crossing were marked using a wooden post with aluminum tags to label each block (Griffin 1968). Until 1991, records were kept by ten acre blocks because they were easier and more manageable to work with (Taylor 1985). After 1991, the Demeritt Forest began to be managed on a stand by stand basis once again. The change was made as a result of a shift in managers and their differing views on the most appropriate management technique. Stands continue to be used as the management units today.

One significant improvement that was made to the University Forest in the mid to late 1980s (Chuck Simpson, Personal Interview, 2010) was the greatly improved and extended road access, which opened up new sections of the forest for harvest (Al Kimball, Personal Interview, 2010). In addition, the University Forest staff also expanded from the two person staff of a superintendant and assistant, to a four person staff of the superintendent, operations manager, GIS technician, and forest technician (Al Kimball, Personal Interview, 2010).

Harvest Trends

As mentioned previously, until 1946, management of the Demeritt Forest consisted mainly of improvement or release cuttings to favor and promote softwood regeneration; particularly white pine and spruce (Taylor 1985). After 1946, once the Demeritt Forest became more intensively managed, even-aged silviculture became the primary approach to management, with the shelterwood method being the principal technique used to regenerate white pine and other desirable species (Taylor 1985, Unknown1987). The shelterwood method is still the dominant method used today. Uneven-aged silviculture has been used primarily to achieve aesthetic objectives, to manage riparian areas, and to promote structural diversity within stands (Unknown 1987). Currently, about 75% of the forest is even-aged, while the other 25% is uneven-aged.

Timber harvested from the Demeritt Forest has historically been primarily sawtimber and pulpwood or fuelwood (Unknown 1987). Early records of timber harvests on the Demeritt Forest indicate that most of the board foot volume harvested came from white pine, while most of the pulpwood volume (in cords) came from hardwood species and spruce and fir, especially in the 1960s (Figures 2 and 3). The figures also indicate that board foot harvest volumes fluctuated significantly between decades, with the most volume being harvested in the 1960s. A total of 1,143,452 BF of volume was harvested in the 1960s. The least amount of board foot volume was harvested in the 1940s, with a total harvest volume of 292,410 BF.

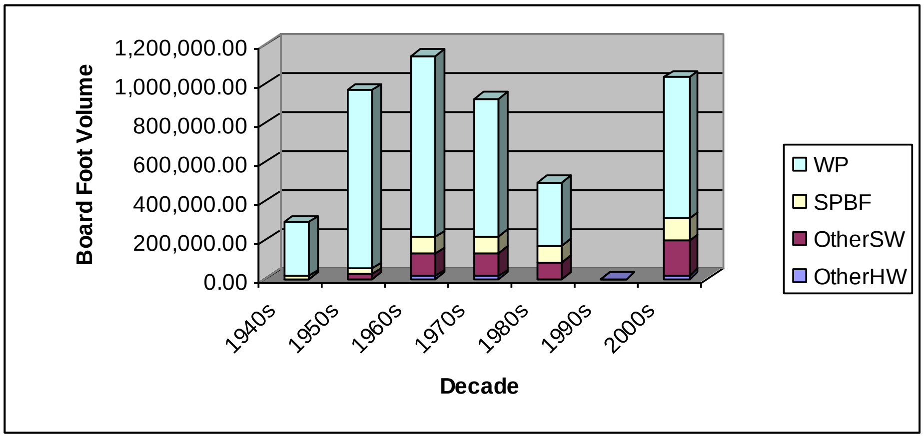


Figure 2: Board Foot Volume Harvested by Species Group from the 1940s through the 2000s

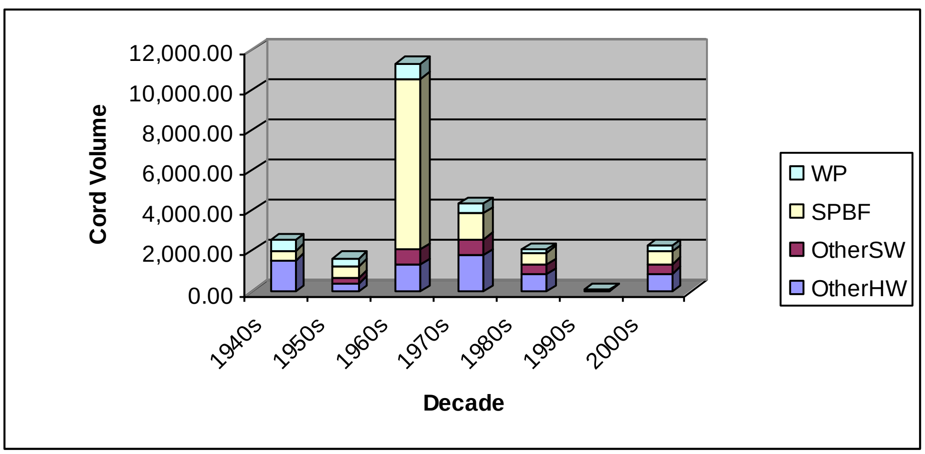


Figure 3: Cord Volume Harvested by Species Group from the 1940s through the 2000s

The amount of cords harvested also fluctuated between periods, and was much higher in the 1960s, where the majority of harvested volume consisted of spruce and fir. A total volume of 11,310 cords were harvested in the 1960s. The least amount of cords were removed in the 1950s, where a total of 1633 cords were harvested.

As seen in Figures 2 and 3, data are missing for part of the 1990s decade. This is due to a shift in managers and methods of record keeping during that time. If and when the data are found, they will be entered into the database and the figures will be updated.

The Management Planning Process

Forest management is a complex process, as managers must attempt to strategically integrate silvicultural techniques with operational efficiency and economic stability, while at the same time, attempting to achieve landowner objectives (Bettinger et al. 2009). Forest management entails long planning horizons, the allocation of limited resources, and competing objectives. As a result, the forest planning process often exposes tradeoffs that must be considered and reconciled in some way. The management planning process typically explores various alternative management scenarios to select the most appropriate balance between competing landowner objectives (Bettinger et al. 2009). The preferred alternative selected in the management planning process becomes the basis for a final management plan.

Final management plans offer a description and suggested timetable of individual management activities that should be implemented to meet the landowner's objectives. They serve to both guide forest management and to demonstrate to landowners and other parties interested in forest management that "economic, ecological, and social goals are being considered" in the management of their forests (Bettinger et al. 2009). As stated by

Bettinger et al. (2009), management plans are also important to land managers because they "provide guidance in implementing activities, predicting future harvest levels, optimizing the use of limited resources, and maintaining or developing habitat areas, while simultaneously balancing several other concerns". Without a forest management plan, forest managers are left without comprehensive guidance. Management can become piecemeal with little direction, no consideration of cumulative impacts, and no ability to adapt approaches based on success or failure.

The first component of a forest management planning process is to identify the landowner's goals and objectives (Bettinger et al. 2009). Management objectives can be defined as the desired future condition and characteristics of the forest resource (Morrill 2009). Objectives help define the purpose for managing a forest in a particular way. For example, two of the objectives established for the Demeritt Forest are to maintain a sustainable timber supply, and to maintain or improve biodiversity values of the forest. Obviously, these are two very different goals that could each be maximized by employing alternative management approaches. The aim of the forest planning process is to identify tradeoffs between competing objectives and allow the landowner to choose the most appropriate balance between them (Bettinger et al. 2009).

Determining the current objectives for the Demeritt Forest required examination of existing documents that outlined pre-established objectives. These objectives were assessed for continued relevancy and compiled. Furthermore, additional objectives of various forest user groups on campus and in the surrounding community were considered. An updated set of objectives was developed and documented so that they could be taken into consideration during the planning process.

In addition to developing a set of objectives, specific measurement criteria were also developed. Criteria are the specific actions or attributes that can be measured or assessed to determine if an objective is being achieved (Morrill 2009). For example, as outlined in the suggested objectives and criteria document developed by the University Forests Office, the criteria for measuring the objective of maintaining a sustainable supply of timber are as follows: 1) removals in any one planning period are within 20% of the average for the entire projection period, 2) the percentage of standing volume of large diameter white pine is within 20% of the current percentage of white pine, and 3) at least a 15% representation from each size class (small, medium, large, and extra large) is maintained in all planning periods (Morrill 2009). Measurable criteria are developed as quantitative measures that allow one to measure if an objective is being achieved. Individual objectives and criteria developed for and used in the Demeritt Forest planning process are described in more detail in the objectives and criteria section of this paper.

The next stage in the planning process involves assessing the current resource conditions (Bettinger et al. 2009, Morrill 2009). The first step is to consult current maps, aerial photographs, and GIS layers of the property to locate areas of special concern, and areas that are available for management (Bettinger et al. 2009). For example, the Demeritt Forest contains areas set aside for research, areas in reserves, forested and non-forested wetlands, and shoreland zoning buffers. It is important to identify these areas prior to developing a management plan and associated harvest schedule so they can be properly taken into consideration when management activities are being implemented. For the Demeritt planning process, GIS layers containing data from the Maine Natural Areas Program (MNAP), Inland Fisheries and Wildlife (IF&W), and National Wetlands

Inventory (NWI) were consulted to determine areas of special concern. In addition, GIS layers from the Maine Office of GIS were augmented to include certain features such as streams and other water bodies. These features were either digitized from aerial photographs or field determined using GPS technology.

The second step involved in assessing the current resource conditions is to conduct a forest inventory (Bettinger et al. 2009). Inventory data provide estimates of the stand conditions and quality and quantity of wood in an area, and allow natural resource managers to make informed management decisions. With the inventory data, mangers are able to summarize, analyze, and evaluate the information to propose management actions most appropriate for stands on the landscape. For example, inventory data can be imported into software programs such as Microsoft Access, Landscape Management System (LMS) which will be described in more detail in the landscape modeling section of this document, and ArcGIS or other geographic information systems. The use of these programs aid land managers in gaining a better understanding of the current conditions of the forest resource. Details of the inventory conducted for the Demeritt planning process are presented in the methods section of this document.

Once the inventory data are imported into LMS, various management scenarios are developed and projections are created in order to help managers and landowners understand how different management techniques are likely to affect the future of the resources (Bettinger et.al.2009). For the Demeritt planning process, three management scenarios were developed ranging from low intensity management (no harvest), to highly intensive management, with a balance of the two extremes in between. The scenarios should envelop a wide array of possibilities, and should allow managers to gain insight from the different ranges in management intensity. The individual scenarios developed for the Demeritt planning process will be discussed in more detail in the methods section.

From the projection of the management scenarios through time, the outcomes may be assessed to determine how well each management alternative will meet the landowner objectives (Bettinger et al. 2009). The comparison of alternative management scenarios should aid managers in making informed decisions. For the Demeritt planning process, tools were developed in Microsoft Access and ArcGIS to summarize results, compare the outcomes to the landowner objectives, and evaluate the results based on the objectives. Once the scenarios are compared, the scenario which best satisfies the objectives should be chosen.

Finally, once the plan is written, it should be reviewed by various user groups, and the plan should be implemented using an adaptive management approach, meaning that future outcomes should be integrated into the plan so that it is continually updated (Morrill 2009).

Thus, the forest management planning process is important to help land managers make informed decisions, and to ensure that the most appropriate management recommendation is implemented to achieve landowner objectives. As described by Bettinger et.al. (2009), a forest management plan should "provide a single management recommendation that describes how a plan of action will contribute to the goals and objectives of the landowner, and how these activities may affect other natural resources of interest". With a management plan set in place, land managers have the necessary guidance needed to implement activities that will achieve the landowner objectives.

Landscape Modeling Background

Landscape Approach to Management

Forest managers often focus on individual stands as their management units. A stand can be defined as a "contiguous group of trees sufficiently uniform in species composition, arrangement of age classes, site quality, and condition to be a distinguishable unit" (Smith et. al.1997). While it is important to observe individual stands and determine the appropriate silvicultural technique to implement in certain stands at a particular time, the management planning process should not stop at the stand-level. Instead, managers need to develop management plans and implement forest practices based on goals across larger landscapes made up of many forest stands (Oliver 1992). Oliver (1992) suggests that recent attention has been misdirected towards stand-level forestry operations. Stand level attention does not address all possible concerns and values for a forest, including wildlife habitat, aesthetics, timber and fuelwood production, cash flow, and biodiversity, among others. The concept of landscape forestry, however, can provide the methods, concepts, and analytical procedures for shifting management from traditional stand-level forestry to landscape forestry (Boyce 1995).

Managing at the landscape-level is a relatively new concept to forest management, having been proposed and developed during the past two decades (Hunter 1999). Landscape forestry is defined as "the art of organizing forested landscapes to produce an array of benefits among two or more kinds of stands throughout space and time" (Boyce 1995). Managing stands at the landscape scale by coordinating management activities in different stands across space and time allows a variety of forest values to be sustained across the landscape (Hunter 1999, Oliver 1992). For example, diverse stand structures can provide for a diversity of habitat structures (Hunter 1999). This is beneficial because some species require habitats that are on the edge of open and closed canopied forest stands, while others require areas that are either completely open or completely closed in canopy cover (Hunter 1999). By maintaining a wide array of stand structures across larger landscapes, a variety of habitats will be available for a multitude of species.

Furthermore, certain catastrophic events are partially based on stand location within the forest as well as the condition of the surrounding stands (Hunter 1999). On a landscape with more diverse stand structures, a reduced percentage of the forest will be highly vulnerable to specific pests, disease, fire, wind, and other natural disturbances which could potentially devastate stands across a more homogeneous landscape. Therefore, maintaining diverse stand structures also offers some insurance against the uncertainty inherent in forest management (McCarter et. al. 1998).

Landscape level management requires that consideration encompasses large spatial and temporal scales when planning and implementing harvests (Hunter 1999). Historically, harvest scheduling was conducted for the forest as a whole without much consideration for potential changes in stand structure, or for whether or not targeted stands were in locations that were economically and operationally efficient (Hunter 1999). Landscape level planning improves this process and ensures that silvicultural activities are implemented within a reasonable spatial and temporal context, and that they produce the outcomes expected (Hunter 1999).

Landscape management offers a greater flexibility to how forests can be managed, because it allows different stands to provide a range of conditions at any one time and the same stand to provide different conditions through time (Hunter 1999). For example, one stand might be managed to promote wildlife habitat, while another stand might be simultaneously managed to produce a maximum supply of timber, while yet another stand might be managed to promote aesthetics and recreational value. Each of the different silvicultural regimes implemented under a landscape management approach offers a wide variety of values at different times (Hunter 1999). For this reason, adopting a landscape approach to forest management has become more popular throughout the past two decades.

Importance of Stand Projections

The aspect of the management planning process which allows forest managers to understand how the implementation of different management scenarios may impact the future of the forest resource is the projection of stands across landscapes into the future using growth and yield simulation models. Long-term forest management requires managers to predict how the forest may grow multiple decades into the future, and be able to determine how forest stands will develop after various silvicultural techniques are implemented. Using growth and yield simulation models, managers can project current stands into the future for a specified number of years, as well as implement various silvicultural treatments in stands and subsequently project the treated stand into the future (Bettinger et. al. 2009). Each of these activities may also be completed for the entire landscape, thus incorporating the landscape forestry approach. Each individual scenario and growth projection will give forest managers an idea of how a forest will develop throughout the future under various management regimes, and by comparing the scenarios, managers and landowners can choose the one that will best achieve the landowner objectives (Bettinger et. al. 2009). As a result of the modeling process, land managers are able to effectively evaluate the economic, environmental, and social aspects of management alternatives (Bettinger et. al. 2009).

Transition from Growth and Yield Tables to Growth and Yield Simulators

Models are simplified representations of certain components of the real world, and in forestry, they are useful for predicting and describing how forests will likely change through time (Husch et. al. 2003). Growth and yield models provide a reliable way to evaluate management options, determine the sustainable timber yield, and assess the impacts of forest management and harvesting operations on other values of the forest (Vanclay 1994). Growth models are composed of mathematical equations, and generally incorporate accretion, mortality, and ingrowth of trees in a stand to describe changes in stand structure and composition over time (Vanclay 1994).

Before computing technology advanced to where it is today, future forest characteristics were estimated using growth and yield tables (Bettinger et. al. 2009). A yield table presents the anticipated volume per unit area at a given age, and is one of the oldest approaches to yield estimation (Bettinger et. al. 2009, Husch et. al. 2003, Vanclay 1994). Natural resource managers in North America have used yield tables to estimate tree volumes and yields for over 80 years (Bettinger et. al. 2009). Traditional yield tables were only applicable to even-aged stands, and were used to aid in regulating harvests, determining rotation length, and making growth estimates for the forest (Husch et. al 2003). In contrast to yield tables in which all trees in a stand are represented, volume tables allow managers to estimate the volume of individual trees, depending on the tree diameter and height (Bettinger et. al. 2009).

As computer technology became more advanced, growth and yield tables, along with the relationships of accretion, ingrowth, and mortality were incorporated into computer simulation models (Bettinger et. al. 2009). Growth and yield simulators function similarly to growth and yield tables in that they can estimate the potential future characteristics of a stand, but yield tables are limited as to how stand volume estimates can be achieved (Bettinger et. al. 2009). Growth and yield simulators allow more possibilities and greater flexibility in determining future conditions of forest stands. According to Bettinger et. al. (2009), to be an effective natural resource manager, and to be able to consider multiple objectives and constraints simultaneously, it is necessary to use contemporary simulation and optimization techniques. Growth models allow managers to investigate quickly and efficiently the response of the forest to various management regimes, subsequently allowing them to make informed management decisions (Vanclay 1994).

Types of Growth and Yield Models

There are various types of growth and yield simulation models, including individual tree, distance-independent models; individual tree, distance-dependent models; and whole stand models, among others. According to Davis et. al. (2001), individual tree models are the best available tools for simulating the growth of trees under different management scenarios. Both the individual tree distance-dependent and distance-independent models are complex, and individually model tree growth based on a tree list developed from inventory data (Davis et. al. 2001). Most individual tree models also calculate a crown competition index (CCI) for each tree to determine how well the tree is able to compete for light and growing space relative to other trees in the stand (Davis et.

al. 2001). This information allows the growth model to predict diameter, height, and crown growth, determine whether or not the tree will survive based on competition with neighboring trees, and calculate volume and growth rates from the stand, among others (Davis et. al. 2001). Individual tree models are useful for projecting the growth of both uneven-aged and even-aged stands (Bettinger et. al. 2009, Husch et. al. 2003).

The primary difference between distance-independent and distance-dependent growth models is that distance-dependent models require detailed measurements to be taken of the actual spatial location of each tree in relation to its neighbors, in order for competition to be modeled directly (Bettinger et. al. 2009, Davis et. al. 2001). Distance dependent models use measures of density to estimate the level of competition for each tree, and model potential growth as a function of tree size and competition (Husch et. al. 2003).

Individual tree, distance-independent models do not take into account the actual distance from one tree to the next, or the explicit competitive relationship of the tree relative to its neighbors (Bettinger et. al. 2009, Davis et. al. 2001). With distance-independent models, it is assumed that growth rates are constant for trees of similar species and size, and that trees are evenly distributed across the landscape (Davis et. al. 2001). They use initial tree characteristics and general expressions of competition, such as stand density index and basal area, to predict tree growth and mortality (Husch et. al. 2003).

Both types of individual tree models (distance dependent and distance independent) use tree records as the modeling unit, with each tree record representing more than one tree per unit area (Bettinger et. al. 2009). In addition, both individual tree models project and grow the individual tree records in 5-10 year increments, apply mortality functions, determine volume, apply an expansion factor, and combine all of the individual tree estimates to determine final stand-level estimates (Bettinger et. al. 2009).

Whole-stand models are growth models that are able to provide stand-level output such as basal area per acre and volume (Bettinger et. al. 2009). They use stand-level data as input, including stand age, site index, stand density, and quadratic mean diameter to predict how the parameters will change over time (Bettinger et. al. 2009, Husch et. al. 2003). Stand level models ignore most of the tree-level detail associated with individual tree simulators (Bettinger et. al. 2009). According to Bettinger et. al. (2009), whole-stand models are easy to use compared to the individual tree models, but they may not be as reliable for mixed species stands. Yield tables and yield functions are two forms of whole-stand models (Bettinger et. al. 2009, Husch et. al. 2003).

LMS Overview

The Landscape Management System (LMS) is a set of software tools developed to aid in forest management at the landscape level (University of Washington College of Forest Resources, and USDA Forest Service 2005). Managers can use LMS to evaluate management techniques and determine those appropriate for various forest stands across the landscape. The development is part of a cooperative effort between the Silviculture Laboratory, College of Forest Resources at the University of Washington, and the USDA Forest Service, Pacific Northwest Research Station (McCarter et. al. 1998).

The software program is designed to integrate inventory information, geographic information, computerized growth and yield models, and decision support systems to aid in landscape management (University of Washington College of Forest Resources, and

USDA Forest Service 2005). The system has been designed as an interface to growth models that operate at the individual tree, distance independent level because most growth models operate at that resolution, and most forest inventory techniques provide this level of information (McCarter et. al. 1998). The growth model within LMS is an individual tree, distance-independent model known as the Forest Vegetation Simulator or FVS. LMS also contains tools such as the Stand Visualization System (SVS) and Envision which allow for stand and landscape visualizations, respectively (McCarter et. al. 1998). In addition, LMS contains tables and graphs which allow for analysis and evaluation of management scenarios, but the data outputs are also flexible enough so that they can be exported to other tools like Microsoft Access and Excel for further analysis (McCarter et. al. 1998).

Stand level information provides the basis for classifying forest stands and predicting future conditions at the landscape scale (McCarter et. al.1998). Therefore, LMS requires that stand level data be input in order to project changes in landscape scale processes. LMS requires that certain information files, including inventory data, stand attributes, digital elevation, and spatial characteristics are input into LMS so that a "landscape portfolio" may be created (University of Washington College of Forest Resources, and USDA Forest Service 2005). Using these data, LMS allows users to project individual stands into the future, implement silvicultural treatments, and visualize current, future, and treated stand conditions. These actions can also be applied at the landscape scale, either stand by stand or as a whole, thus automating the steps needed to project stand level data at the landscape scale (McCarter et. al. 1998).

LMS allows managers to implement the landscape management approach discussed previously, by developing and evaluating stand and landscape scale forestry techniques for both the short and long term planning horizons (McCarter et. al. 1998). Although growth and yield models may be valuable tools in determining future conditions of the forest, they have their limitations as well, since all models are abstractions of reality (Bettinger 2009, McCarter et. al. 1998, Vanclay 1994). LMS is useful in that it allows forest managers to look at conditions across a landscape far into the future, thus allowing them to consider multiple spatial and temporal scales at once (McCarter et. al. 1998).

Objectives and Criteria

Objectives and criteria for the Demeritt Forest were defined by consulting and modifying previous management planning documents, and considering additional objectives of multiple forest user groups. Objectives are generalized statements about the desired future condition of the forest resource, while criteria are specific elements that can be quantified to determine achievement of an objective (Morrill 2009). All of the following information concerning objectives and criteria for the Demeritt Forest can be found in the Draft Planning Document (Morrill 2009) developed by the University Forests office (Appendix I). Table 1 presents a summary of all of the objectives and criteria developed for the Demeritt Forest, and their respective codes that will be referenced throughout this document.

Table 1: Summary of All Objectives & Criteria

Objectives & Criteria
1) Education & Research
O1C1: Diversity of Stand Structures: 24 categories, all >= 1% in all periods
O1C2: Silvicultural Treatments: >= 10ac of each treatment per period
O1C3: Area in Reserve: >=10% of total forest area
2) Forest Structure & Species Composition (Same as objective 1)
3) Sustainable Timber Supply
O3C1: Harvest Removal: w/in 20% of average in each period
O3C2: Standing Volume (large DBH WP): w/in 20% of current levels in each period
O3C3: Diversity of size classes: 4 categories, all >= 15% in all periods
4) Income Generation
O4C1: Income is between $325,000 and $385,000 (2009 dollars) in each period
5) Biodiversity, Habitat, and Areas of Special Concern
O5C1: Harvests excluded from SLZ 75 buffers, vernal pool 100ft zones, and reserves
O5C2: Harvests reduced in SLZ 250 buffers and other unique areas
O5C3: Reserve/Control areas excluded from harvest
6) Recreation & Aesthetics
O6C1: <=75 acres of HRV stands harvested per period
O6C2: Exclude OSR and CC treatments in HRV stands
7) Forest Health & Protection
O7C1: Wind Susceptibility Ratings: <=20% of forest with high/severe rating
O7C2: HWA Susceptibility Ratings: <=20% of forest with high/severe rating
O7C3: SBW Susceptibility Ratings: <=20% of forest with high/severe rating
8) Water & Soil Quality
O8C1: Harvests excluded from SLZ 75 buffers
O8C2: Harvests reduced in SLZ 250 buffers and other areas with soil/water quality value
9) Non-Timber Products
O9C1: Restrict treatments in Sugarbush stands to thinning and planting
10) Historic and Cultural Resources
O10C1: Harvests excluded from designated harvest exclusion polygons
O10C2: Harvests reduced in designated polygons

1) Education & Research

The first objective for the Demeritt Forest is to provide continuous and diverse opportunities for education, research, and demonstration. This has been the primary purpose of the Forest since its inception in 1939 (Demeritt 1972, Griffin 1968), and thus, it is important for these opportunities to continue for future benefit. One way that the forest can continue to provide educational, research, and demonstration opportunities to the University and surrounding community is to ensure that a diversity of stand structures and species composition are maintained. Employing a variety of silvicultural treatments in each planning period is one way to accomplish this goal. By having the opportunity to study a wide variety of stand types and structures and see the effects of various silvicultural treatments, the educational experiences of researchers and students will be greatly enhanced.

The criteria to measure achievement of the first objective include the following (the labels are from the Draft Planning Document in Appendix I, and include both the objective number and the criteria number): O1C1) 24 categories of stand structure will be maintained, with each category representing at least 1% of the total forest area in all planning periods. Categories will each include a) stratum (single or multi), b) size class (small, medium, large, or extra large), and c) cover type (hardwood, softwood, or oak-pine); O1C2) A variety of silvicultural treatments will be implemented, including shelterwood establishment, shelterwood overstory removal, selection, thinning, and clearcutting. At least 10 acres will be treated with each silvicultural treatment during every 5 year planning period; O1C3) At least 10% of the total forest area will remain as control or reserve areas, in addition to the area left as 75ft shoreland buffer zones.

2) Forest Structure & Forest Species Composition

The second objective is to provide a diverse forest structure and species composition across the entire forest during all periods. This is important for both educational and research purposes as mentioned previously, but also for silvicultural purposes. To achieve this objective, various silvicultural treatments should be implemented each period to create a diversity of stand structures. The same criteria are used to evaluate this objective as in the first objective (see above).

3) Sustainable Timber Supply

The third objective is to maintain a sustainable supply of high quality timber in managed stands throughout the forest planning period. Maintaining a sustainable timber supply is important to the economic values of the landowner. It is important to maintain an adequate supply of standing volume so that the landowner can be ensured a sufficient income throughout each period.

The criteria to measure achievement of the third objective include the following: O3C1) Harvest volume removals for each planning period are within 20% of the average for the entire projection period; O3C2) The standing volume of large diameter white pine is within 20% of current levels during each period; O3C3) Four categories of size classes (small, medium, large, and extra large) will be maintained across the forest, with at least 15% representation from each class in all planning periods.

4) Income Generation

The fourth objective is that management activities will provide a consistent income to support continued management of the forest. Providing a consistent income is important to be able to continue to properly manage the forest and satisfy each landowner objective. This means that harvesting activities must occur regularly and produce enough volume to provide an adequate amount of income. The criterion to measure fulfillment of this objective (O4C1) is that management activities will provide an income ranging from $325,000 to $385,000 (in 2009 dollars, i.e. timber prices are expected to rise at the same rate as inflation) in each planning period.

5) Biodiversity, Habitat & Areas of Special Concern

The fifth objective is that critical habitats and unique areas will be protected and biodiversity will be enhanced across the landscape during each planning period. This is important in order to preserve species diversity and maintain habitats for various animal species at the landscape level. This objective suggests that harvests should either be restricted or reduced in areas of special concern for habitat and biodiversity. The criteria to measure achievement of the fifth objective include the following: O5C1) No harvesting activities will be conducted in SLZ 75 buffers, vernal pool 100ft buffers, or reserve or research areas; O5C2) Harvest levels will be reduced in SLZ 250 buffers and other unique areas; O5C3) Reserve and scientific control areas are excluded from harvest.

6) Recreation & Aesthetics

The sixth objective is that the Demeritt Forest will continuously offer safe, sustainable, attractive, and diverse opportunities for recreation. Because the Demeritt Forest is situated in close proximity to campus and can be easily accessed by people in surrounding communities, recreation has always been an important aspect to management of the Forest. Managing for recreation means that consideration should be taken so as to reduce or restrict harvests along recreational trails. The criteria to measure fulfillment of the sixth objective are as follows: O6C1) No more than 75 acres will be harvested in stands considered to be of high recreation value in any planning period. O6C2) Clearcutting and overstory removals will not be implemented in stands of high recreational value.

7) Forest Health & Protection

The seventh objective is that the Demeritt Forest will be protected from unwanted pests and disease, invasive plants, wildfire, and unlawful trespass. This objective is important to maintaining a healthy forest that can continue to provide various benefits into the future. The criterion to measure achievement of this objective (O7C1) is that a) wind, b) hemlock wooly adelgid, and c) spruce budworm susceptibility indices should indicate that no more than 20% of the forest is classified as having a “high” or “severe” susceptibility rating in any period.

8) Water & Soil Quality

The eighth objective is that water bodies are protected from pollution and soil productivity is preserved. This is important to maintaining ecological values on the forest. In order for water bodies to be adequately protected, harvests should be restricted in areas in close proximity to water. The criterion to measure achievement of the eighth objective is that (O8C1) harvests will be excluded from SLZ 75 buffers and (O8C2) reduced in SLZ 250 buffers, as well as other stands with particular soil or water quality values.

9) Non-Timber Products

The ninth objective is that non-timber forest resources are maintained. Perhaps the most important non-timber forest products on the Demeritt Forest are maple sugar products. Maple sugaring activities provides students and student workers with a unique educational experience. Therefore, it is important to maintain the sugarbush sap production capacity into the future. The criterion to measure the ninth objective (O9C1) is to restrict treatment types in sugarbush designated stands to thinning and planting.

10) Historic and Cultural Resources

Finally, the tenth objective is to properly identify and manage stands containing resources of historical and cultural significance. It is always important to preserve artifacts of historical or cultural value so that managers can be informed of previous forest history, and because these resources may serve as valuable educational tools. The criterion to measure this objective (O10C1) is that harvests will be minimized in stands of special historical and cultural significance. There is currently one known prehistoric archaeological site on the Demeritt Forest, located opposite the Sewall Road in Compartment D. There are also two areas considered "sensitive" prehistoric sites located in close proximity to the known site.

All of these objectives and criteria are important for land managers to keep in mind as the management planning process unfolds. The development and evaluation of alternative management scenarios will allow managers to identify tradeoffs between the objectives and allow for the selection of the scenario which offers the most appropriate balance.

It is important to note that the results and discussion sections of this document will only present and analyze four of the ten objectives described above. These include the education and research, sustainable timber supply, recreation and aesthetics, and forest health and protection objectives. The criteria used to analyze these particular objectives are highly quantitative, and can be easily attained through the modeling process. The other objectives presented above are less quantitative, and analysis is more subjective. The final management plan developed by the University Forest Office staff will include results and discussion for all ten objectives. Table 2 below presents a summary of the objectives and criteria analyzed in this document.

Table 2: Summary of Objectives & Criteria Analyzed for this Project

Objectives & Criteria
1) Education & Research
O1C1: Diversity of Stand Structures: 24 categories, all >= 1% in all periods
O1C2: Silvicultural Treatments: >= 10ac of each treatment per period
O1C3: Area in Reserve: >=10% of total forest area
3) Sustainable Timber Supply
O3C1: Harvest Removal: w/in 20% of average in each period
O3C2: Standing Volume (large DBH WP): w/in 20% of current levels in each period
O3C3: Diversity of size classes: 4 categories, all >= 15% in all periods
6) Recreation & Aesthetics
O6C1: <=75 acres of HRV stands harvested per period
O6C2: Exclude OSR and CC treatments in HRV stands
7) Forest Health & Protection
O7C1: Wind Susceptibility Ratings: <=20% of forest with high/severe rating
O7C2: HWA Susceptibility Ratings: <=20% of forest with high/severe rating
O7C3: SBW Susceptibility Ratings: <=20% of forest with high/severe rating

Methods

Inventory

The inventory data used for the management planning process were collected in 2006 and 2009. The 2006 inventory data were collected by Jeremy Greenwood as part of his MF project. The 2009 inventory data, consisting of approximately 300 cruise points, were collected by student employees of the University Forest Office, and by students in FTY 476.

The point centers of the 2006 inventory were intended to coincide with the point centers of the 1986 and 1995 inventories. The point centers were determined by registering a scanned copy of the original 1986 inventory map to current GIS layers of the Demeritt forest, and downloading the inventory points into a GPS (Greenwood 2007). This was found to be unsuccessful due to creases in the map which prevented it from being registered correctly (Greenwood 2007). Instead, plot centers were established by compass and pacing, using block lines and corner posts as a reference point (Greenwood 2007).

The 2009 inventory was intended to collect data for stands that had not been inventoried in 2006, including the stands in compartment K. All 2009 point centers were established using Hawths Tools random point generator in ArcGIS, and were distributed on a stand by stand basis within each stand polygon (Figure 4).

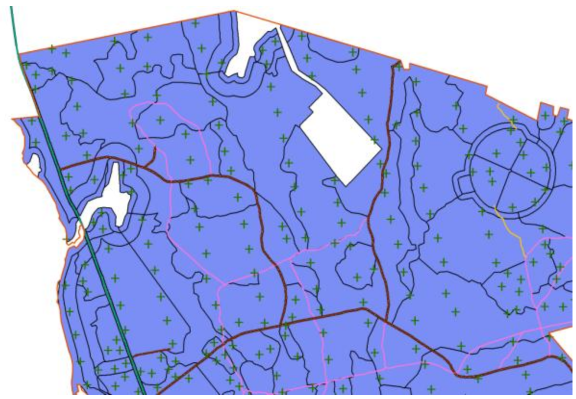


Figure 4: Cruise points generated in ArcGIS

Each point was uploaded to a Garmin GPS unit, which was then used to navigate to each point in the field. Plot centers were located in an unbiased manner, using a compass to follow the GPS azimuth directions until the unit displayed a distance of two meters or less to the plot center. Each plot center was marked with the Haglof transponder pole, and a tree near the center was flagged and labeled with the Sample ID and Stand ID. If the plot center fell outside of the specified stand boundary, the point center was moved 20 feet into the stand from the stand edge. If a plot was located along the "hard" edge of a stand, such as a field, plantation, or boundary line, the walk-through method was used to double count the trees that were considered "in". For plot centers located outside of a forest boundary, such as in open water or on roads (not-including skid-trails), a new plot center and new waypoint were created and recorded in the field.

At each point center, three nested sample plots (seedling, sapling, and tree) were established. Seedlings were measured with a 1/1000th acre fixed radius circular plot (3.724 ft radius). Each seedling was placed in 1-5 ft classes, determined using a height stick. Seedlings less than or equal to 6 inches in height were not tallied. A dot tally was used to count seedlings.

Saplings were measured with a 1/100th acre fixed radius circular plot (11.8 ft radius). DBH and species of all live trees greater than 0.6 inch and less than or equal to 3.5 inches DBH, falling within the plot were tallied. Plot radius was determined using either a tape or the distance measurement from a Haglof hypsometer. For each sapling plot, species type was noted, DBH class was determined using a tree fork, and an average tree height for each species and each size class was recorded.

The overstory was measured using a variable radius point sample, with a BAF 20 prism. Data were collected for all live trees equal to or greater than 3.6 inches DBH. Plot ID, tree number, species code, DBH, and growing stock quality, including acceptable, unacceptable, or snag, were measured and recorded for each "in" tree. The limiting distance for all borderline trees was checked either by using the Haglof, which calculates the minimum DBH of a tree at a certain distance to plot center, or by multiplying the DBH of the tree by the plot radius factor of 1.944. If the limiting distance is greater than the actual distance of the tree to plot center, then the tree is "in". Total height and height to crown base were measured for each softwood tree "in" with a 75 BAF prism. Tree cores were also taken for these trees. For all sample plots, seedlings, saplings, and overstory included, trees were recorded starting from north and continuing clockwise.

Equipment used for the inventory included a diameter tape, Haglof Vertex Hypsometer and transponder, plot center Haglof pole, loggers tape, increment borer and core board, flagging tape and sharpie to mark flagging at the point center, 20 BAF prism, tree fork, height stick for seedlings, GPS, and compass. The data were recorded on a Trimble Recon PDA with the SprintDBPro data collection program. The inventory information was saved in a Microsoft Access database, which was then manipulated to create an LMS portfolio. (Information for the inventory section provided by the inventory protocol document Morrill, 2009, Appendix J).

Mapping

Spatial information is necessary to aid in assessment of the current inventory conditions. ArcGIS, a geographic information system, was used to compile existing data layers, create new layers, and analyze various attributes among layers. In addition, stand polygons were delineated and inventory plot centers were established at random within ArcGIS.

Using GIS layers, current maps, and aerial photographs, managers can locate and identify areas available for management and areas of special concern (Bettinger et al. 2009). Figure 5 is an aerial photo from of a section of the Demeritt Forest, and Figure 6 is an image of the stand polygon layer from ArcGIS that corresponds to the same area of forest. Used together, the GIS layers are essential forest management tools.

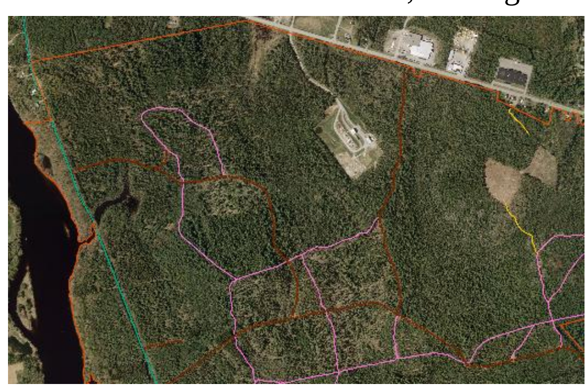


Figure 5: Aerial photo of a Section of the Demeritt Forest

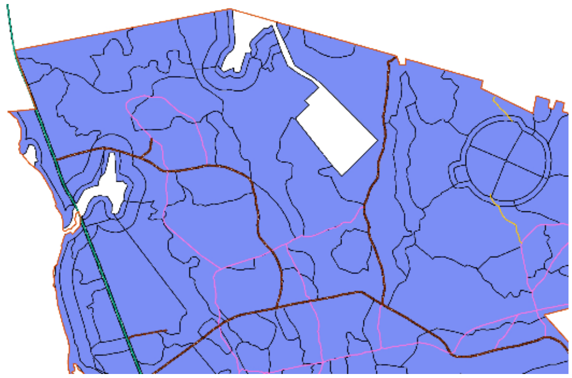


Figure 6: Stand polygon layer from ArcGIS of area of forest corresponding to the area of the photo in Figure 2.

GIS layers containing data from the Maine Natural Areas Program (MNAP), Inland Fisheries and Wildlife (IF&W), and National Wetlands Inventory (NWI) were consulted to determine special areas for the planning process. In addition, GIS layers from the Maine Office of GIS were augmented to include features such as streams and other water bodies. These features were either digitized from aerial photographs or field determined using a global positioning system (GPS). National Wetland Inventory (NWI) GIS data were used in conjunction with ortho-photography to identify isolated non-forested wetland polygons ≥ 10 acres in size, and those polygons that are part of a larger wetland complex. These wetland polygons were used to develop layers representing 75ft and 250ft shoreland zoning (SLZ) buffers. All non-forested wetland polygons were assigned 75 ft buffers, while polygons or complexes ≥10 acres were assigned 75ft and 250ft buffers. The newly created stand polygons were then split along these buffer layers in order to create new stand polygons that accurately reflect the areas requiring special management protocols. Each stand was given a unique ID value to enable spatial integration with LMS. The spatial information in the ArcGIS database, along with the inventory information were imported into LMS to create the portfolio. The ArcGIS database was also linked to a Microsoft Access database containing tables of information exported from LMS to allow for data analysis.

Portfolio Development

Development of the LMS portfolio requires that spatial information, inventory information, digital elevation files, and stand attributes be imported into LMS. The inventory information required to be input into LMS includes year of portfolio development, stand ID, tree number, species, DBH, height, crown ratio, expansion factor, volume per tree, and maximum crown width (University of Washington College of Forest Resources, and USDA Forest Service 2005). This information was assembled from the inventory data in an Excel spreadsheet that was then easily imported into LMS. Height, volume per tree, and maximum crown width can be calculated by the growth model in LMS if they are not measured in the field (University of Washington College of Forest Resources, and USDA Forest Service 2005).

Stand attribute information can be collected from field data, aerial photographs, or GIS layers (University of Washington College of Forest Resources, and USDA Forest Service 2005). The necessary information includes stand ID, site index, age, slope, aspect, elevation, and area in acres. Also entered as default values are plot, location, habitat code, and latitude (University of Washington College of Forest Resources, and USDA Forest Service 2005).

Digital elevation information was imported in the form of an electronic topographic map, downloaded from the USGS web site. When combined and properly aligned with the spatial characteristics of the area in ArcGIS, the data can then be imported into LMS to create the portfolio (Figure 7).

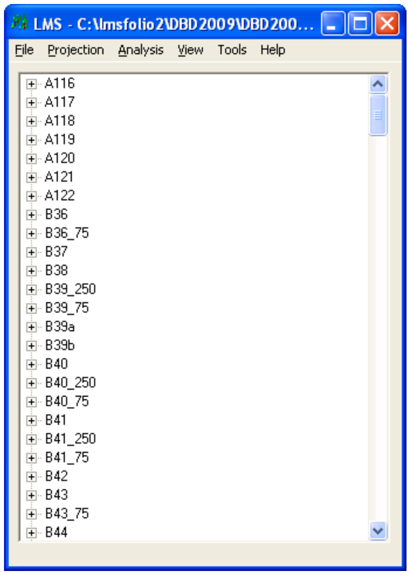


Figure 7: Screenshot of the LMS portfolio

Scenario Development

Three management scenarios were developed ranging from low intensity management (no harvest), to highly intensive management, and a third scenario that attempts to incorporate elements that help satisfy measurable criteria in the first two scenarios.

<u>Scenario 1: No Harvest</u>

For Scenario 1, the no harvest scenario, the original portfolio was simply projected 50 years to 2059. Because some stands had been harvested since the inventory was conducted in 2009, this was accounted for by implementing harvests in those particular stands in 2009. Only after these harvests were implemented was the portfolio projected to 2059.

Scenario 2: More Intensive

Scenario 2, a more intensive scenario, was implemented based on an 80 year rotation age. Using an area control spreadsheet developed in Excel (Appendix E), the number of acres to regenerate per period with either a shelterwood overstory removal, clearcut, or selection harvest, for even-aged and multi-aged stands respectively, was calculated. Each period was specified to be 5 years in length. By dividing the total number of acres in even-aged stands by the 80 year rotation length, and then multiplying this number by 5 years per period, the number of acres of even-aged stands to regenerate with an overstory removal per period was calculated. The same calculation was performed using the total number of acres in multi-aged stands to determine the number of acres of multi-aged stands to regenerate with a selection harvest per period. It was determined that 70 acres of even-aged stands and 23 acres of multi-aged stands should be regenerated per period.

To determine the total number of acres to treat per period with either shelterwood establishment or commercial thinning treatments, it was first assumed based on past estimates, that University Forest staff could reasonably treat about 85 acres per period. Shelterwood establishment treatments should be allotted roughly 70 acres per period, since that is the amount of acreage allowed for shelterwood overstory removal treatments. It makes sense to allot these two treatments equal acreage, since they are part of the same silvicultural system, and stands that have been treated with a shelterwood establishment will eventually be treated with an overstory removal. This leaves a remaining 15 acres for commercial thinning treatments. The appropriate acreage to treat with a pre-commercial thinning (PCT) was determined separately. It was determined that an additional 5 acres per period would be adequate to treat with PCT, though due to stand sizes of the stands treated with PCT, the acreage treated was often much more than 5 acres.

Scenario 3: Moderate

Scenario 3, a more moderate scenario, was implemented based on a longer rotation age of 100 years. The number of years per period remained the same. Again, the area control spreadsheet was used to determine the number of acres to regenerate per period with overstory removal or selection harvests for even-aged or multi-aged stands, as well as the total number of acres to treat with either shelterwood establishment or commercial thinning treatments per period (Appendix E). The same calculations were used as in the intensive scenario area control calculations. It was determined that 56 acres of even-aged stands and 19 acres of multi-aged stands should be regenerated per period, using overstory removal and selection harvests, respectively. In addition, about 85 acres should be treated with either shelterwood establishment or commercial thinning treatments per period. Since 56 acres are being harvested under a shelterwood system, 56 acres are allotted for overstory removal with the remaining 29 acres allotted to commercial thinning. It was determined that approximately 3 acres should be treated with pre-commercial thinning.

Harvest Scheduling

Once the available number of acres to treat per period for each scenario was determined using the area control spreadsheet, it was possible to begin the process of assigning harvest treatments to individual stands until the acreage requirements were met in each period. To begin the process for the first period of each scenario, the logfile and treelist file from the original LMS portfolio were saved, and each was linked to a Microsoft Access database for further analysis (Figure 8).

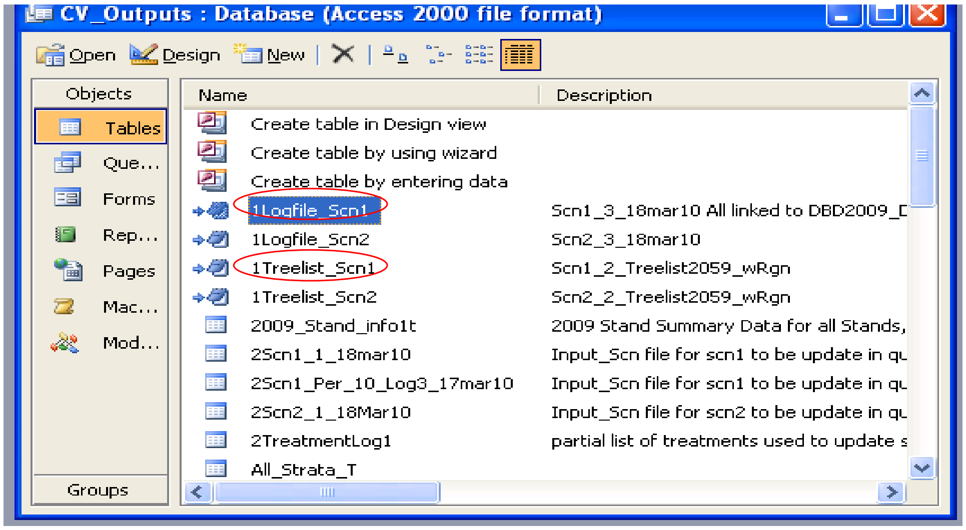


Figure 8: Screenshot of Access database where logfile and treelist files are linked.

In Access a series of queries, called W2next, were developed to help determine which stands to harvest at a particular time. These queries evaluated standing volume by species, polygon size, and previous entries to rank stands for potential treatments. When the first year of the period of interest is entered into the beginning query of the W2next series (W2next_A), the last query of the series is populated with stands that are available for treatment during that period. For example 2009 is entered for period 1, 2014 for period 2, and so on until 2059. The records of the W2next_G query (Figure 9) are sorted from highest to lowest volume, and the table is copied and pasted into a harvest scheduling spreadsheet in Excel for further analysis. Stands with the greatest amount of standing volume are targeted for treatment.

W2next_G : Select Query

Stand_ID	Current_YR	Last_Op	Last_Treat	Time_Past_Op	Suggest_Treat	Silvi_Sys	BF_ac	Cd_ac
C79b	2014	2054		-40	?	EA	26594.496768	81.912115905
C79b	2014	2054		-40	?	EA	26594.496768	81.912115905
C79b	2014	2054	SWOSR	-40	?	EA	26594.496768	81.912115905
C79a	2014	2054		-40	?	EA	26226.912096	80.384436105
C79a	2014	2054	SWOSR	-40	?	EA	26226.912096	80.384436105
C79a	2014	2054		-40	?	EA	26226.912096	80.384436105

Figure 9: Screenshot of W2next_G query to aid in harvest scheduling.

The harvest scheduling spreadsheet contains a calculator that determines the number of acres being harvested with specific types of treatment. The calculator assigns a treatment code to five different types of treatment categories. The treatment codes and category options include the following: 1- overstory removal (OSR) or clearcut, 2- selection, 3- shelterwood establishment, 4- thinning, 5- pre-commercial thinning (PCT). As specified previously in the discussion of the area control spreadsheet, for the more intensive scenario, 70 acres are available for OSR and clearcut treatments, both of which are even-aged regeneration treatments, and 23 acres are available for selection harvests, which is a multi-aged regeneration treatment. In total, 82 acres are available to treat with either shelterwood establishment or thinning treatments. 70 acres are allocated to shelterwood establishment harvests, while 12 acres are allocated to thinning treatments. PCT treatments were given an additional 5 acres. For the more moderate scenario, 56 acres are available for OSR and clearcut treatments, both of which are even-aged regeneration treatments, and 19 acres are available for selection harvests, which is a multi-aged regeneration treatment. In total, 81 acres are available to treat with either shelterwood establishment or thinning treatments. 56 acres are allocated to shelterwood establishment harvests, and 25 acres are allocated to thinning treatments. PCT treatments were given an additional 3 acres.

A "sumif" statement is used to calculate the number of acres being assigned to each treatment. The statement is as follows: =sumif (L:L, "1", K:K), where L represents the treatment code column, K represents the acreage column, and 1 represents the treatment code assigned to each type of treatment. This number changes to either 1,2,3,4,or 5 depending on the type of treatment that is targeted. An example of the harvest scheduling calculator used throughout the planning process can be found in Appendix F.

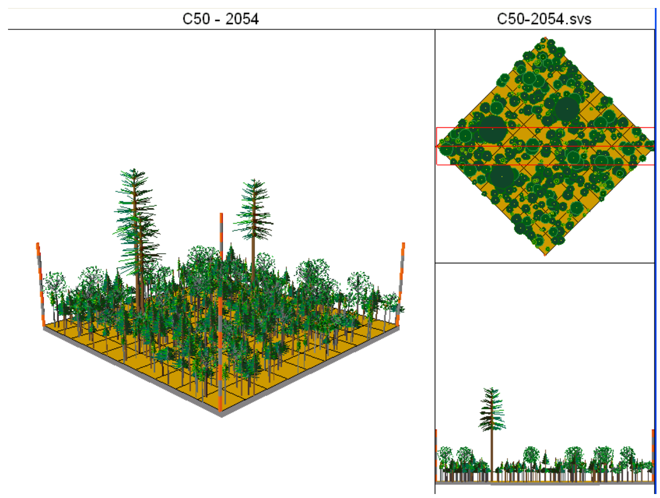


Figure 10: SVS visualization generated in LMS

To aid in determining what type of treatment should be used for each individual stand, and to determine whether or not a particular stand looked like it was ready to be harvested in a particular period, LMS stand visualizations were used. Figure 10 is an SVS screenshot of a stand that was harvested in 2054, generated from LMS.

To further aid in determining what stands to harvest at a particular time, a series of queries in the Access database calculated the number of years since the previous harvest had been implemented in each stand, and provided suggestions for when the next harvest should take place and what type of treatment it should be.

Once all of the area requirements were met for each scenario and the stands were assigned a particular treatment, the treatments were implemented in LMS. Then, the landscape was projected 5 years to the next period, and the logfile and treelist files were saved and linked to the Access database. The entire process was repeated for each period for both scenarios.

Regeneration Input

After each scenario was developed, the regeneration file was created and run through LMS. The sapling and seedling inventory data were used to determine the species and number of stems of regeneration per acre to allow the model to plant. Height classes for each species were also roughly determined based on shade tolerance and relative size of the trees in the inventory data. The tree records from the regeneration inventory data were separated into twelve categories, based on site index (3 classes) and basal area (4 classes) of each stand. LMS and Microsoft Access were used to determine which stand fell into which category. This information was used to create the regeneration key file, which was then imported into LMS, and planted into each scenario to get a better representation of how much regeneration is in the forest (Appendix D).

Analysis

Once the regeneration file was inserted into LMS and the scenarios were run once more, the treelist and logfiles were saved for each scenario in LMS, and were linked to both the SBW and Outputs databases in Microsoft Access. Within these two databases, multiple series of queries were written to assign pass/fail grades to each criterion, and to determine whether or not the criteria for each objective were met. The data from each of the final queries were copied and pasted into Excel, where graphs were created to provide a better visual representation of the data, and to aid in the analysis and evaluation of each criterion. A score card was also created from these pass/fail queries, and presented the average percentage of passing grades over all periods for each criterion (Table 3). The original score sheet compiled both the number and percentage of passing grades by period for all criteria for each scenario (Appendix C). The number of passing grades given to each criterion was divided by the total number of instances that the criterion could possibly receive a passing grade, in order to determine the average. For example, for criterion O1C1, the number of passing grades was divided by the total number of possible structural classes (24), to determine the percentage of passing grades received in each period. For other criteria, such as O6C1, where the criteria can strictly either pass or fail, a 0% or 100% was assigned. The final score sheet compiled the average percentage of passing grades over all periods, which allowed comparisons to be made between each criterion and provided a better overall picture of how each scenario performed as a whole.

Table 3: Score Sheet to Compare Criteria for All Scenarios

Objective & Criteria		**Scn1 No Harvest**	**Scn2 Intensive**	**Scn3 Moderate**
Stand Structure	O1C1	41	55	48
Treatment Type	O1C2	0	84	80
Reserve Area	O1C3	0	0	0
Harvest Vol.	O3C1	80	80	82
Standing Vol.	O3C2	100	100	100
Size Class	O3C3	61	61	61
Area in HRV	O6C1	0	91	82
Treatment Type in HRV	O6C2	0	64	82
Wind Risk	O7C1	0	0	0
HWA Risk	O7C2	100	100	100
SBW Risk	O7C3	45	55	55

Results

Scenario 1: No Harvest

General Characteristics:

Throughout the projection period, among trees with a DBH greater than 1 inch and less than 6 inches, the highest percentage of basal area (BA) consisted of balsam fir. Fir represents 40% of the BA at the beginning of 2009, increases to 60% in the middle of the projection period, and then decreases to 40% at the end of the projection period (Figure B 1- in Appendix B). Red maple represents the second highest amount of basal area in this size class, starting off at 17% in 2009, decreasing to 13% by 2039, and then increasing to 24% by 2059. White pine represents 5% of the BA in 2009, decreasing to less than 1% by 2039, and then increasing to 2% at the end of the projection.

Among larger trees (DBH ≥ 6 inches), the highest percentage of basal area consisted of white pine, making up 30% of the total BA of the forest at the beginning of 2009 (Figure B 2). This percentage decreases to 23% by the end of the projection. The amount of fir increases significantly throughout time, representing 6% of the BA in 2009, and 25% of the BA in 2059.

Figure B 3 depicts the percentage of standing volume in cords by species across the projection period. White pine represents the highest percentage of standing volume, at 40% in 2009. This percentage decreases by about 10% across the planning horizon. The percent volume of fir increases from 3% in 2009 to 15% by 2059.

The growth rate of white pine was found to be 180,059 board feet per year and 358 cords per year, while the growth rate of all species is 1307 cords per year (Table 4). There are no harvest rates for this scenario.

Table 4: Scenario 1 Growth and Harvest Rates

	Growth Rate (Total Vol/Yr)	Harvest Rate (Total Vol/Yr)
Board Feet (WP only)	180059	0
Cords (WP only)	358	0
Cords (All Species)	1307	0

1. Education & Research Objective:

O1C1a

Figure B 4 shows the proportion of single-strata versus multi-strata stands across the landscape, by period. At the beginning of 2009, about 3% of the forest is composed of single-strata stands, but this percentage increases to about 41% at the beginning of 2059. Conversely, at the beginning of 2009, about 96% of the forest is composed of multi-strata stands, which declines to about 58%, by the end of the projection period.

O1C1b

Figure B 5 presents the proportion of the forest comprised of size classes B-E across the entire forest. Size class B represents small trees, C represents medium trees, D represents large trees, and E represents extra large trees (See Appendix G for strata component descriptions). As seen in the figure, there is hardly any representation of size class B throughout the entire projection period. The percentage ranges from 2.4% in 2009 to 0% in 2059. The percentage of area in size class C is 34% in 2009, and decreases to 4% in 2059. The percentage of forest area in size class D is 43% in 2009 which decreases to 21% in 2059. At the beginning of 2009, 19% of the forest consists of size class E, but this percentage increases greatly to 73% by 2059.

O1C1c

The percentages of the forest classified in softwood, hardwood, or oak-pine stand types are shown in Figure B 6. The hardwood stand type is the least represented, contributing to roughly 10% of the forest area across the entire projection period. The softwood stand type is the most highly represented cover type, increasing from 55% of the total area in 2009 to 68% by 2059. The oak-pine stand type decreases from 34% of the forest area to 24% in 2059.

O1C1

By combining all of the possible combinations of strata, size, and cover type, 24 unique categories of stand structure are created. As described in the objectives section, O1C1 measures achievement of the education and research objective as having at least one percent of the forest in each of the 24 categories of stand structure in all periods. Figure B 7 shows that 38% of the 24 possible structures are represented on the landscape in the first period, which increases to 46% by the end of the planning horizon. If the individual percentages of stand structures represented across the landscape are analyzed more closely, structures containing size class B are either missing or present in very small amounts throughout the projections.

O1C3

This criterion requires that at least 10% of the total forest area, not including SLZ 75 buffers, remain in reserves. As seen in Figure B 8, the criterion is not satisfied, as only 5% of the entire forest area is currently designated as a reserve. This result will remain the same for all scenarios, as no reserves are created throughout the projection period.

3. Sustainable Timber Supply Objective:

O3C1

This criterion states that harvest removals in each period must stay within 20% of the average volume removals over the entire projection period. The no harvest scenario generates no harvest volume and fails this measure in all periods.

O3C2

The standing board foot volume of large diameter white pine, (diameter greater than 12 inches), is shown in Figure B 9. As stated in the objectives and criteria section, the standing volume of WP must remain within 20% of the current (2009) levels of WP throughout the projection period. The graph shows that the standing volume steadily increases from 4,705,795 BF at the beginning of 2009 to 10,885,209 BF by 2059. It does not fall below the 20% limit. The red line in the graph indicates the 20% limit, while the green line represents the current amount of volume.

O3C3

In order to achieve the sustainable timber supply objective, it was also specified that there must be at least a 15% representation from all four categories of size classes in each planning period. As seen in Figure B 10, which represents only the managed forest area, size class "B" fails in all 10 periods, and size class "C" fails in the last 6 periods. All other size classes receive a passing grade throughout the planning horizon.

6. Recreation & Aesthetics Objective:

O6C1 & O6C2

The two criteria to measure and satisfy the recreation objective are that no more than 75 acres of stands characterized as having high recreational value will be harvested in each period, and that OSR and clearcutting treatments will be excluded in stands identified as having high recreational value. Because no harvesting activity takes place in this scenario, the scenario easily passes these criteria.

7. Forest Health & Protection Objective:

O7C1a

Figure B 11 shows that the proportion of forest area classified as having severe wind risk vulnerability varies between 41% and 49% at different points throughout the entire planning horizon. These proportions are much greater than the 20% maximum set forth by this criterion and all periods receive a failing grade.

O7C1b

As seen in Figure B 12, the proportion of the Demeritt Forest classified as having a high or very high density of hemlock is only slightly more than 10% in all planning periods, which meets the criterion stating that no more than 20% of the forest should receive a rating of "high" or above in any period. Thus, all periods receive a passing grade for this criterion.

O7C1c

The proportion of the Demeritt Forest classified as having a severe or very severe vulnerability to spruce budworm infestation is greater than 20% in five out of the ten planning periods (Figure B 13). The percentage of area classified as severe or very severe increases from less than 1% at the beginning of 2009 to 66% at the beginning of 2059. Five out of the ten periods exceed 20% of the forest in "severe" or greater vulnerability and receive a failing grade.

Scenario 2: More Intensive

General Characteristics:

In this scenario balsam fir dominates BA in the 1 to 6 inch DBH class until the end of the projection (Figure B 14). Fir represents 40% of the BA at the beginning of 2009, and decreases to 20% at the end of the projection period. Red maple represents the second highest amount of basal area, growing from 14% to 18 % across the projection period. White pine represents about 5% of the BA until 2039 when it decreases to about 1%.

Among trees with a DBH above 6 inches, the highest percentage of basal area consisted of white pine (Figure B 15). White pine makes up 30% of the total BA of the forest at the beginning of 2009. This percentage decreases to 20% by the end of the projection. The amount of fir increases significantly throughout the projection, representing 7% of the BA in 2009, and 28% of the BA in 2059.

Figure B 16 shows the percentage of standing volume in cords by species across the projection period. White pine represents the highest percentage of standing volume, at 40% of the volume at the beginning of 2009. This percentage decreases slightly to 26% by 2059. The percent volume of fir increases from 3% in 2009 to 18% by 2059.

The growth rate of white pine was found to be 127,396 board feet per year and 286 cords per year, while the growth rate of all species is 1158 cords per year (Table 5). The harvest rate for white pine is 145,200 board feet per year and 345 cords per year, while the harvest rate for all species is 877 cords per year.

Table 5: Scenario 2 Growth and Harvest Rates

	Growth Rate (Total Vol/Yr)	Harvest Rate (Total Vol/Yr)
Board Feet (WP only)	127396	145200
Cords (WP only)	286	345
Cords (All Species)	1158	877

1. Education & Research Objective:

O1C1a

Figure B 17 shows the proportion of single-strata versus multi-strata stands across the landscape, by period. At the beginning of 2009, 3% of the forest is composed of single-strata stands, but this percentage increases to 31% by 2059. Conversely, at the beginning of 2009, 96% of the forest is composed of multi-strata stands, which declines to about 68% by the end of the projection period.

O1C1b

Figure B 18 presents the proportion of total forest area comprised of size classes B-E. As seen in the figure, there is hardly any representation in size class B throughout the entire projection period. The percentage ranges from 1.6% in 2009 to 0.7% in 2059. The percentage of area in size class C remains relatively constant across the entire projection period. The percentage of forest area in size class D decreases from 40% in 2009 to 20% by 2059. At the beginning of 2009, 15% of the forest consists of size class E, but this percentage increases slightly to 30% by 2059.

O1C1c

The percentage of forest area classified as softwood, hardwood, or oak-pine stand types is shown in Figure B 19. The hardwood stand type is the least well represented, consisting of 10% of the forest area across the projection period. The softwood stand type is the most highly represented cover type, increasing from 55% of the total area in 2009 to 76% by 2059. The oak-pine stand type decreases from 33% of the forest area to 16% in 2059.

O1C1

O1C1 measures achievement of the education and research objective as having at least one percent of the forest in each of the 24 categories of stand structure in all periods. Figure B 20 shows that between 46% and 63% of structures are represented across the landscape at different times during the planning horizon. If the individual percentages of stand structures represented across the landscape are analyzed more closely, all structures containing the size class B are either missing or present in small amounts in every period. The stand structure that is most highly represented in all periods is msCSW.

O1C2

Figure B 21 shows the area of managed forest treated with each treatment type throughout the projection period. To meet the criterion, at least 10 acres must be treated with each treatment type per period. Over the entire projection period, only one failing grade was given. In the second period, only 8 acres were treated with a thinning treatment. No clearcutting treatments were implemented.

3. Sustainable Timber Supply Objective:

O3C1

This criterion states that harvest removals in each period must stay within 20% of the average volume removals over the entire projection period. It was calculated that the average board foot volume harvested over all time periods is 973,917 board feet. As Figure B 22 shows, the harvested volume remains within 20% of the average removal, except in the first and third periods where the harvested volume was greater than the average, and ninth period in which the harvested volume was lower than the average. Thus, the first, third, and ninth periods received a failing grade. Furthermore, the average cord volume over all time periods is 4023 cords. As Figure B 23 shows, the harvested volume also remains within 20% of the average removal, except in the first period, which receives a failing grade.

O3C2

Figure B 24 shows the standing board foot volume of large diameter white pine, with a diameter greater than 12 inches DBH. O3C2 states that the standing volume of WP must remain within 20% of the current (2009) levels of WP throughout the projection period. The graph shows that the standing volume remains well within the upper and lower limits of the 20% range, and remains fairly consistent compared to the current amount of volume. The red lines in the graph indicate the upper and lower limits, while the green line represents the current amount of volume.

O3C3

In order to achieve the sustainable timber supply objective, it was also specified that there must be at least a 15% representation from all four categories of size classes in each planning period. As seen in Figure B 25, which represents only the managed forest area, size class “B” fails in all 10 periods, and size class “E” fails in the first 6 periods. All other size classes receive a passing grade throughout the planning horizon.

6. Recreation & Aesthetics Objective:

O6C1

The first criterion to measure and satisfy the recreation objective is that no more than 75 acres of stands characterized as having high recreational value will be harvested in each period. As seen in Figure B 26, all periods receive a passing grade, except for the first period, in which 82 acres of high recreation value stands are affected by harvesting activities. This acreage equates to approximately 25% of the area in high recreation stands being affected by harvesting in the first period. This percentage may be seen in Figure B 27. High recreation value stands are minimally impacted in periods three and five, and are not affected whatsoever in period ten.

O6C2

Criterion O6C2 specified that OSR and clearcutting treatments should be excluded in stands identified as having high recreational value. It was found that only four high recreation stands were treated with an overstory removal over the entire projection period. This occurred in the first, sixth, seventh, and eighth periods (2009, 2034, 2039, 2044).

7. Forest Health & Protection Objective:

O7C1a

Figure B 28 below shows that the proportion of forest area classified as having severe wind risk vulnerability varies between 46% and 69% at different points throughout the entire planning horizon. These proportions are much greater than the 20% maximum set forth by this criterion, and all periods receive a failing grade.

O7C1b

As seen in Figure B 29, the proportion of the Demeritt Forest classified as having a high or very high density of hemlock is no more than 10% in all planning periods, which meets criterion O7C1b which states that no more than 20% of the forest should receive a rating of “high” in any period. Thus, all periods receive a passing grade for this criterion. The density of hemlock remains constant over the entire planning period.

O7C1c

As seen in Figure B 30, the proportion of the Demeritt Forest classified as having a severe or very severe vulnerability to spruce budworm infestation is greater than 20% in four out of the ten planning periods. The percentage of area classified as severe or very severe increases from about 20% at the beginning of 2039 to about 50% at the beginning of 2059. Therefore, four out of the ten periods receive a failing grade.

<u>Scenario 3: Moderate</u>

General Characteristics:

In this scenario, balsam fir dominates the basal area in the 1 to 6 inch DBH class until the end of the projection (Figure B 31). Fir represents 38% of the BA at the beginning of 2009, increases to 55% in 2034, and decreases to 22% at the end of the projection period. Red maple represents the second highest amount of basal area, growing from 16% to 20 % across the projection period. White pine represents about 5% of the BA in 2009, decreasing to less than 1% by 2039, and then increasing to 4% at the end of the projection period.

Among trees with a DBH above 6 inches, the highest percentage of basal area consists of white pine (Figure B 32). White pine makes up 30% of the total BA of the forest at the beginning of 2009. This percentage decreases to 18% by the end of the projection. The amount of fir increases significantly throughout the projection, representing 6% of the BA in 2009, and 28% of the BA in 2059.

Figure B 33 shows the percentage of standing volume in cords by species across the projection period. White pine represents the highest percentage of standing volume, at 40% of the volume at the beginning of 2009. This percentage decreases to 26% by the beginning of 2059. The percent volume of fir increases from 3% in 2009 to 18% by 2059.

The growth rate of white pine was found to be 129,843 board feet per year and 288 cords per year, while the growth rate of all species is 1179 cords per year (Table 6). The harvest rate for white pine is 141,260 board feet per year and 320 cords per year, while the harvest rate for all species is 771 cords per year.

Table 6: Scenario 3 Growth and Harvest Rates

	Growth Rate (Total Vol/Yr)	Harvest Rate (Total Vol/Yr)
Board Feet (WP only)	129843	141260
Cords (WP only)	288	320
Cords (All Species)	1179	771

1. Education & Research Objective:

O1C1a

Figure B 34 shows the proportion of single-strata versus multi-strata stands across the landscape, by period. At the beginning of 2009, 3% of the forest is composed of single-strata stands, but this percentage increases to 34% by the beginning of 2059. Conversely, at the beginning of 2009, 96% of the forest is composed of multi-strata stands, which declines to 65%, by the end of the projection period.

O1C1b

Figure B 35 presents the proportion of total forest area comprised of size classes B-E. As seen in the figure, there is hardly any representation in size class B throughout the entire projection period. The percentage ranges from 3.5% in 2009 to 0.2% in 2059. The percentage of area in size class C remains relatively constant across the entire projection period. The percentage of forest area in size class D decreases from 42% in

2009 to 23% by 2059. At the beginning of 2009, 16% of the forest consists of size class E, but this percentage increases slightly to 39% by 2059.

O1C1c

The percentage of forest area classified as softwood, hardwood, or oak-pine stand types is shown in Figure B 36. The hardwood stand type is the least well represented, consisting of 10% of the forest area across the projection period. The softwood stand type is the most highly represented cover type, increasing from 56% of the total area in 2009 to 75% by 2059. The oak-pine stand type decreases from 32% of the forest area to 16% in 2059.

O1C1

As mentioned in the objectives section, O1C1 measures achievement of the education and research objective as having at least one percent of the forest in each of the 24 categories of stand structure in all periods. Figure B 37 shows that between 33% and 62% of structures are represented across the landscape at different times during the planning horizon. At the beginning of the planning period, 42% of the structures are represented, which decreases to 33% by the fifth period, and increases to 58% by the end of the projection period. If the individual percentages of stand structures represented across the landscape are analyzed more closely, all structures containing the size class B are either missing or present in small amounts in every period. The stand structure that is most highly represented in all periods is msCSW.

O1C2

Figure B 38 shows the area of managed forest treated with each treatment type throughout the projection period. To meet the criterion, at least 10 acres must be treated with each treatment type per period. No failing grades were given in this scenario for the treatment types that were implemented. However, still no clearcut harvests were implemented.

3. Sustainable Timber Supply Objective:

O3C1

Criterion O3C1 states that harvest removals in each period must stay within 20% of the average volume removals over the entire projection period. It was calculated that the average board foot volume harvested over all time periods is 901,375 feet. As Figure B 39 shows, the harvested volume remains within 20% of the average removal, except in the first period where the harvested volume was greater than the average, and in the seventh and tenth periods in which the harvested volume was lower than the average. Thus, the first, seventh, and tenth periods received a failing grade. Furthermore, the average cord volume over all time periods is 3570 cords. As Figure B 40 shows, the harvested volume also remains within 20% of the average removal, except in the first period, which receives a failing grade.

O3C2

The standing board foot volume of large diameter white pine, (diameter greater than 12 inches) is shown in Figure B 41. O3C2 states that the standing volume of WP must remain within 20% of the current (2009) levels of WP throughout the projection period. The graph shows that the standing volume remains well within the limits of the 20% range, and remains very consistent with the current amount of volume. The red line in the graph indicates the 20% limit, while the green line represents the current amount of volume.

O3C3

In order to achieve the sustainable timber supply objective, it was also specified that there must be at least a 15% representation from all four categories of size classes in each planning period. As seen in Figure B 42, which is a representation of the managed forest area only, size class “B” fails in all 10 periods, and size class “E” fails in the first 6 periods. All other size classes receive a passing grade throughout the planning horizon.

6. Recreation & Aesthetics Objective:

O6C1

This criterion to measure and satisfy the recreation objective states that no more than 75 acres of stands characterized as having high recreational value will be harvested in each period**.** All periods receive a passing grade, except for the first and seventh periods, in which 86 and 92 acres of high recreation value stands are affected by harvesting activities (Figure B 43). These acreages equate to approximately 25% and 27% of the area in high recreation stands being affected by harvesting in the first and seventh periods, respectively (Figure B 44).

O6C2

This criterion specified that OSR and clearcutting treatments should be excluded in stands identified as having high recreational value. It was found that only two high recreation stands were treated with an overstory removal over the entire projection period. This occurred in the first and sixth periods (2009, 2034).

7. Forest Health & Protection Objective:

O7C1a

Figure B 45 below shows that the proportion of forest area classified as having severe wind risk vulnerability varies between 46% and 63% throughout the entire planning horizon. These proportions are much greater than the 20% maximum set forth by this criterion and all periods receive a failing grade.

O7C1b

As seen in Figure B 46, the proportion of the Demeritt Forest classified as having a high or very high density of hemlock is not much more than 10% in all planning periods, which meets the criterion stating that no more than 20% of the forest should receive a rating of "high" or above in any period. Thus, all periods receive a passing grade for this criterion. The density of hemlock remains constant over the entire planning period.

O7C1c

The proportion of the Demeritt Forest classified as having a severe or very severe vulnerability to spruce budworm infestation is greater than 20% in four out of the ten planning periods (Figure B 47). The percentage of area classified as severe or very severe increases from 26% at the beginning of 2039 to 51% at the beginning of 2059. Four out of the ten periods exceed 20% of the forest in "severe" or greater vulnerability and receive a failing grade.

Score Sheet for All Scenarios:

The score sheet compares all criteria and determines which scenario produces the best results (Table 7). The intensive scenario scores a higher percentage of passing grades than the other two scenarios for criteria O1C1, O1C2, and O6C1. The moderate scenario scores higher than the other scenarios for criteria O3C1 and O6C2. All of the other criteria are equal across all scenarios. Overall, the intensive scenario produces the highest percentage of passing grades.

Table 7: Score Sheet to Compare Criteria for All Scenarios

Objective & Criteria		**Scn1 No Harvest**	**Scn2 Intensive**	**Scn3 Moderate**
Stand Structure	O1C1	41	55	48
Treatment Type	O1C2	0	84	80
Reserve Area	O1C3	0	0	0
Harvest Vol.	O3C1	80	80	82
Standing Vol.	O3C2	100	100	100
Size Class	O3C3	61	61	61
Area in HRV	O6C1	0	91	82
Treatment Type in HRV	O6C2	0	64	82
Wind Risk	O7C1	0	0	0
HWA Risk	O7C2	100	100	100
SBW Risk	O7C3	45	55	55

Discussion

Although no individual scenario produces results that satisfy all objectives and criteria throughout the planning horizon, the intensive scenario produces slightly better results overall (Table 7). The intensive scenario offers an improvement over the moderate and no harvest scenarios in that it has the highest percentage of stand structures represented over all periods (O1C1), it allows more acres to be treated with a different treatment type in all periods (O1C2), and it excludes OSR harvests in high recreation stands in nine of the ten periods (compared to eight with the moderate scenario) (O6C2). The moderate scenario offers an improvement over the intensive scenario only for criteria

O3C1 and O6C2. The no harvest scenario was found to be the least favorable of the three scenarios, receiving failing grades in a majority of the criteria.

Although the intensive scenario produces slightly better results compared to the no harvest and moderate scenarios, it is important to note that the intensive scenario is not the final scenario that should become the basis for the final management plan. Instead, it is recommended that the intensive scenario be modified slightly or another scenario be developed to attempt to address the concerns that arose from the results and better meet the landowner objectives.

One important point to take note of is that data from harvests occurring previous to 2009 but after the latest inventory were included in the modeling of the Demeritt Forest, and thus, there is essentially twice the amount of harvests included in the first period. This is why spikes are seen in the harvest volume figures, as well as the figures showing the amount of area treated with different treatment types in the first period (Figures B 21-23 and B 38-40). This is also why a higher percentage of failing grades was given to several of the criteria for the first period. This should be taken into consideration when evaluating each scenario.

A main point of concern that becomes apparent when looking at the figures for O1C1 is that only about half of the 24 possible structures are represented on the landscape at a particular time throughout the projection period across all of the scenarios (Figure 11). (See also Figure B 20, and Figures B 7 and B 37 for other scenarios).

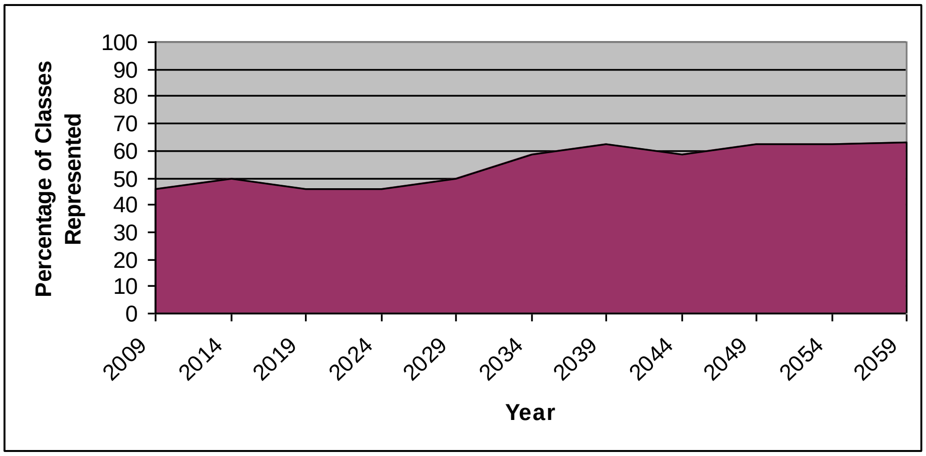


Figure 11: Scn2 Percentage of All Stand Structural Classes Represented Across the Landscape by Period

Structures containing size class B are the most scarcely represented on the landscape across the various projections (Figure 12). (See also Figure B 18 and Figures B 5 & B 35 for other scenarios). This is the smallest size class, which suggests that there is very little regeneration or saplings in the understory.

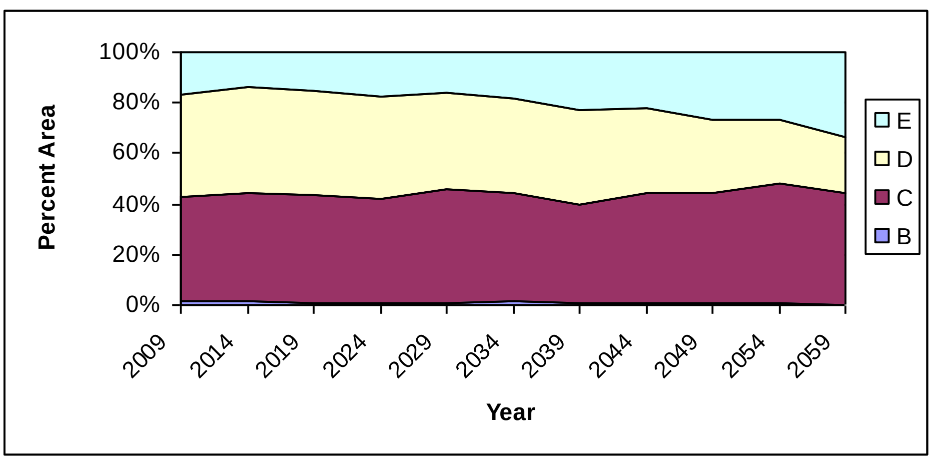


Figure 12: Scn2 Percentage of Total Forest Represented by 4 Size Classes in Each Period

It is interesting to note that size class B is underrepresented throughout the forest even though about 70 acres of OSR are implemented each period in the intensive scenario, and 56 acres are implemented in the moderate scenario. These treatments should promote regeneration growth and increase the percentage of size B stands across the forest. The lack of size class B across the forest is due to an abundance of trees being retained in the midstory after shelterwood overstory removals are implemented. These trees have enough basal area to skew the classification system, tagging the stands as size C instead of size B. It is suggested that the shelterwood establishment and overstory removal treatments be modified to more aggressively remove the midstory, and that the number of OSR and clearcut treatments be increased in order to achieve better representation of size class B. With these two types of treatments, the larger sized trees in the overstory will be removed, creating openings for regeneration to become established and grow into the understory.

Size class E is most highly represented in all three of the scenarios. However, the no harvest scenario produces the greatest percentage of size class E throughout the projection period (Figures B 5, 18, 35). The no harvest scenario likely produces the greatest percentage of larger sized trees because the pole sized and smaller sized sawlog trees (class C and D) are not cut, and are allowed to grow larger and move into the E class by the end of the projection period. Increasing the diversity of harvest treatment types is a reasonable recommendation to attempt to create a greater percentage of all stand structures across the landscape.

The increasing percentage of size class E represented across the landscape is also highly correlated to the extremely high vulnerability of wind damage across the forest (Figure 13). (See also Figure B 28 and Figures B 11 & B 45 for other scenarios).

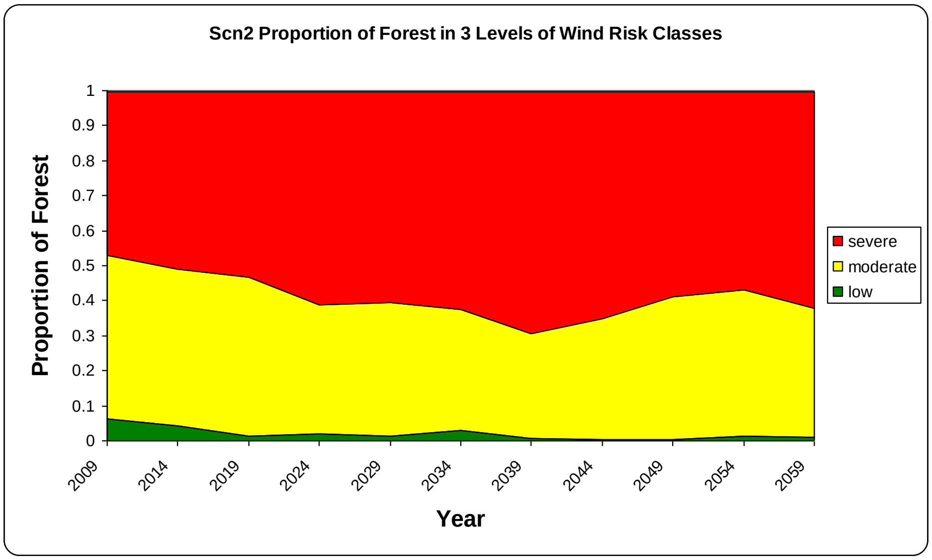


Figure 13: Scn2 Proportion of Forest in 3 Levels of Wind Risk Classes

Wind damage vulnerability in this analysis is based on a combination of height to diameter ratio (H/D, a measure of tree stability) and overall height. There are many relatively tall trees in the Demeritt and even though they may have moderate H/D ratios, their overall vulnerability to wind damage is high. It is not likely that these large trees would be snapped or uprooted unless the forest experienced a strong wind event. In New England, catastrophic windstorm events are known to occur every 20 to 40 years (Barnes et. al 1998). Even if damaging events are rare, having so much of the forest area in highly susceptible conditions to wind damage is a concern that forest managers need to recognize and address. Wind vulnerability could be lowered by reducing the forest area dominated by large trees, or by conducting a more detailed evaluation of wind vulnerability that considered recent treatments, soils, species, and topographic exposure. This second approach would allow for planning where tall trees and stands have the highest likelihood of persisting.

Another concern among all scenarios is that the basal area and volume of white pine decreases slightly over time, while the basal area and volume of balsam fir increases dramatically over time (Figure 14). (See also Figure B 15 and Figures B 2 & B 32 for other scenarios).

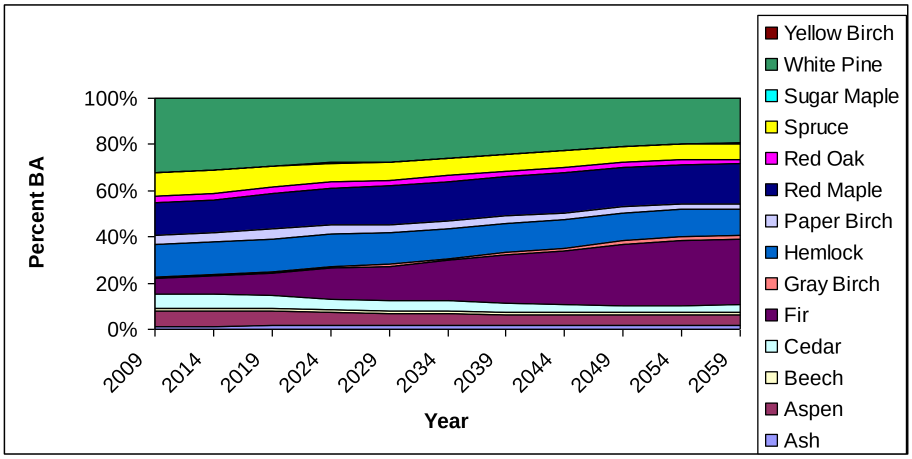


Figure 14: Scn3 Percent Basal Area by Species, >6in DBH, by Period

Ideally, the amount of white pine existing on the forest should remain relatively constant or increase slightly throughout time. White pine is a valuable species and an important source of income for the University Forest. These findings do not suggest that the mature white pine resource will be depleted over the planning period; however, they imply that forest management strategies should focus on promoting the regeneration and growth of immature white pine.

The initially high and increasing amount of fir in the understory is in response to continued canopy openings created through harvesting activities. Balsam fir currently dominates the sapling size classes and is a large component of the harvested stands. This is further indicated in Figure 15, which shows that the greatest percentage of basal area in the 1-6 inch classes is represented by fir. (See also Figure B 14 and Figures B 1 & B 31 for other scenarios)

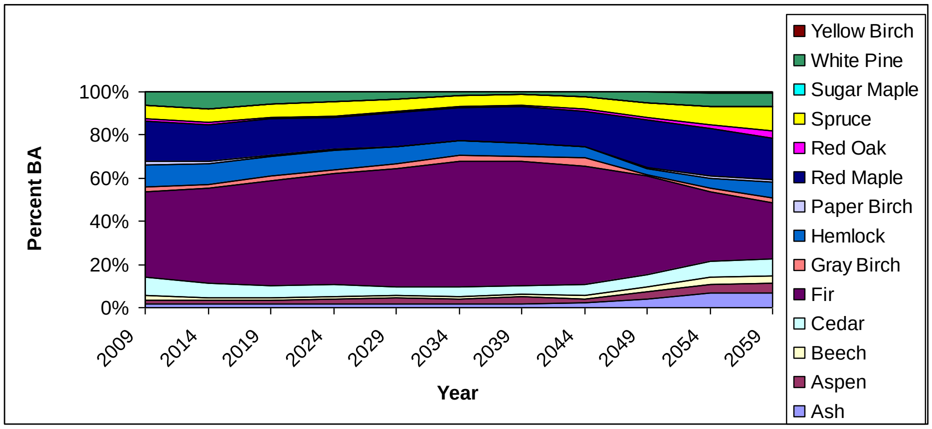


Figure 15: Scn2 Percent Basal Area by Species, >1 in, < 6in DBH, by Period

The increasing amount of fir throughout the forest is also highly correlated to the increasing susceptibility to spruce budworm (Figure 16). (See also Figure B 30 and Figures B 13 & B 47 for other scenarios).

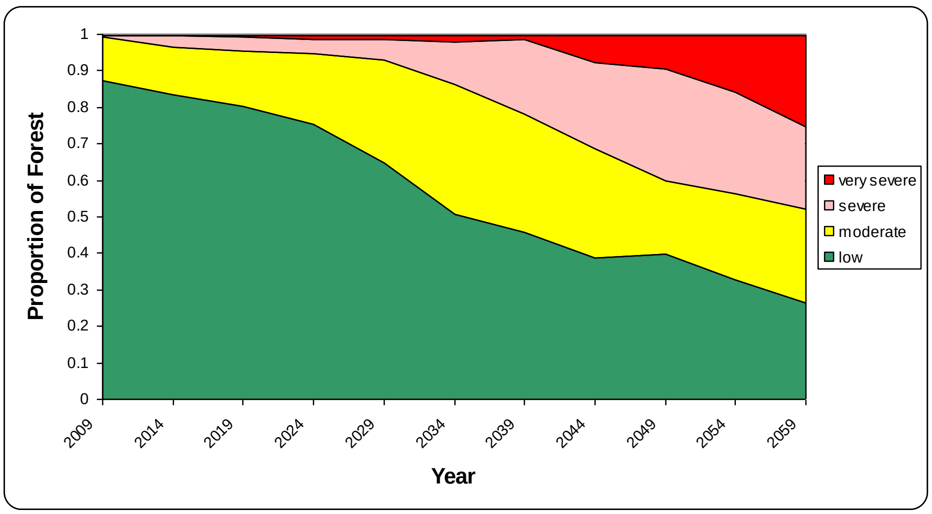


Figure 16: Scn2 Proportion of Forest in 4 Levels of Spruce Budworm Risk Classes

The figures indicate that greater than 20% of the forest is classified as having a severe or very severe spruce budworm vulnerability rating from 2034 to 2059. Spruce budworm preferentially feeds on mature and over-mature balsam fir trees. As balsam fir regenerates through the planning period and the substantial component of fir in the understory grows, it becomes a greater component of the forest. As this fir component becomes more mature throughout the projection period, the potential for a substantial impact from spruce budworm becomes a larger concern. A recommendation to reduce the vulnerability of the forest to spruce budworm is to focus on harvesting the mature balsam fir trees throughout the forest in all of the management scenarios. This will reduce the percentage of mature balsam fir, and reduce future vulnerability of spruce budworm outbreak. More importantly may be to treat balsam fir dominated sapling understories that have developed in past white pine shelterwood cuts on the forest. These precommercial thinnings should be designed to reduce the importance of balsam fir and promote the growth and development of immature white pine.

The results also show that the forest is lacking the desired percentage of reserve area. O1C3 states that at least 10% of the total forest area remains in reserve, not including 75ft SLZ buffers. Currently, only 5% of the total forest area is set aside as reserve area, which is half of the suggested amount (Figure B 8). Since no reserve areas are created in any of the scenarios, the result of this criterion remains constant over all three scenarios. In order to improve the results, it is recommended that the forest managers set aside a few more stands as reserves. The forest managers would need to decide which of the currently managed stands should be set aside as reserves, perhaps based on unique stand characteristics that should be preserved.

One other observation that can be made from the results is that the area control approach to harvest scheduling and forest regulation proved to work very effectively throughout the modeling process. As seen in Figures B 22-24 and B 39-41, the volume harvested and the standing volume both remained very constant relative to the average volume harvested and the current (2009) standing volume, respectively. This would be expected if a volume control approach had been used, but it is very surprising that the results were that constant using the area control approach. Normally, an area control approach, which keeps the amount of area harvested constant throughout each period, would allow the amount of volume harvested to fluctuate significantly throughout the projection period. Interestingly, as seen in the results, this was not the case in this instance. This suggests that the long history of relatively consistent harvesting on the Demeritt has generated a relatively well regulated forest that is not dominated by a single stand condition or maturity class.

As mentioned previously, no clearcut treatments were implemented throughout this modeling process. Most stands in the Demeritt are a larger acreage than the acreage of clearcuts likely to be implemented. As a result, separate polygon layers would need to be created in a GIS. This spatial information would then be imported into LMS where treatments could be assigned. For the purpose of this project, the process of implementing and modeling small clearcut harvests was too time-consuming. As a management plan is implemented, it is suggested that the University Forests Office conduct a few acres of clearcut harvests during each planning period. This may help to improve the results of some of the criteria, especially those dealing with structure.

The measurable criteria and their evaluation in the ratings table assumed that the criteria were absolute floors or ceilings; the criteria either passed and was given a 100%, or failed and was given a 0%. It would be interesting to develop and compare results of this analysis to a complementary series of criteria that were based on targets so that distance from the target rather than an absolute condition was evaluated in the scoring and ranking.

It should be noted that certain assumptions were made throughout the planning process, which may have affected the results of the analysis. First of all, it was assumed that the inventory was conducted in an unbiased manner, that the protocol was followed strictly and uniformly for all plots sampled, that all size classes were evenly represented in the inventory, and a sufficient number of plots were installed. Errors within the inventory would cause the data to change and the projections to be altered. Generally, the inventory seemed sufficient for the analysis, but future planning efforts may need to supplement the number of plots in certain stand types.

Furthermore, it is important to recognize that although software tools such as LMS allow great flexibility in forest management, and although growth and yield models are valuable tools in determining future conditions of the forest, they also have their limitations. All models are abstractions of reality and thus do not provide a correct or final answer. Instead, they are only useful tools to aid in making important management decisions, and managers must be critical of their outputs. Future planning efforts may find it invaluable to compare output from multiple existing models and use local data to calibrate models.

Finally, an adaptive management approach will be utilized to integrate future outcomes into the planning process. Thus, the criteria that were developed by the University Forests staff to measure the objectives are not final and will be modified as necessary as the final management plan is developed.

Conclusion

Forest management involves long planning horizons, the allocation of limited resources, and competing objectives. Forest managers must attempt to implement silvicultural techniques that maintain operational efficiency, economic stability, and ecological values of the forest, all while trying to meet landowner objectives. This is a very complex process. The management planning process exposes certain tradeoffs between alternative management scenarios, and allows managers to find an appropriate balance between landowner objectives. Managing at the landscape scale rather than at the stand level further allows a variety of forest values to be sustained across the entire landscape (Hunter 1999 and Oliver 1992).

By creating and analyzing three alternative management scenarios for the Demeritt Forest (a no harvest, a more intensive harvest, and a moderate harvest scenario), forest managers can determine which scenario best meets the landowner objectives. The analysis and results suggest that the more intensive scenario best satisfies the landowner objectives throughout the planning horizon. However, there are benefits and disadvantages to each scenario, and although the intensive scenario best meets landowner objectives, none of the scenarios meet all criteria for each objective.

In order to improve the results and better meet the landowner objectives for each scenario, multiple recommendations should be considered. First, it is recommended that the shelterwood establishment and overstory removal harvests be modified to eliminate more of the existing midstory, which will create a higher percentage of size class B throughout the forest. Implementing a small number of clearcut harvests is another solution this problem, as well as some of the other issues that have arisen.

A simplified model of wind risk suggests that large areas of the Demeritt Forest are vulnerable to wind damage in each of the scenarios. Managers should investigate this trend using vulnerability models that include soil conditions and topographic exposure. A simple solution would be to reduce the area dominated by large trees across the forest. The height of these trees rather than their H/D ratio appears to be driving the vulnerability trend. Wind events normally occur over a long time horizon and thus are relatively rare, but having so much of the forest area in highly susceptible conditions to wind damage is a concern that forest managers should recognize and begin to address.

Harvesting a greater amount of mature fir and implementing more precommercial thinning treatments across the forest is important to reduce the basal area of fir growing in the forest, and concurrently reduce the risk of spruce budworm damage. The results indicated that spruce budworm damage becomes a risk especially in the last five periods of the planning horizon. Thus, forest managers should recognize this concern and address it with appropriate management activities.

Finally, because white pine is considered the most valuable species on the Demeritt Forest, it is important that forest management focus on promoting regeneration and growth of immature white pine across the landscape. The results indicate that the white pine resource declines slightly across the planning horizon, which does not mean that the resource will become depleted, but rather, indicates that management should focus on implementing management activities that will improve this trend.

Forest managers should weigh the benefits and disadvantages of each alternative scenario, and take into consideration the multiple concerns each scenario produces in order to develop the final management plan. The final management plan should ultimately offer a single management recommendation that provides a description of the recommended management activities and how they meet landowner objectives, a timetable to suggest when the activities should be implemented, and an explanation as to how the management activities may affect other natural resources. With a management plan set in place, land managers have the necessary guidance needed to implement activities that will achieve the landowner objectives.

Literature Cited

Barnes, B.V., D.R. Zak, S.R. Denton, and S.H. Spurr. 1998. Forest Ecology. 4th Edition. John Wiley & Sons, Inc. New York, NY. 774 p.

Bettinger, P.B., K. Boston, J.P. Siry, and D.L. Grebner. 2009. Forest Management and Planning. Academic Press. New York, NY. 331 p.

Boyce, S.G. 1995. Landscape Forestry. John Wiley & Sons, Inc. New York, NY. 239 p.

Davis, L.S., K.N. Johnson, P. Bettinger, and T.E. Howard. 2001. Forest Management: To Sustain Ecological, Economic, and Social Values. 4th Edition. Waveland Press, Inc. Long Grove, IL. 804 p.

Demeritt, D.B. 1972. Background and History of the University of Maine Forest. Life Sciences and Agriculture Experiment Station, University of Maine, Orono. Bulletin 696. 27 p.

Greenwood, J.S. 2007. Inventory and Forest Management on the D.B. Demeritt Forest. Master of Forestry Project. School of Forest Resources, University of Maine, Orono. 130 p.

Griffin, R.H. 1968. The University Forest. College of Forest Resources, University of Maine, Orono. 21 p.

Hunter, M.L. 1999. Maintaining Biodiversity in Forest Ecosystems. Cambridge University Press, Cambridge, UK; New York, NY. 698 p.

Husch, B., C.I. Miller, and T.W. Beers. 1993. Forest Mensuration. Krieger Pub. Co., Malabar, Fla. 402 p.

Kimball, A. 2010. Personal Interview.

McCarter, J.B., J.S. Wilson, P.J. Baker, J.L. Moffett, and C.D. Oliver. 1998. Landscape management through integration of existing tools and emerging technologies. Journal of Forestry 96(6):17-23.

Morrill, R.R. 2009. Draft planning document. University Forests Office, University of Maine, Orono. 3p.

Morrill, R.R. 2009. Inventory protocol for the Demeritt Forest. University Forests Office, University of Maine, Orono. 3p.

Oliver, C.D. 1992. A landscape approach - achieving and maintaining biodiversity and economic productivity. Journal of Forestry 90(9):20-25.

Simpson, C.J. 2000. A Stewardship Incentive Plan for the University of Maine Forest Located in Old Town and Orono, Maine. University Forests Office, University of Maine, Orono. 15p.

Simpson, C.J. 2010. Personal Interview.

Smith, D.M., B.C. Larson, M.J. Kelty, P.M.S. Ashton. 1997. The Practice of Silviculture: Applied Forest Ecology. 9th Edition. John Wiley & Sons, Inc. New York. 537 p.

Taylor, R.F. 1985. An Historical Review of the University of Maine Forest. Maine Agricultural Experiment Station, Orono. Miscellaneous Bulletin 682. 39 p.

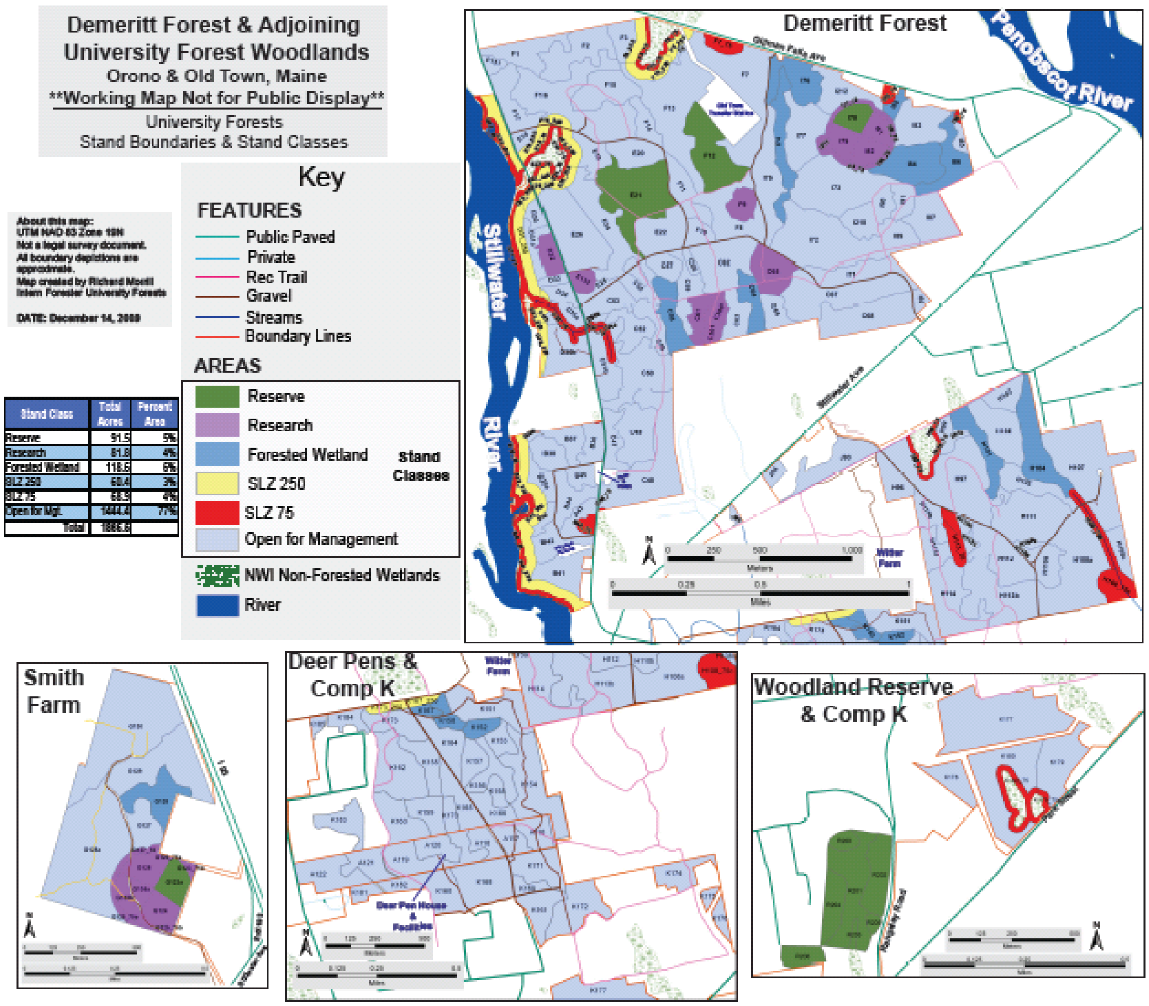
University of Washington College of Forest Resources, and USDA Forest Service. 2005. Introduction and loading of the landscape management system. http://lms.cfr.washington.edu/download/01-Introduction.pdf; Last accessed March 21, 2010.

Unknown. 1987. Management policy, objectives and practices on the University Forests. College of Forest Resources, University of Maine, Orono. 8 p.

Unknown. 1956. University Forest. Forestry Department, University of Maine, Orono. 4 p.

Vanclay, J.K. 1994. Modeling forest growth and yield: applications to mixed tropical forests. CAB International, Wallingford, U.K. 312 p.

Appendix A: Working Map of the Demeritt Forest



Appendix B: Figures

Scenario 1: No Harvest

Figure B 1: Scn1 Percent Basal Area by Species, >1 in, < 6in DBH, by Period

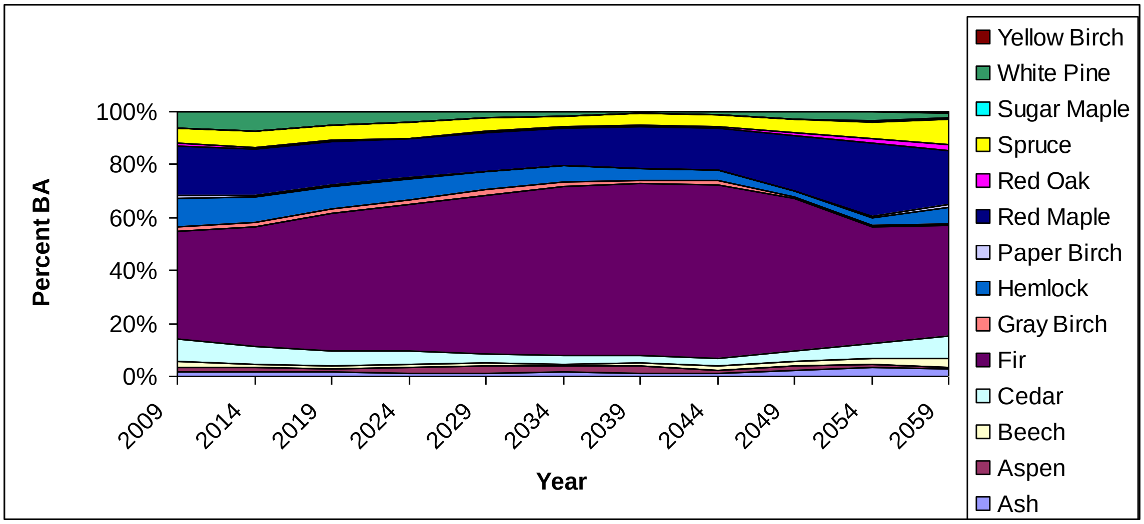


Figure B 2: Scn1 Percent Basal Area by Species, >6in DBH, by Period

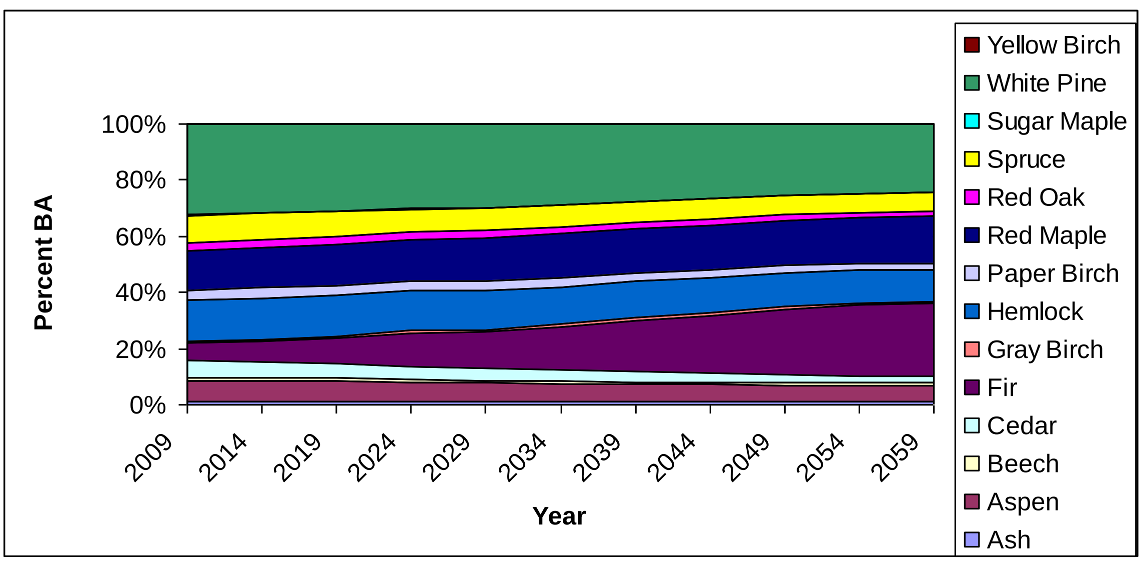


Figure B 3: Scn1 Percent Standing Cord Volume by Species, >6in DBH, by Period

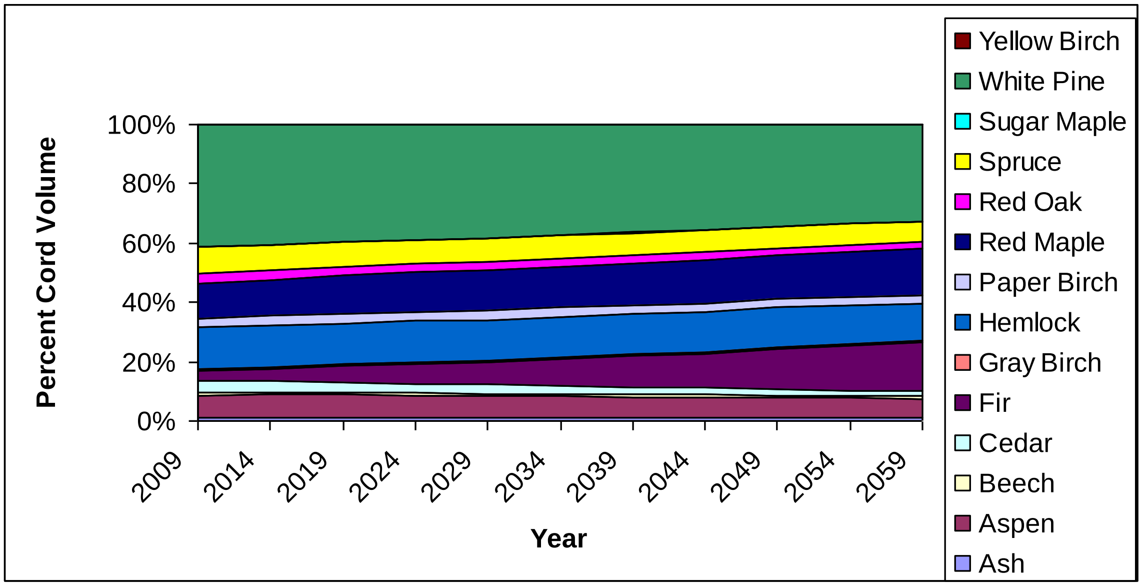


Figure B 4: Scn1 Percentage of Total Forest Represented by Multi-strata or Single-strata Structures in Each Period

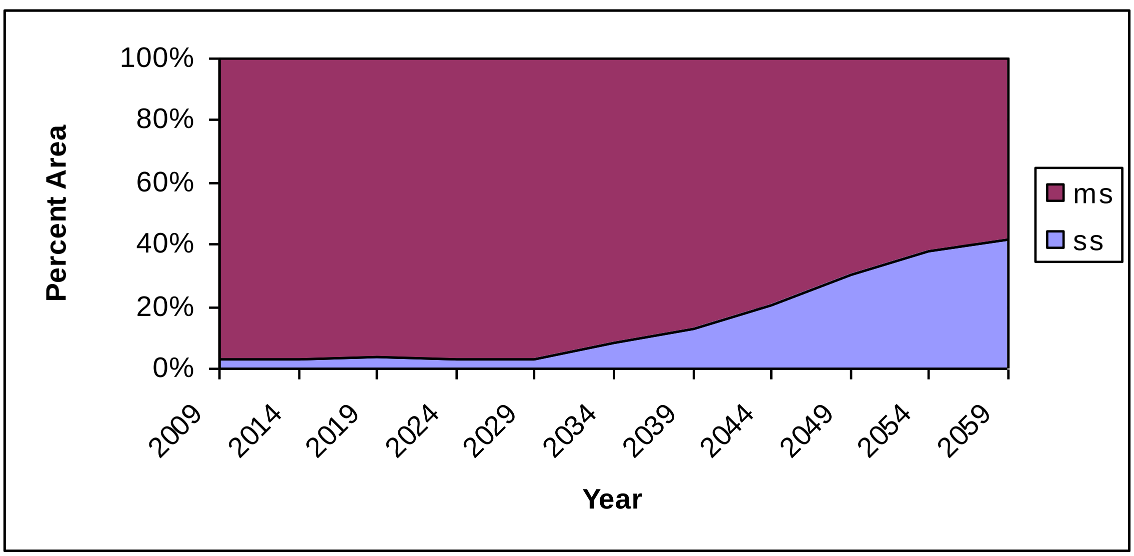


Figure B 5: Scn1 Percentage of Total Forest Represented by 4 Size Classes in Each Period

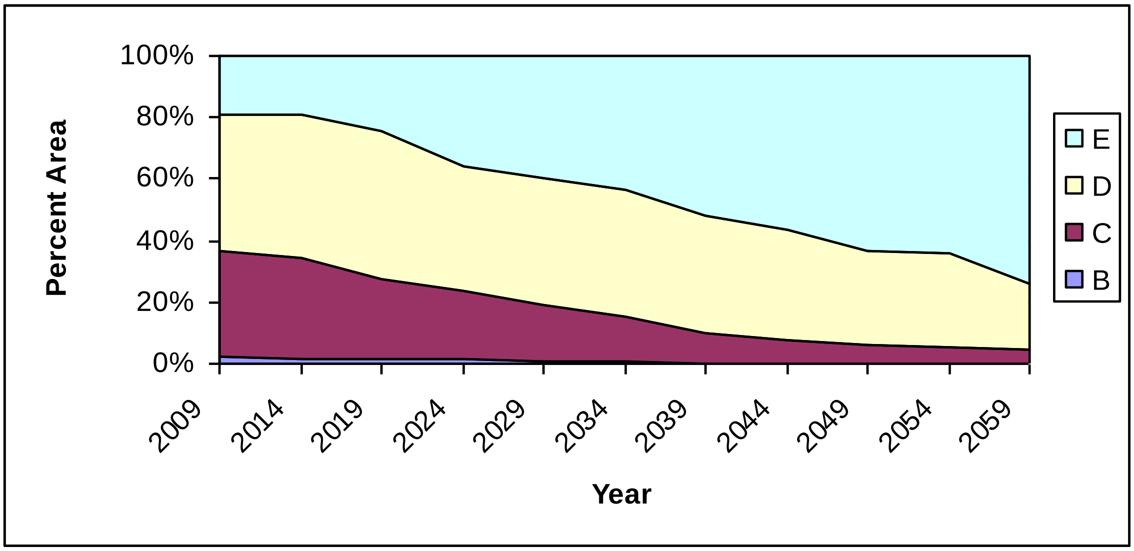


Figure B 6: Scn1 Percentage of Total Forest Represented by Softwood, Hardwood, and Oak-Pine Forest Types in Each Period

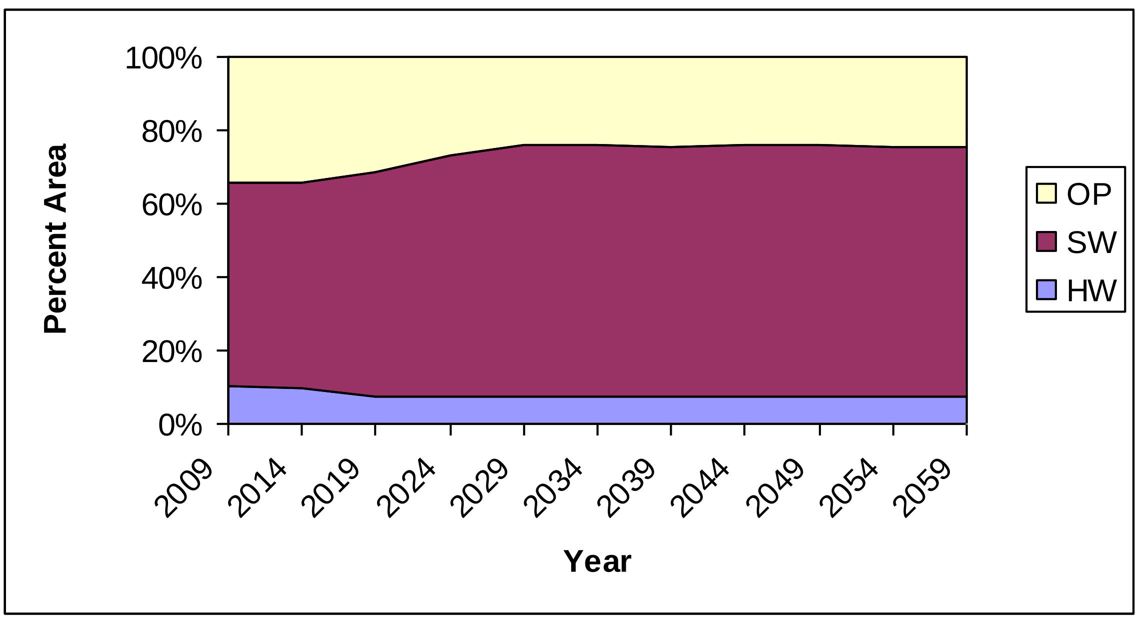


Figure B 7: Scn1 Percentage of All Stand Structural Classes Represented Across the Landscape by Period

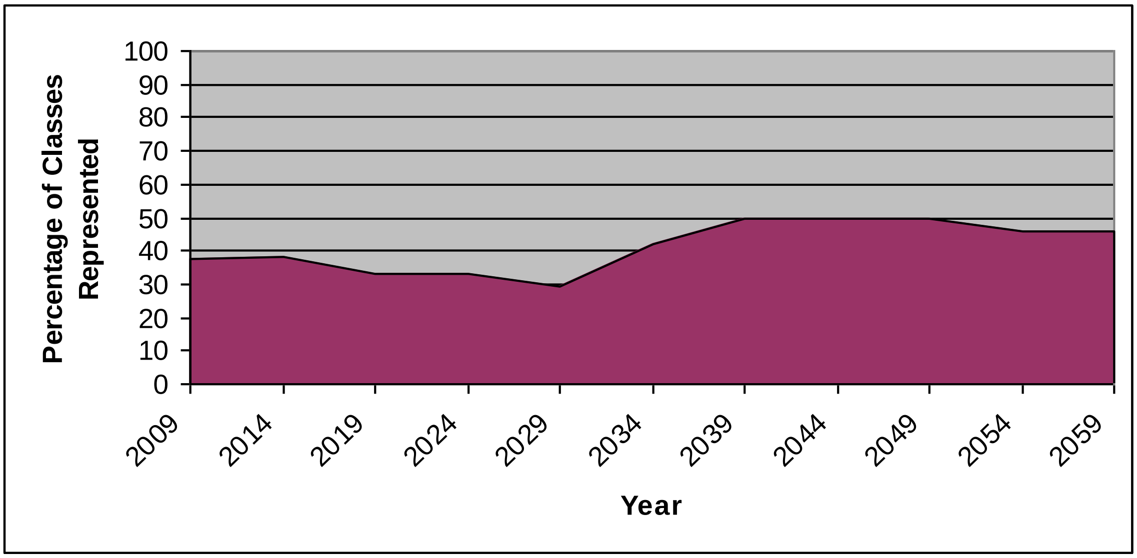


Figure B 8: All Scenarios: Percentage of Area in Various Stand Classes

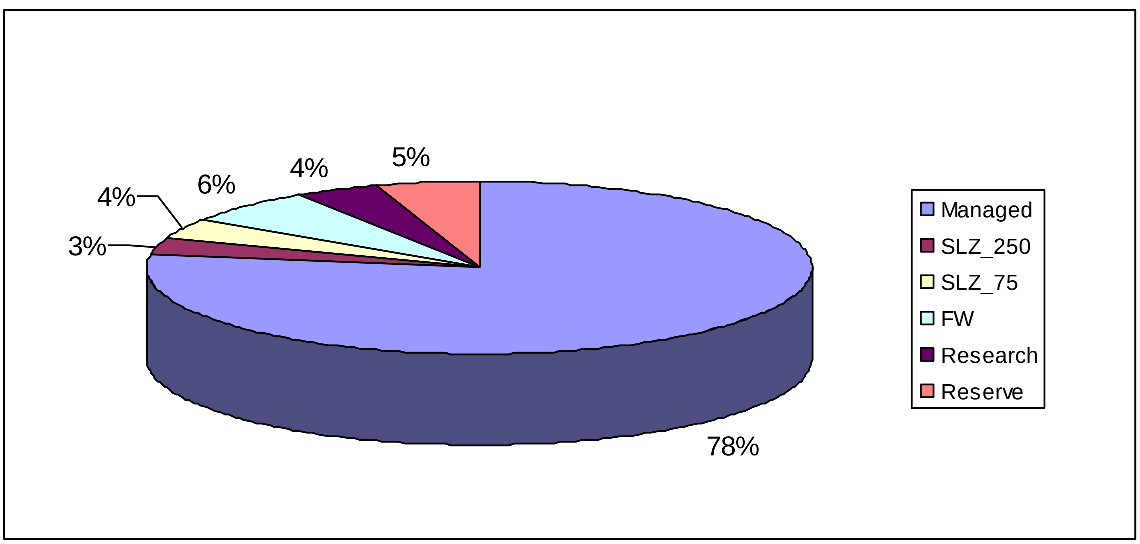


Figure B 9: Scn1 Standing Board Foot Volume of White Pine >12 in DBH, Compared to the Current Standing Volume of WP in 2009

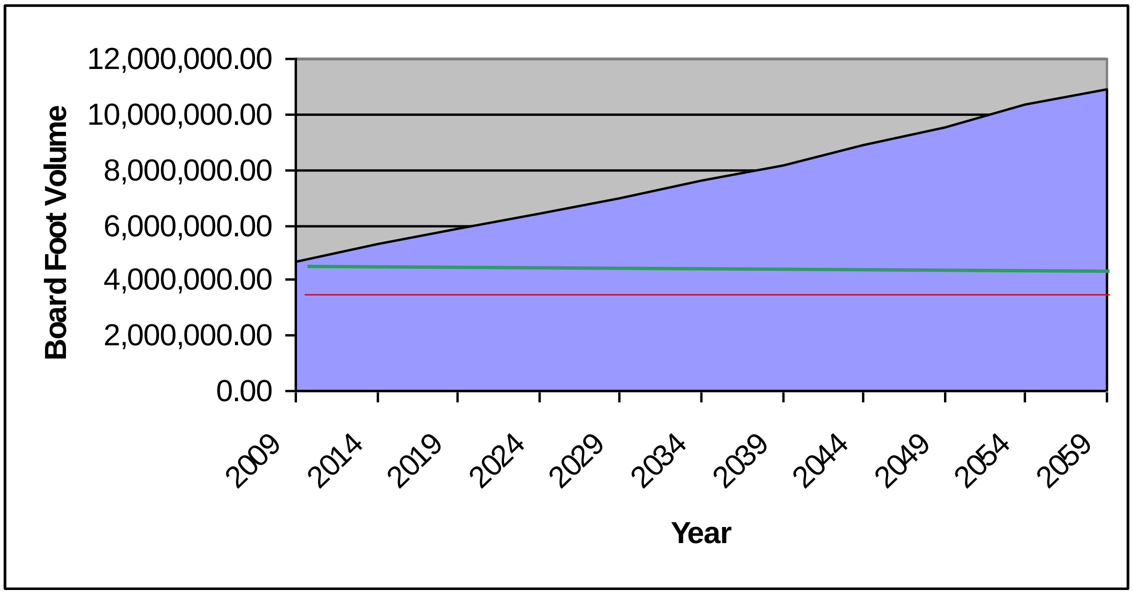


Figure B 10: Scn1 Percentage of Managed Forest Area Represented by 4 Size Classes by Period

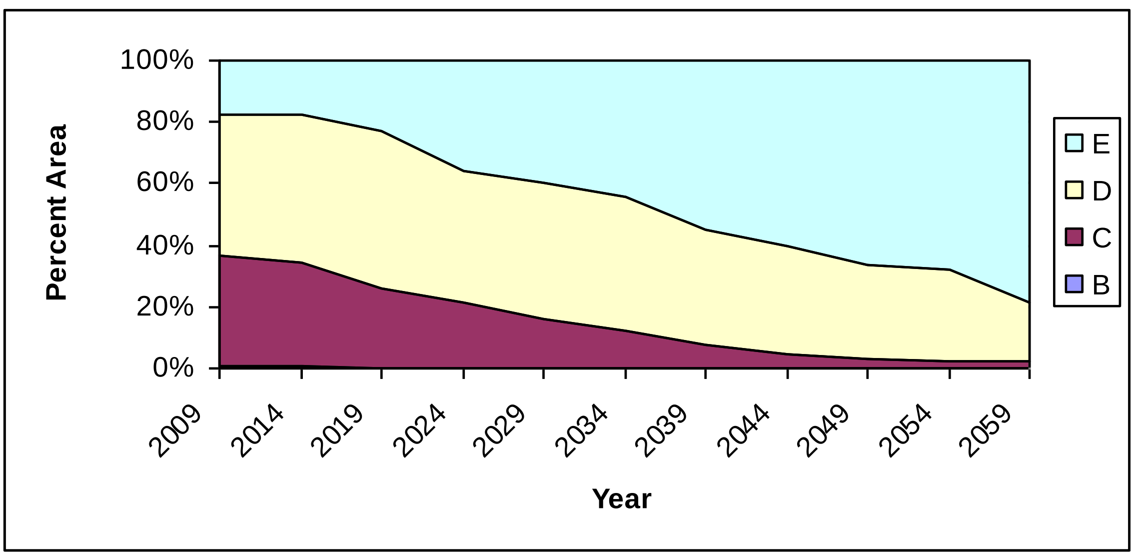


Figure B 11: Scn1 Proportion of Forest in 3 Levels of Wind Risk Classes

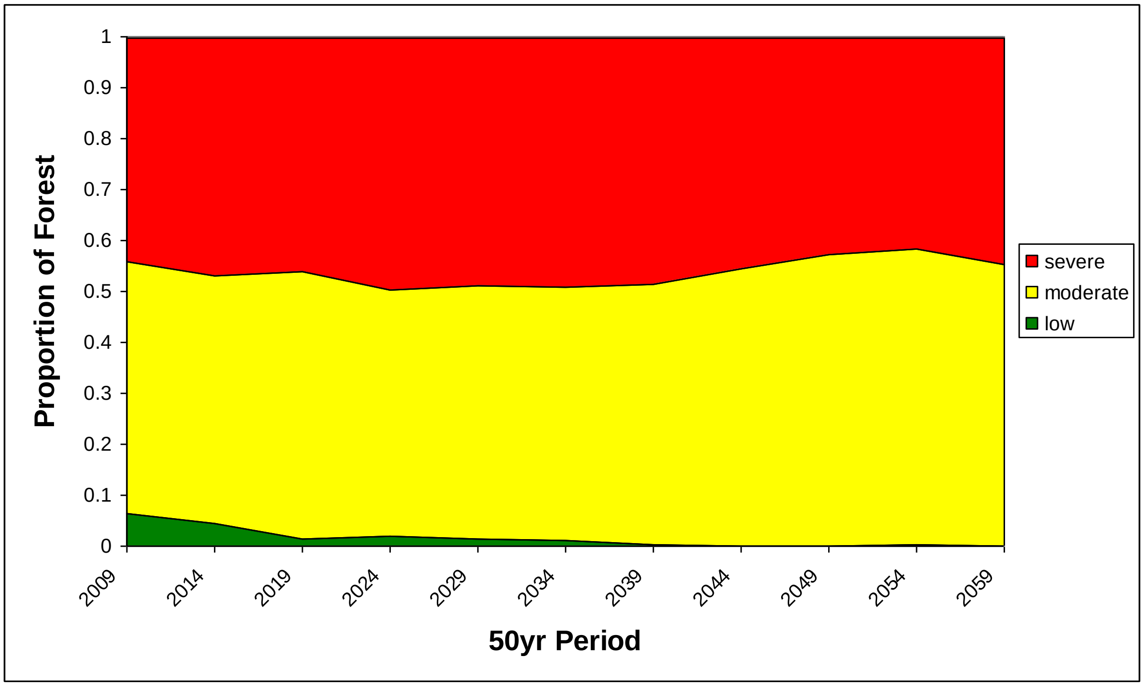


Figure B 12: Scn1 Proportion of Forest in 4 Levels of Hemlock Wooly Adelgid Risk Classes

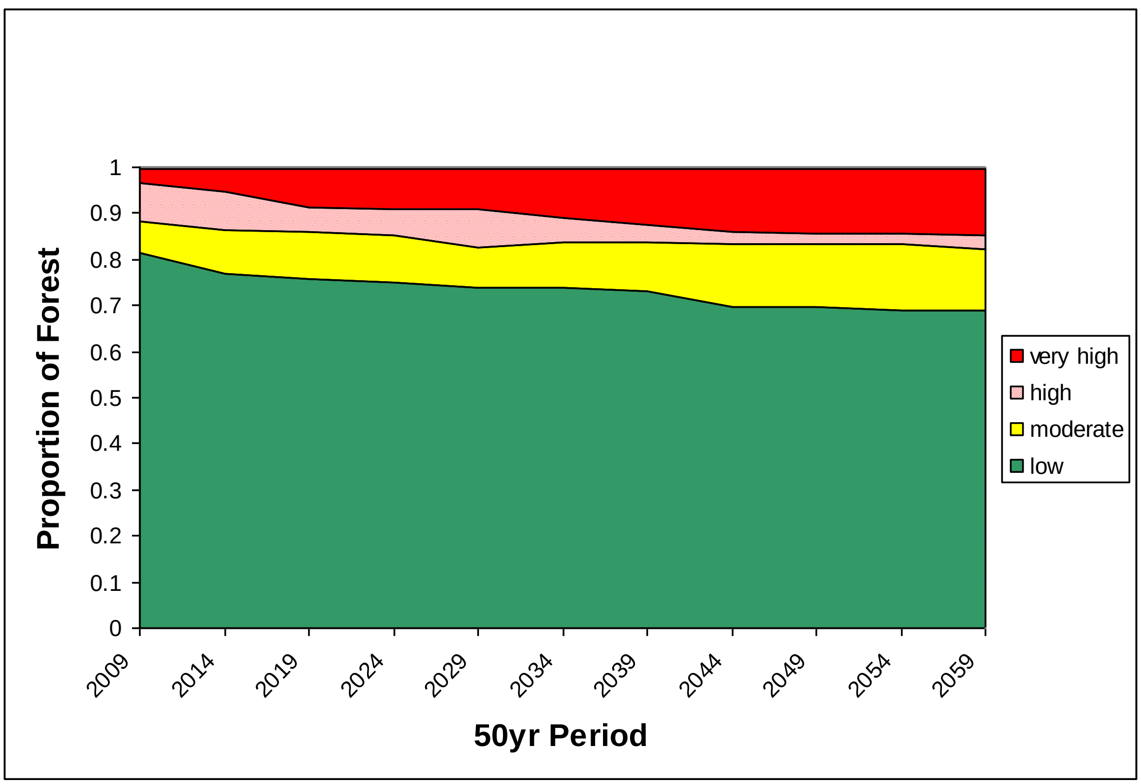
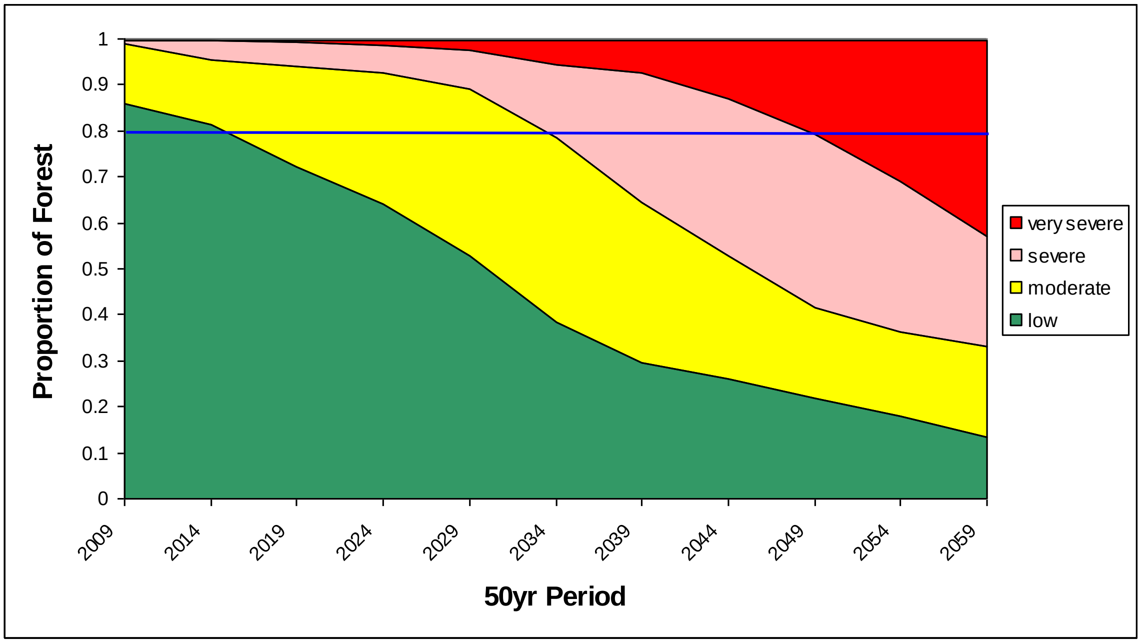


Figure B 13: Scn1 Proportion of Forest in 4 Levels of Spruce Budworm Risk Classes



Scenario 2: More Intensive

Figure B 14: Scn2 Percent Basal Area by Species, >1 in, < 6in DBH, by Period

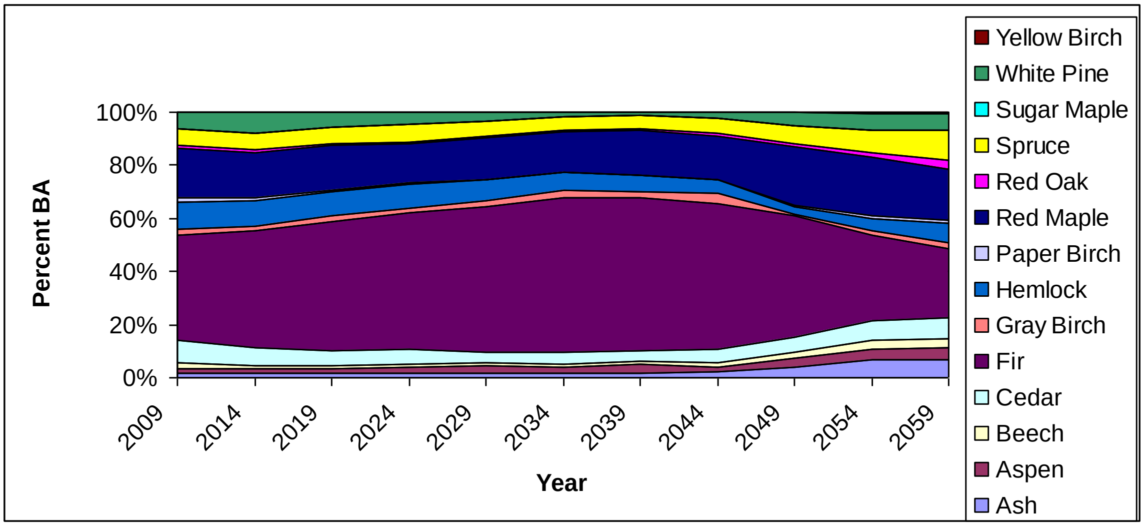


Figure B 15: Scn2 Percent Basal Area by Species, >6in DBH, by Period

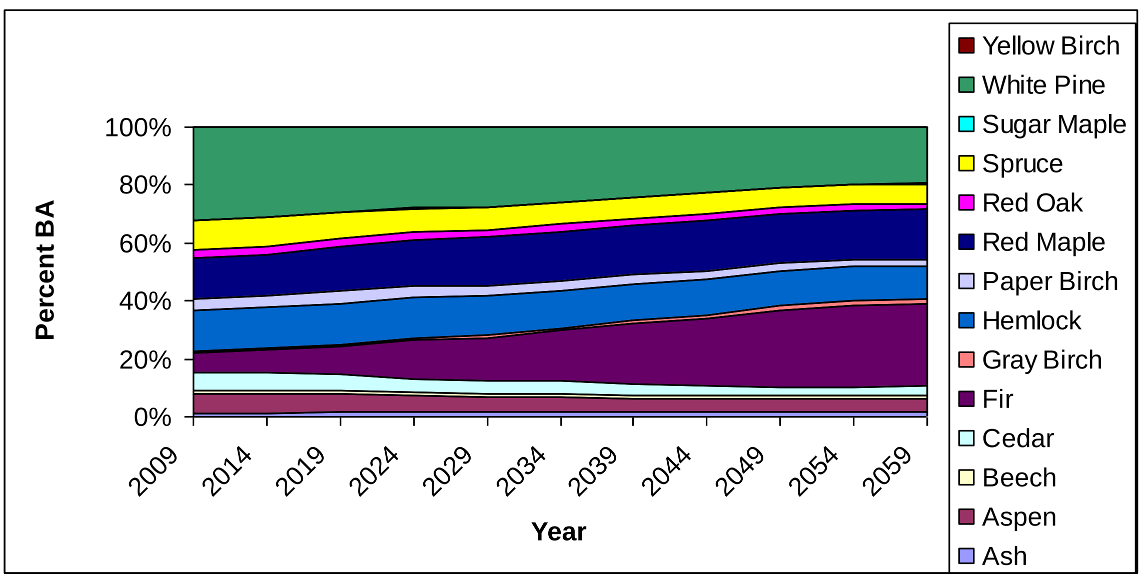


Figure B 16: Scn2 Percent Standing Cord Volume by Species, >6in DBH, by Period

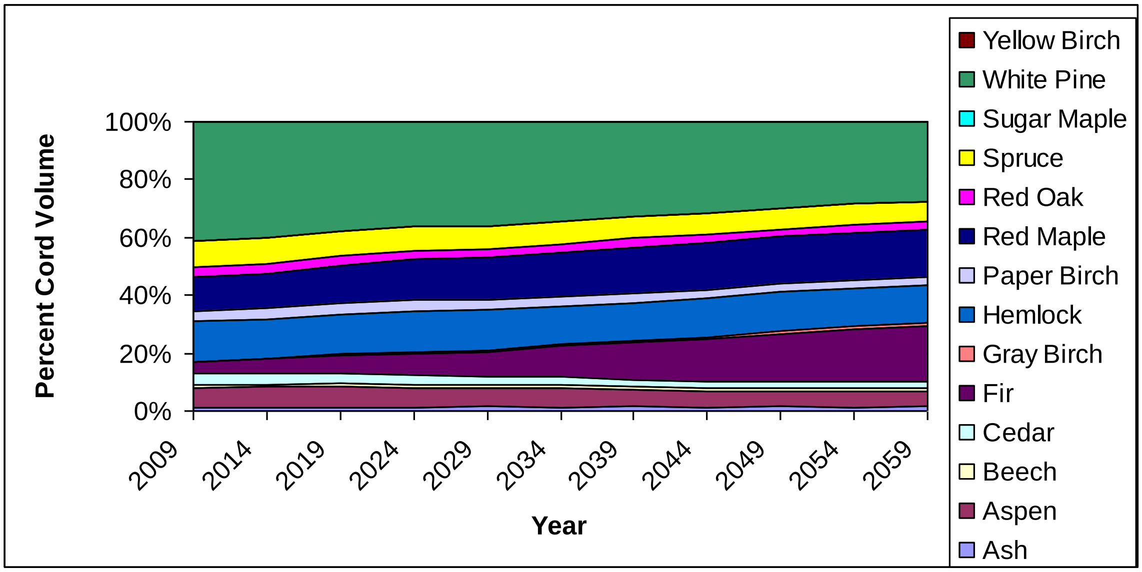


Figure B 17: Scn2 Percentage of Total Forest Represented by Multi-strata or Single-strata Structures in Each Period

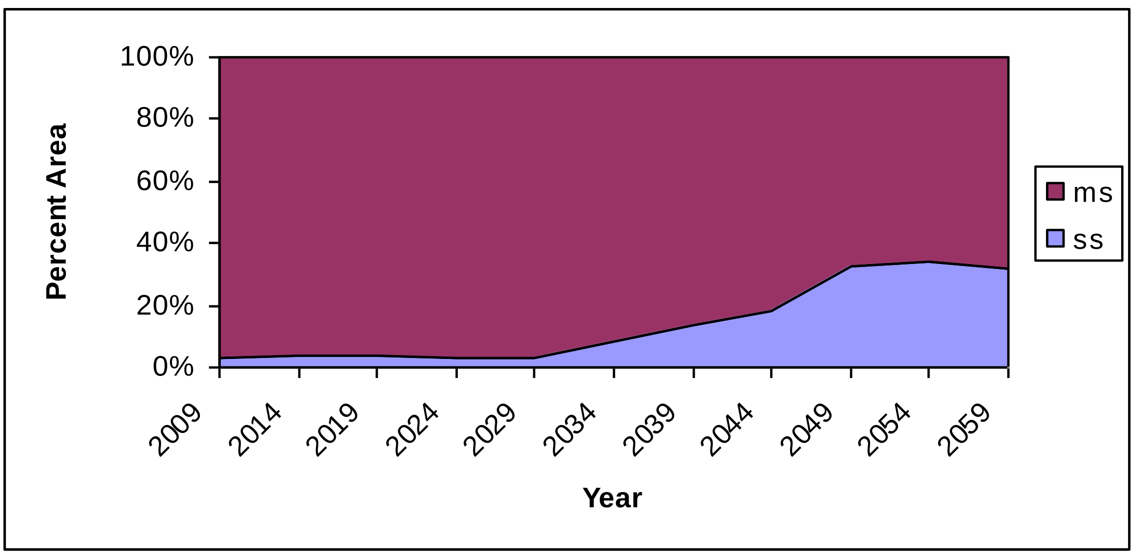


Figure B 18: Scn2 Percentage of Total Forest Represented by 4 Size Classes in Each Period

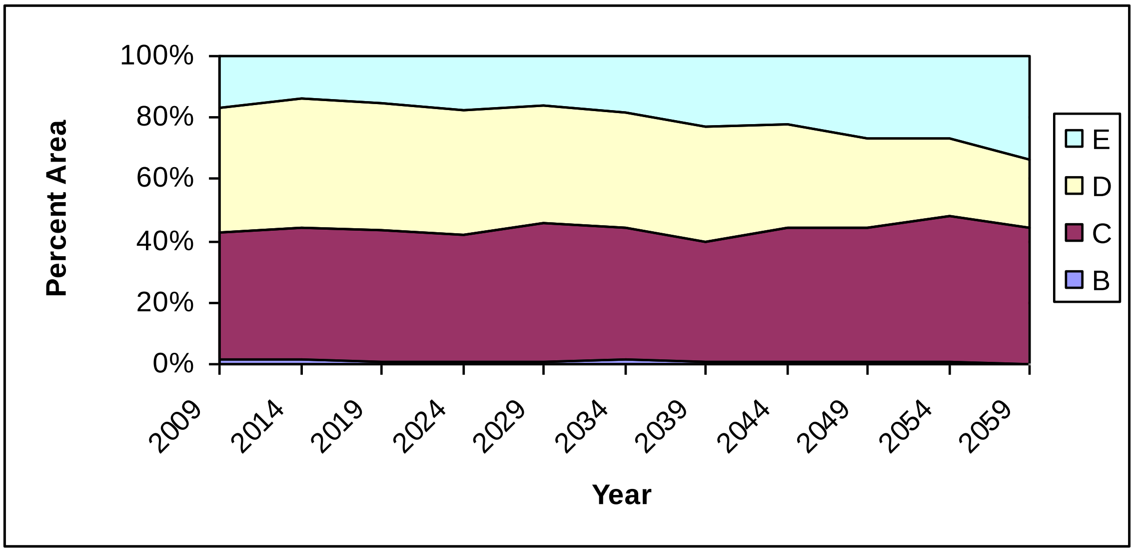


Figure B 19: Scn2 Percentage of Total Forest Represented by Softwood, Hardwood, and Oak-Pine Forest Types in Each Period

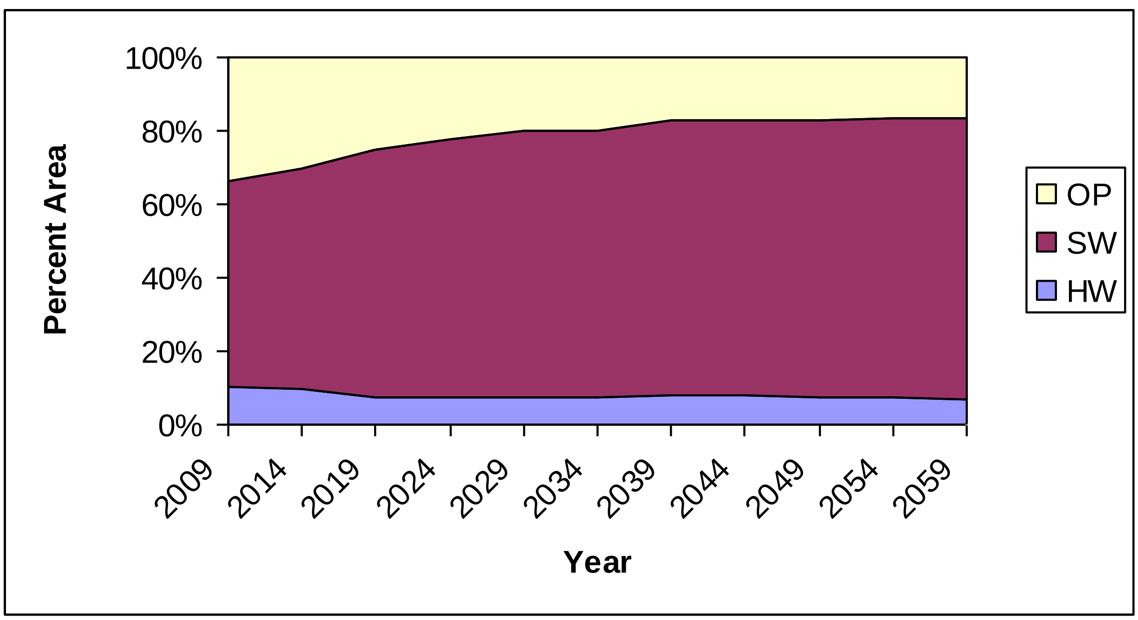


Figure B 20: Scn2 Percentage of All Stand Structural Classes Represented Across the Landscape by Period

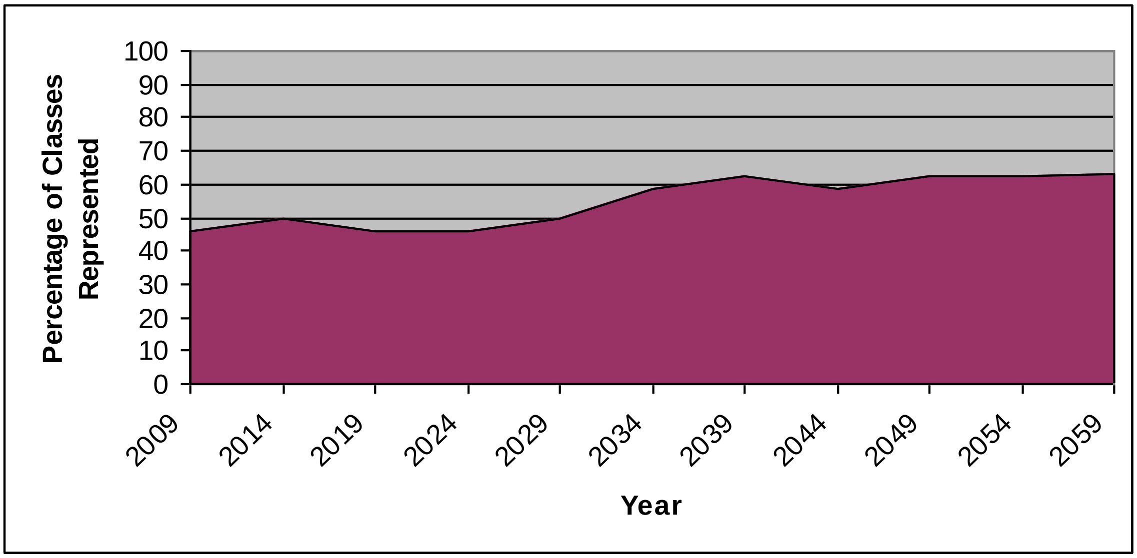


Figure B 21: Scn2 Area of Managed Forest Treated with 4 Different Treatment Types by Period

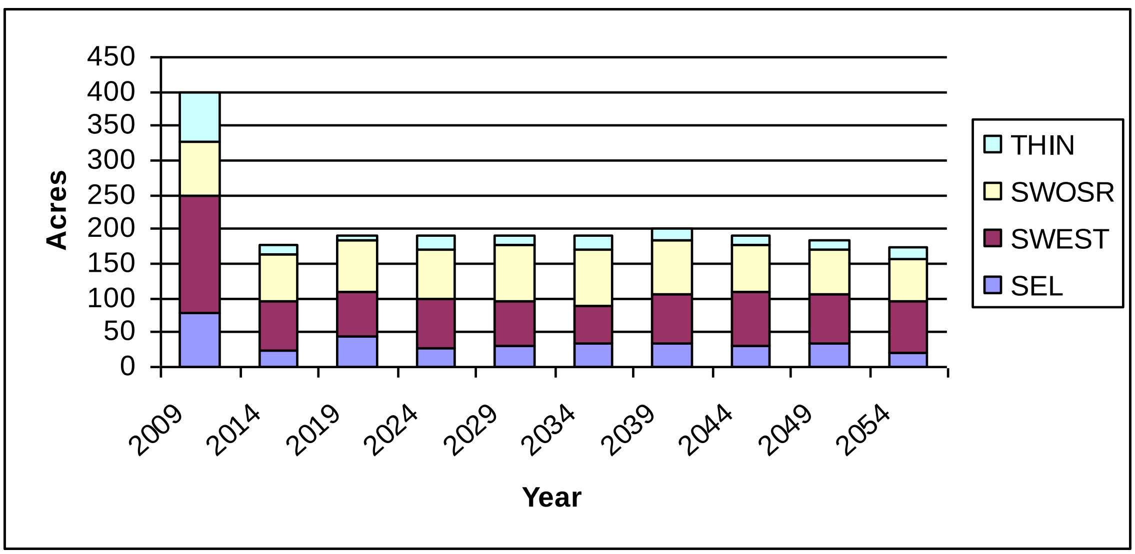


Figure B 22: Scn2 Total Board Foot Volume Removed in Each Period, as Compared to the Average Board Foot Volume Removed Throughout the Entire Projection Period

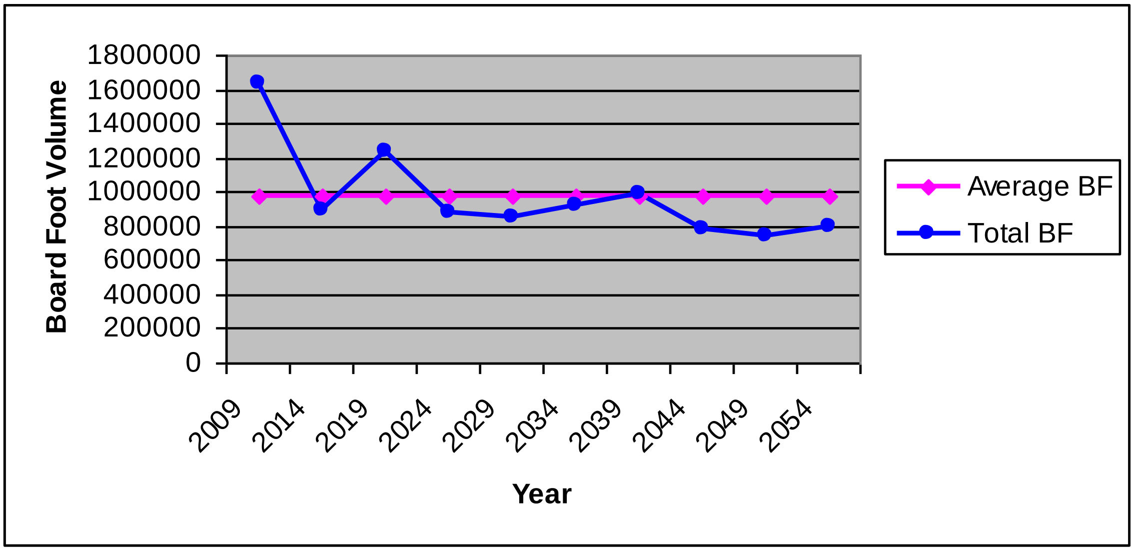


Figure B 23: Scn2 Total Cord Volume Removed in Each Period, as Compared to the Average Cord Volume Removed Throughout the Entire Projection Period

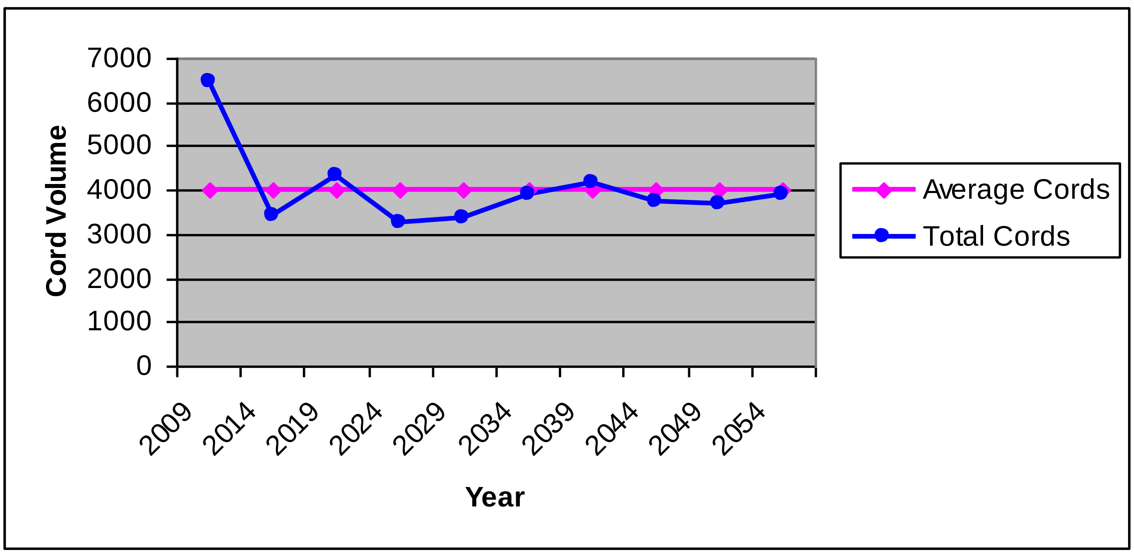


Figure B 24: Scn2 Standing Board Foot Volume of White Pine >12 in DBH, Compared to the Current Standing Volume of WP in 2009

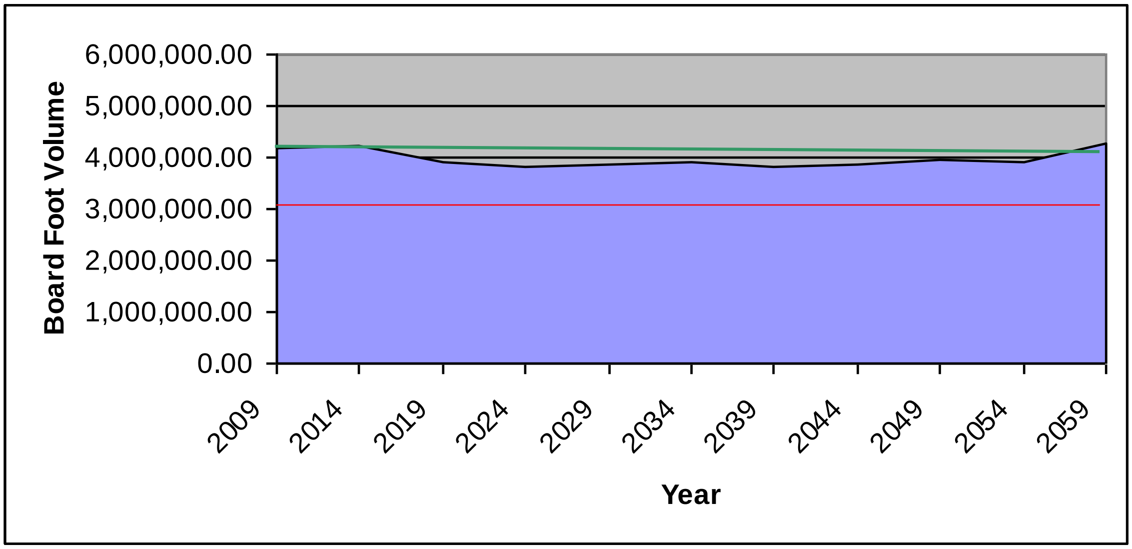


Figure B 25: Scn2 Percentage of Managed Forest Area Represented by 4 Size Classes by Period

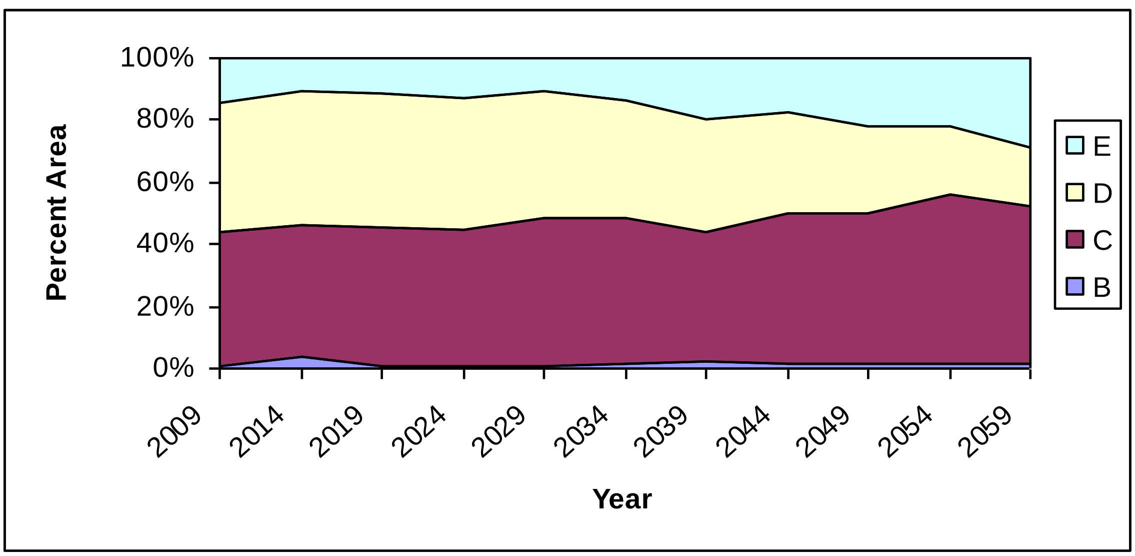


Figure B 26: Scn2 Total Area of Stands with High Recreational Value Affected by Harvest Activity by Period

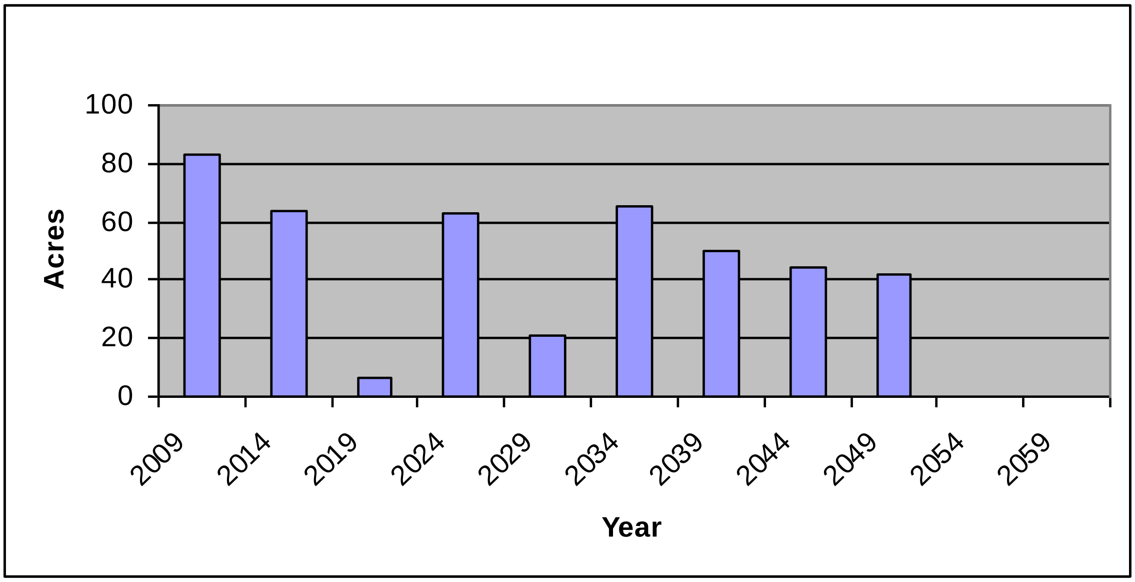


Figure B 27: Scn2 Percentage of Area in High Recreational Value Affected by Harvest Activity by Period

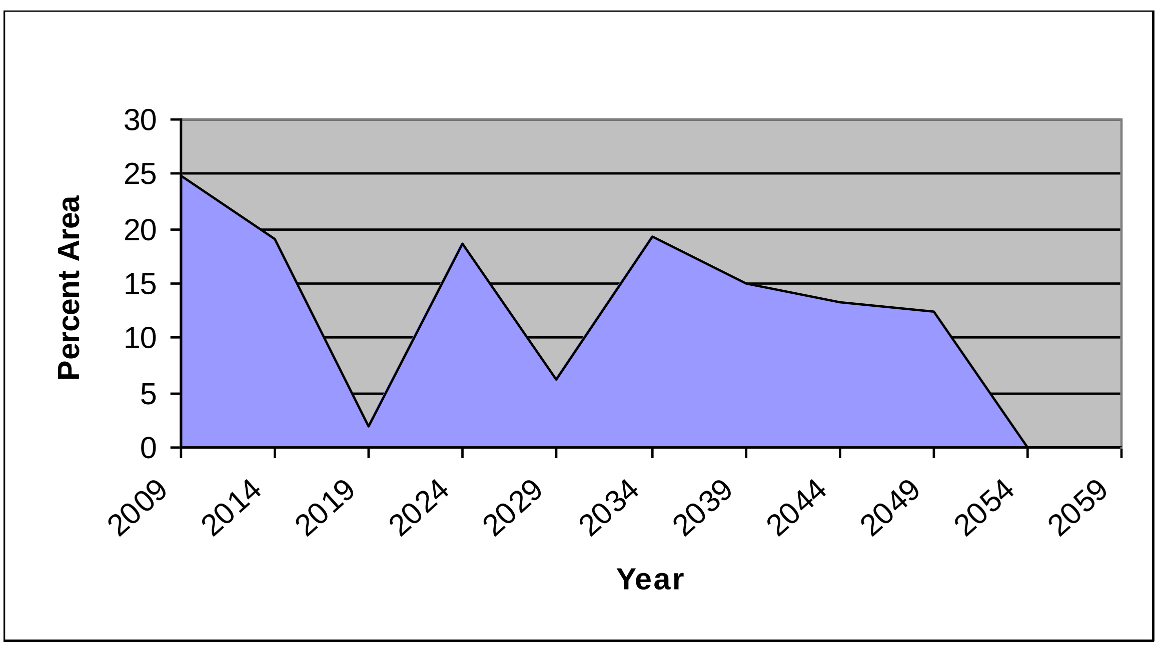


Figure B 28: Scn2 Proportion of Forest in 3 Levels of Wind Risk Classes

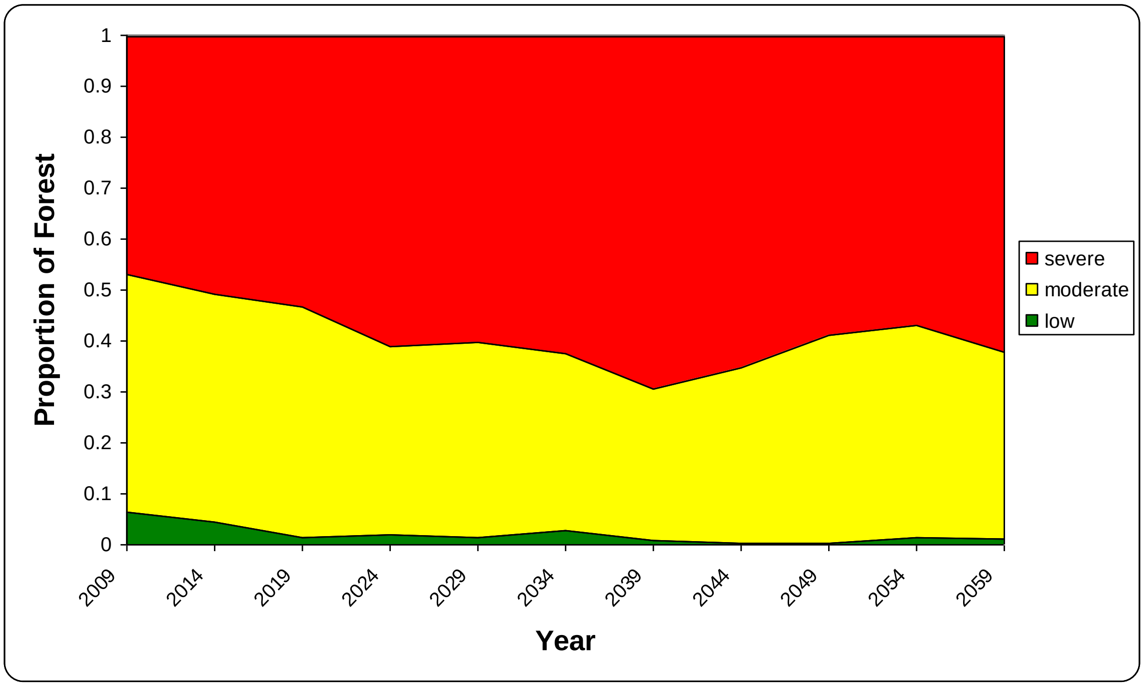


Figure B 29: Scn2 Proportion of Forest in 4 Levels of Hemlock Wooly Adelgid Risk Classes

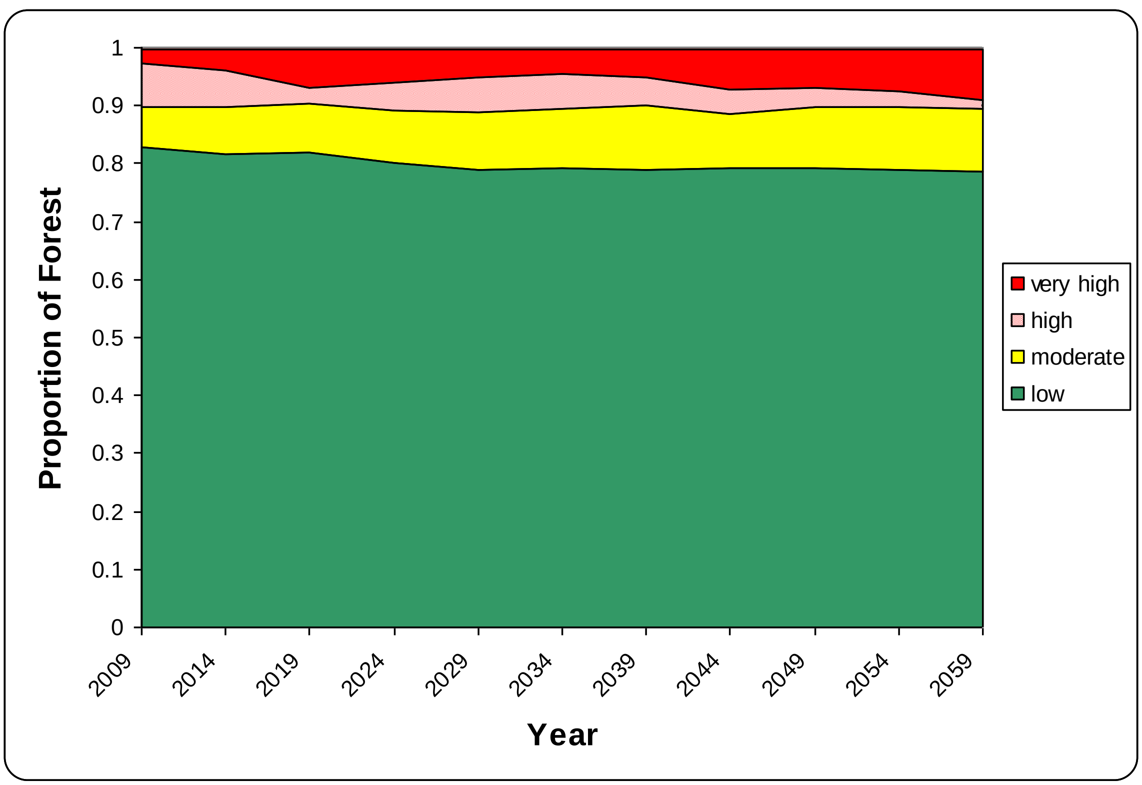
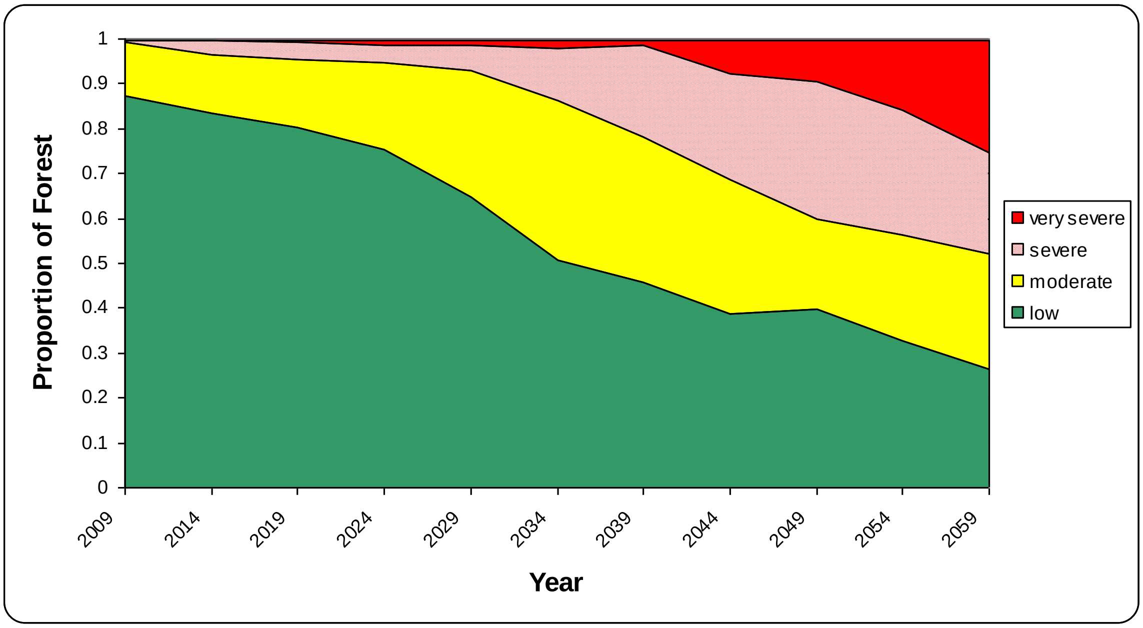


Figure B 30: Scn2 Proportion of Forest in 4 Levels of Spruce Budworm Risk Classes



Scenario 3: Moderate

Figure B 31: Scn3 Percent Basal Area by Species, >1 in, < 6in DBH, by Period

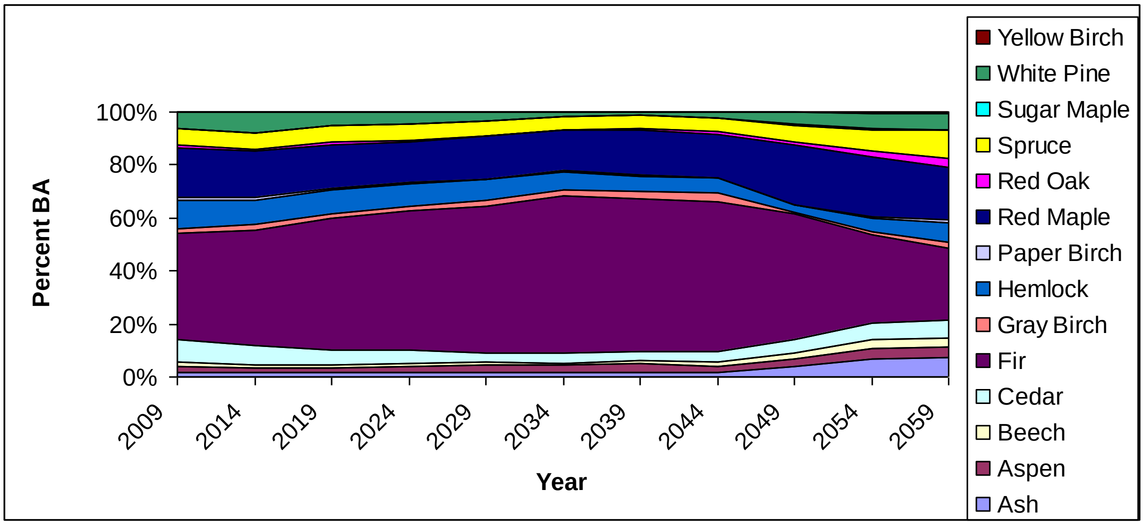


Figure B 32: Scn3 Percent Basal Area by Species, >6in DBH, by Period

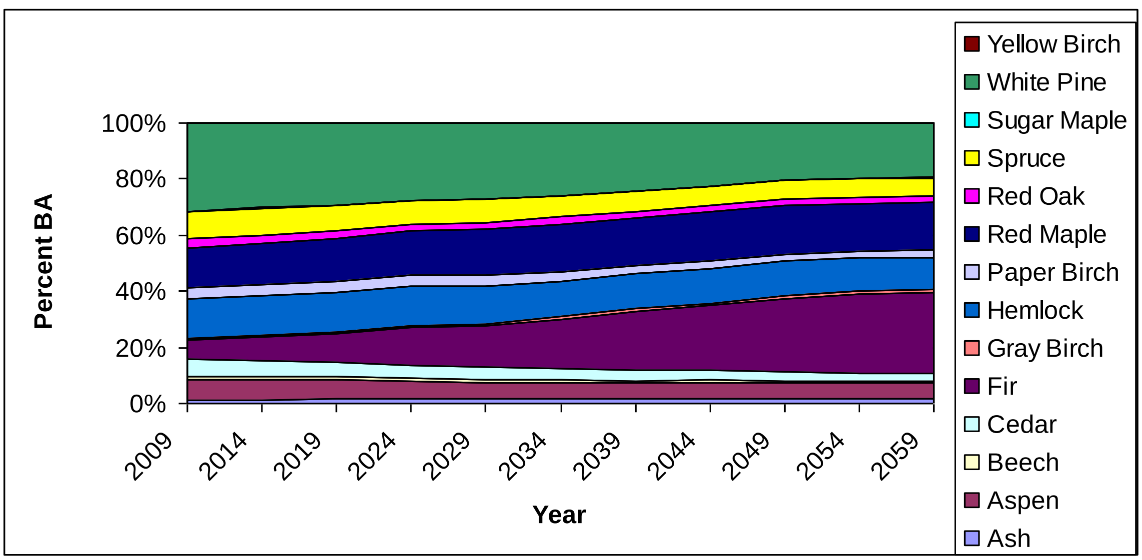


Figure B 33: Scn3 Percent Standing Cord Volume by Species, >6in DBH, by Period

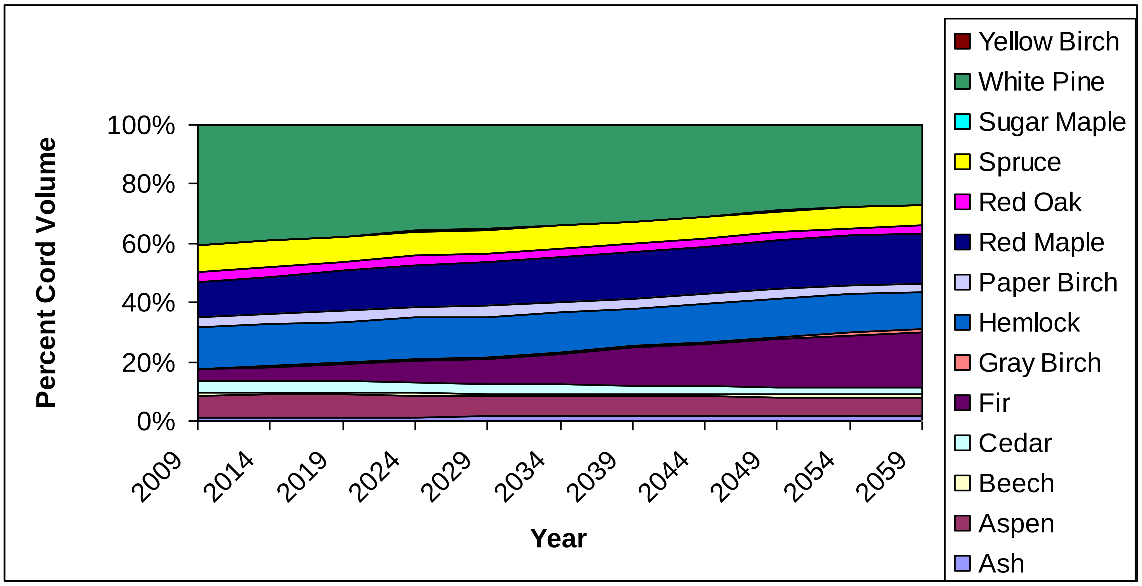


Figure B 34: Scn3 Percentage of Total Forest Represented by Multi-strata or Single-strata Structures in Each Period

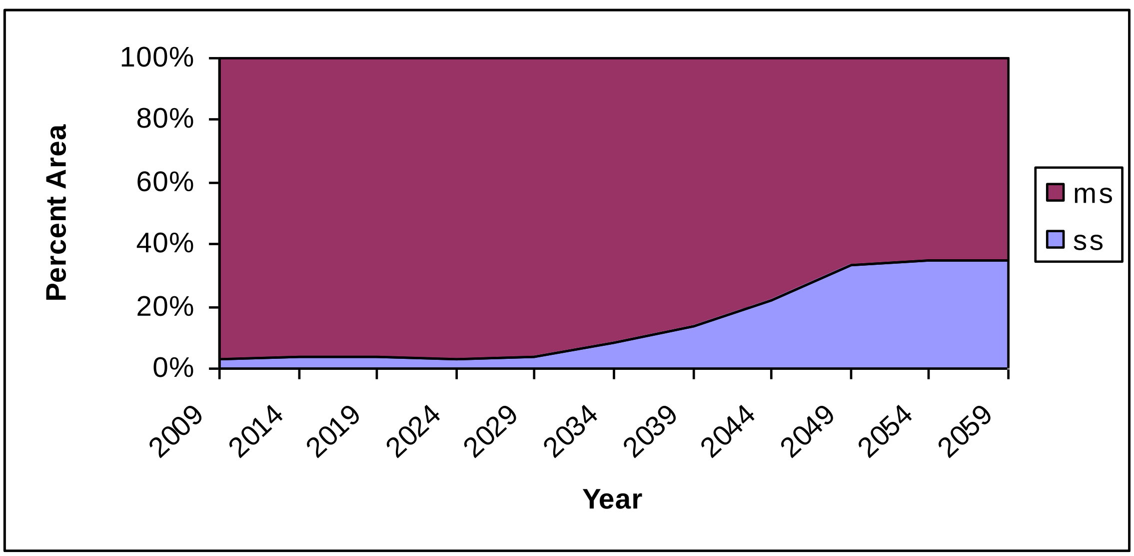


Figure B 35: Scn3 Percentage of Total Forest Represented by 4 Size Classes in Each Period

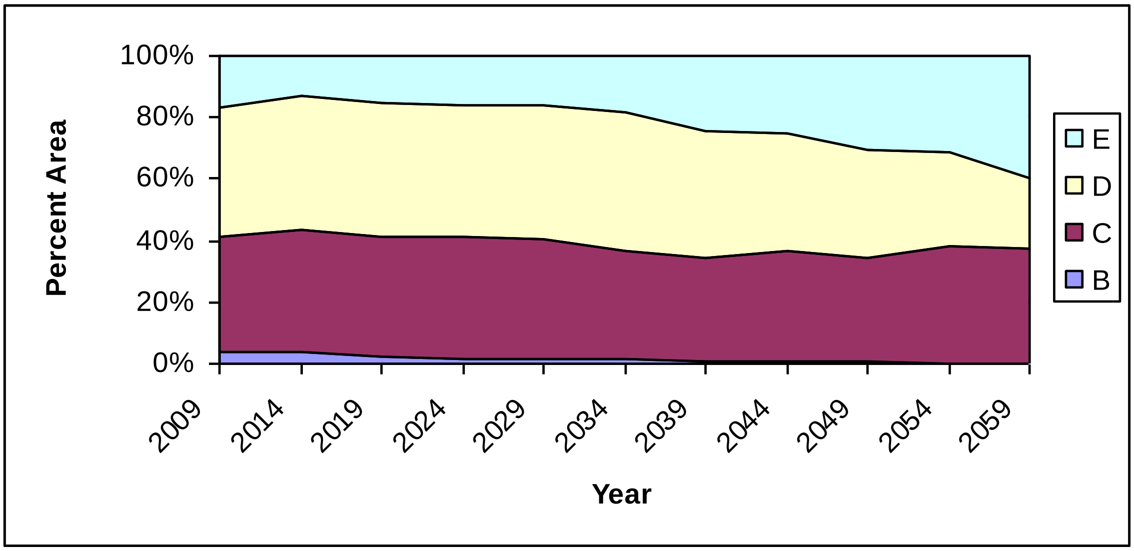


Figure B 36: Scn3 Percentage of Total Forest Represented by Softwood, Hardwood, and Oak-Pine Forest Types in Each Period

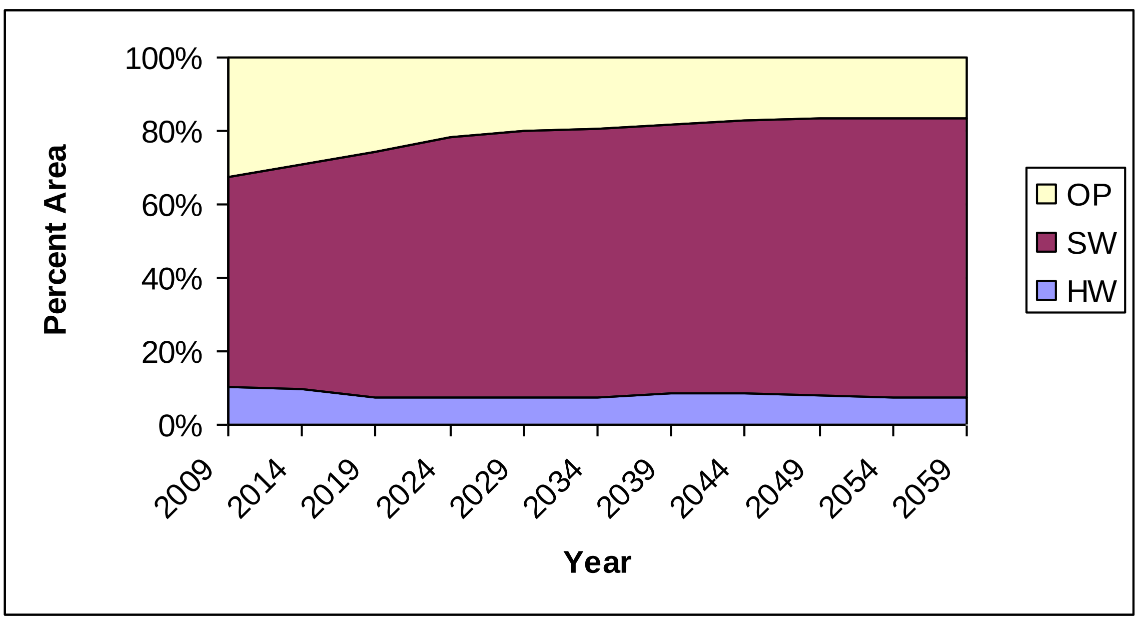


Figure B 37: Scn3 Percentage of All Stand Structural Classes Represented Across the Landscape by Period

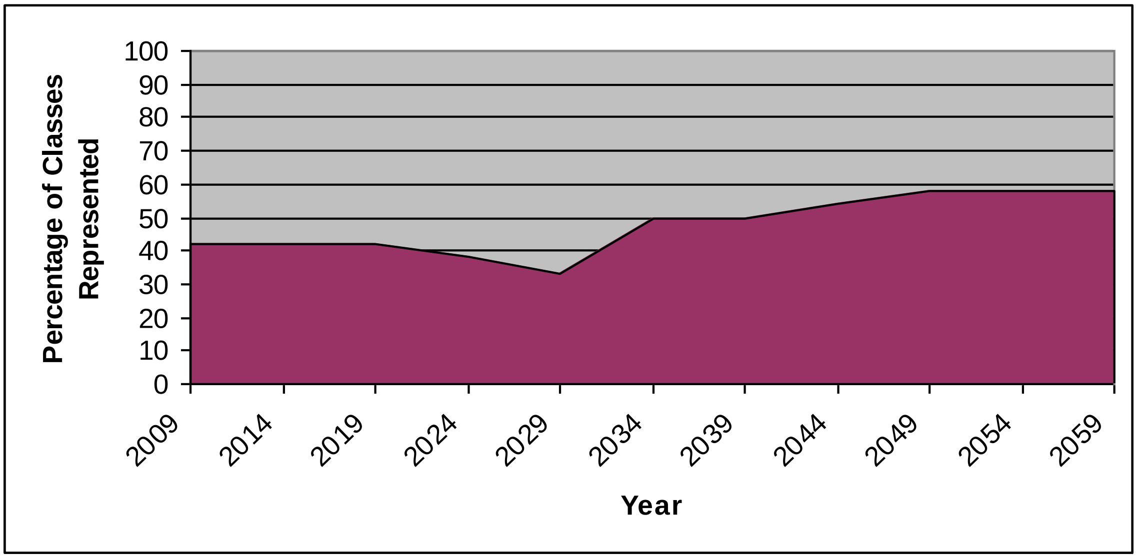


Figure B 38: Scn3 Area Treated with 4 Different Treatment Types by Period

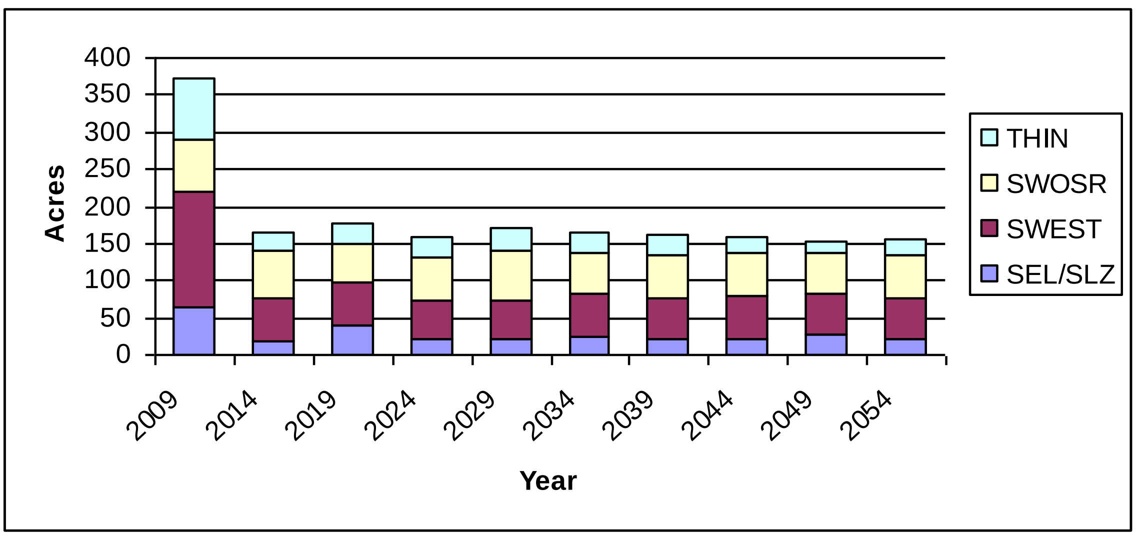


Figure B 39: Scn3 Total Board Foot Volume Removed in Each Period, as Compared to the Average Board Foot Volume Removed Throughout the Entire Projection Period

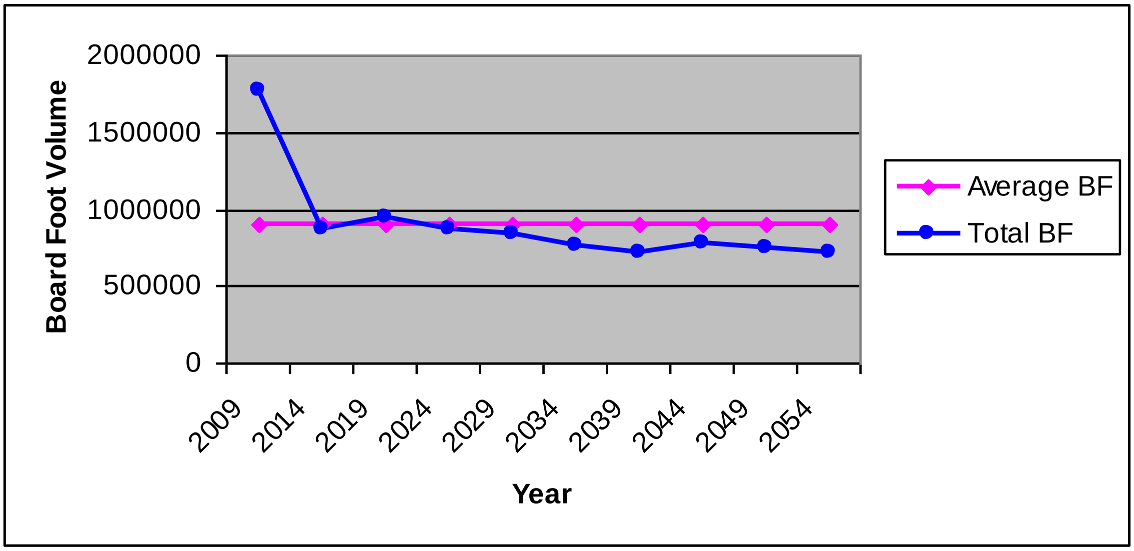


Figure B 40: Scn3 Total Cord Volume Removed in Each Period, as Compared to the Average Cord Volume Removed Throughout the Entire Projection Period

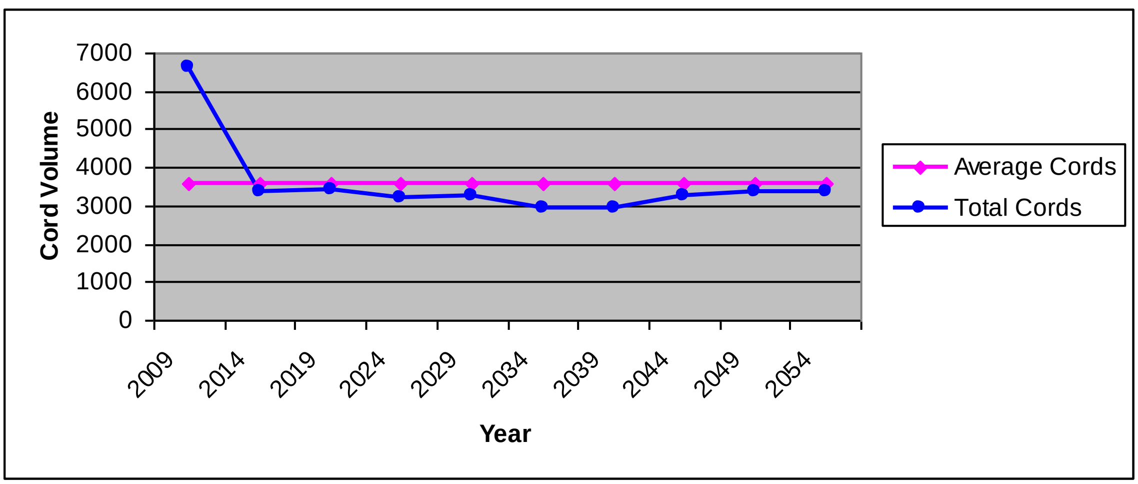


Figure B 41: Scn3 Standing Board Foot Volume of White Pine >12 in DBH, Compared to the Current Standing Volume of WP in 2009

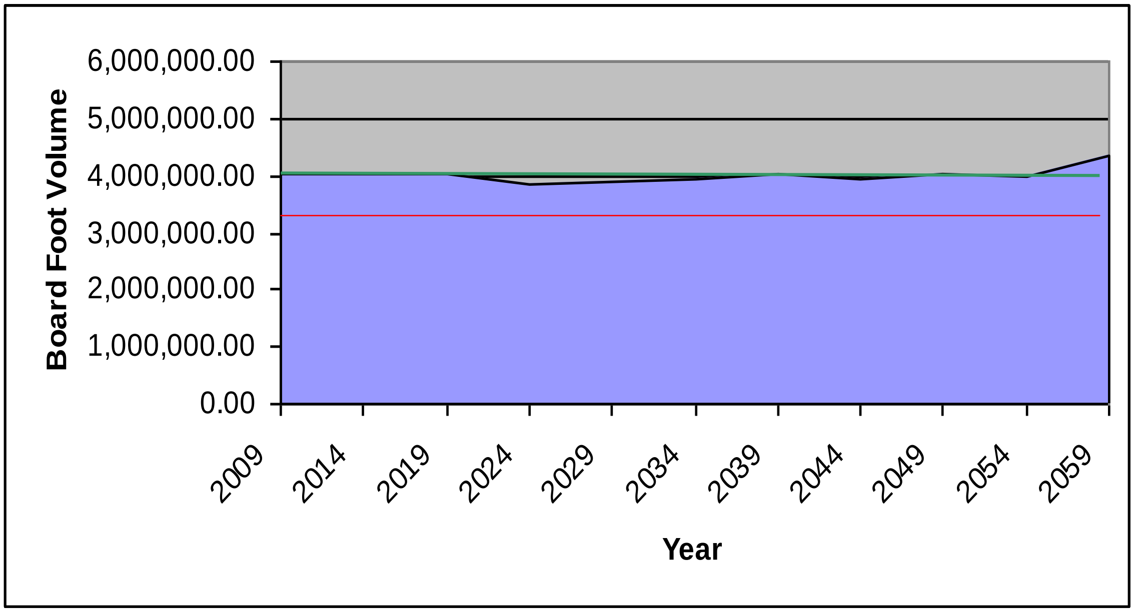


Figure B 42: Scn3 Percentage of Managed Forest Area Represented by 4 Size Classes by Period

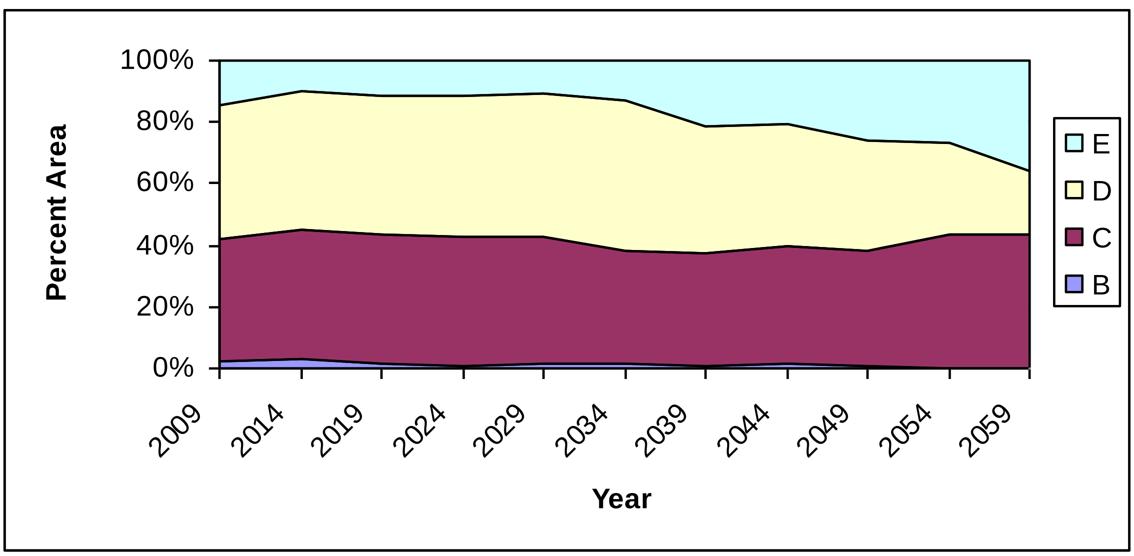


Figure B 43: Scn3 Total Area of Stands with High Recreational Value Affected by Harvest Activity by Period

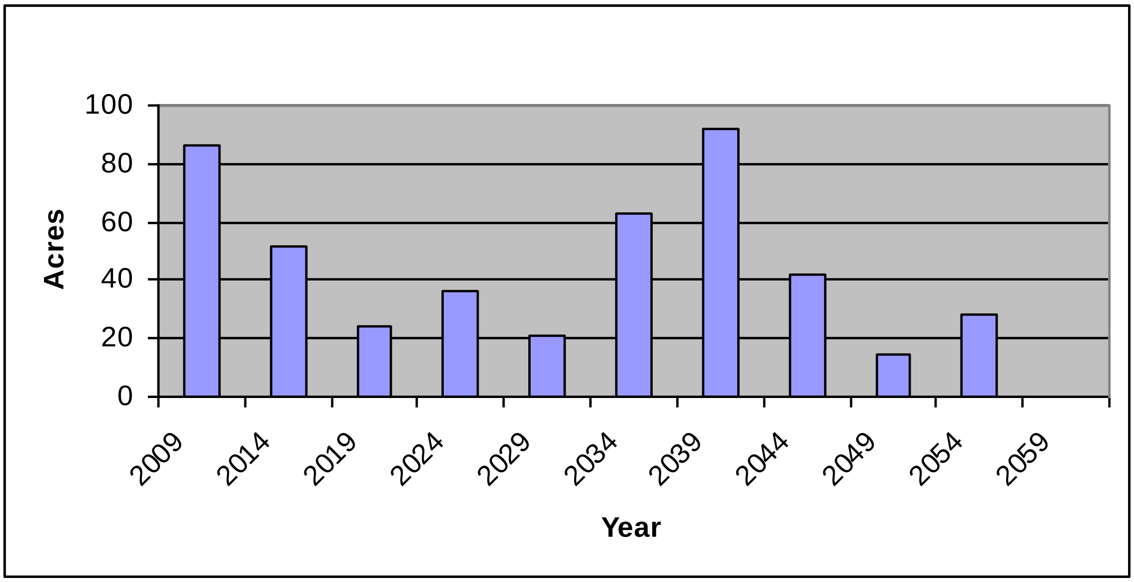


Figure B 44: Scn3 Percentage of Area with High Recreational Value Affected by Harvest Activity by Period

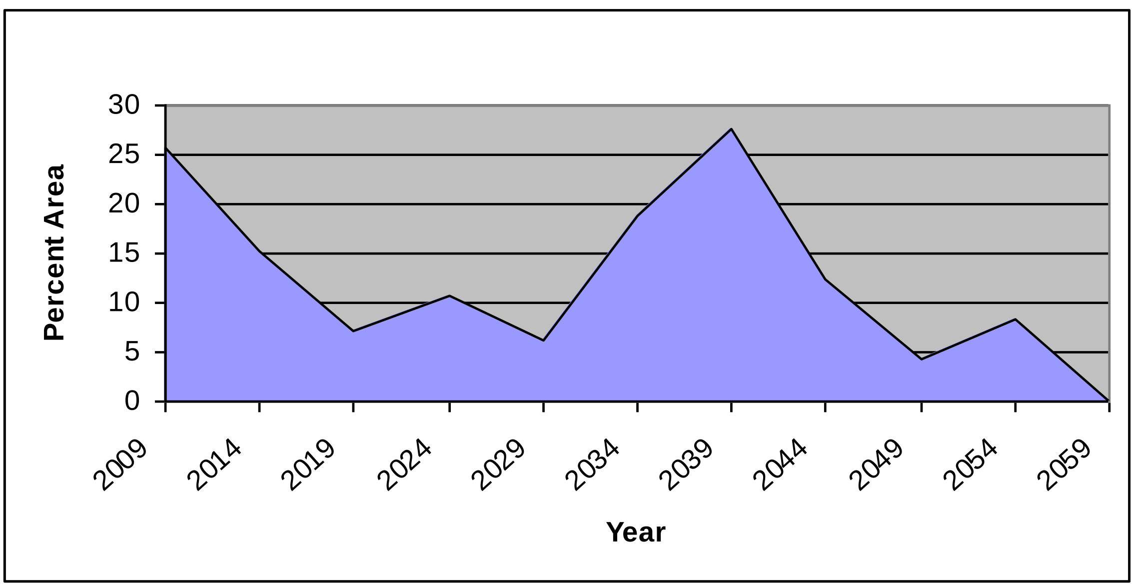


Figure B 45: Scn3 Proportion of Forest in 3 Levels of Wind Risk Classes

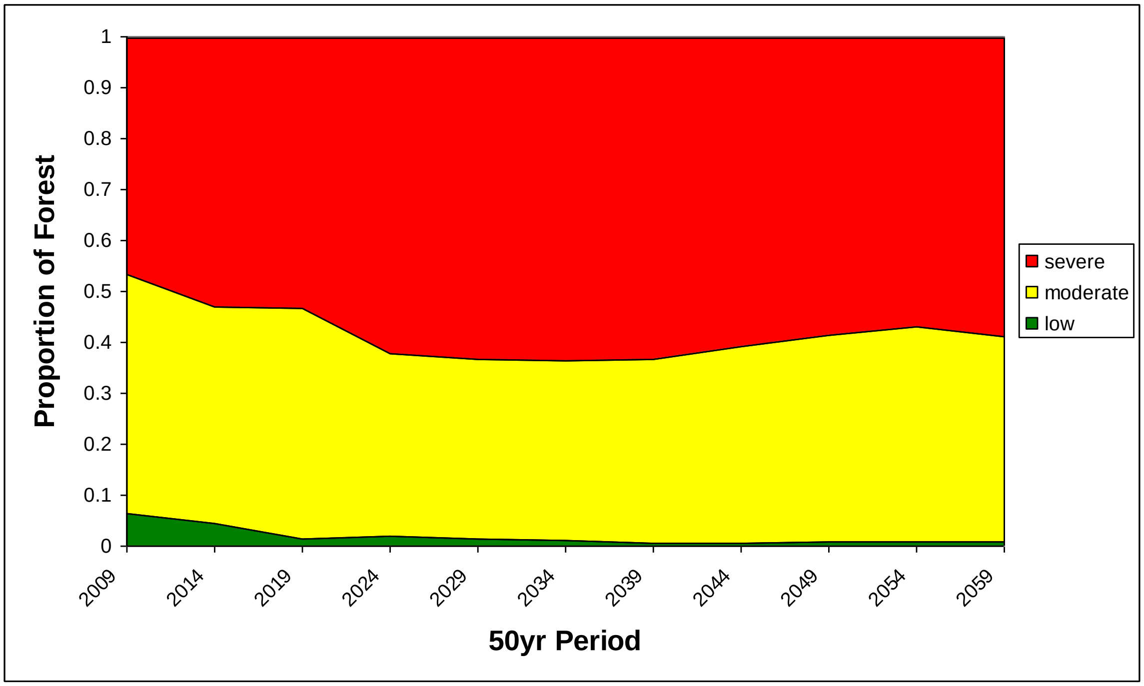


Figure B 46: Scn3 Proportion of Forest in 4 Levels of Hemlock Wooly Adelgid Risk Classes

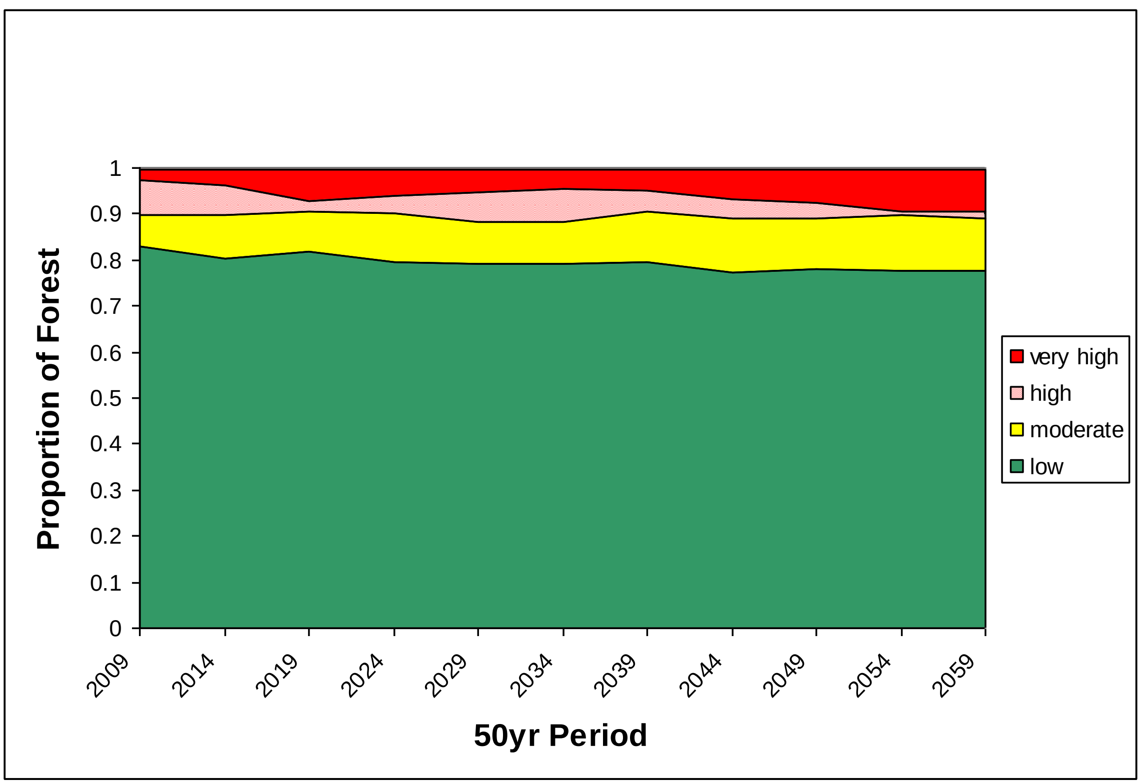
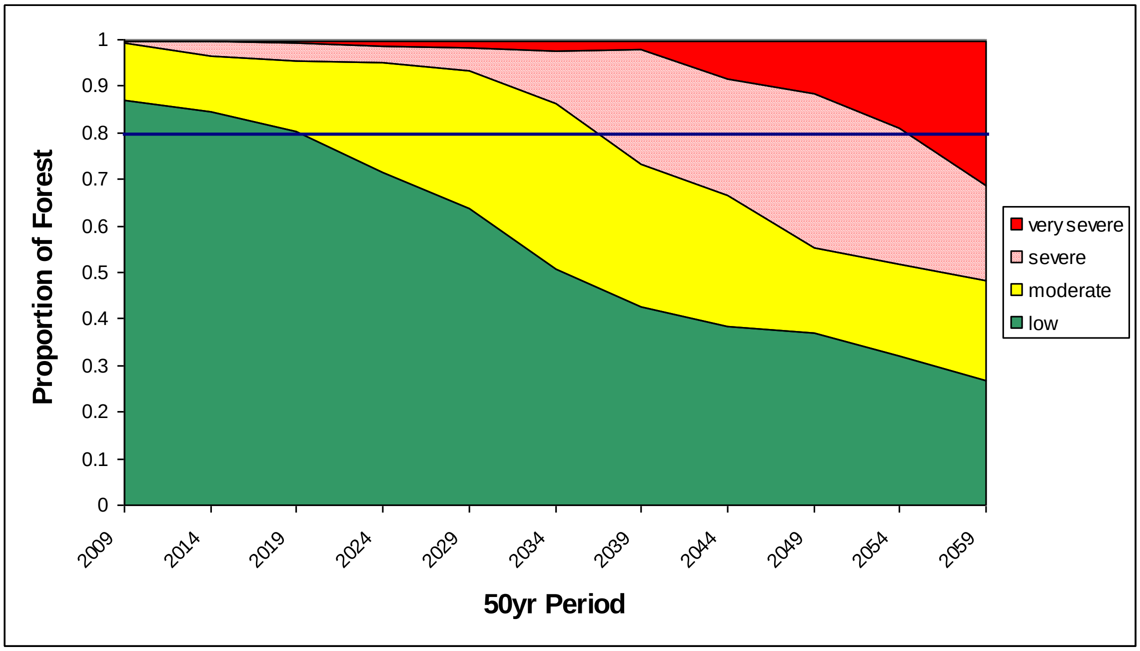


Figure B 47: Scn3 Proportion of Forest in 4 Levels of Spruce Budworm Risk Classes



<u>Appendix C</u>: Score sheet Summary

Objectives & Criteria	Year	Scn1 No Harvest		Scn2 Intensive		Scn3 Moderate	
		# Pass	% Pass	# Pass	% Pass	# Pass	% Pass
1) Education & Research	2009	9	38	11	46	10	42
O1C1: Diversity of Stand Structures: 24 categories, all >= 1% in all periods	2014	9	38	12	50	10	42
	2019	8	33	11	46	10	42
	2024	8	33	11	46	9	38
	2029	7	29	12	50	8	33
	2034	10	42	14	58	12	50
	2039	12	50	15	63	12	50
	2044	12	50	14	58	13	54
	2049	12	50	15	63	14	58
	2054	11	46	15	63	14	58
	2059	11	46	15	63	14	58
1) Education & Research	2009	0	0	4	80	5	100
O1C2: Silvicultural Treatments: >= 10ac of each treatment per period	2014	0	0	5	100	5	100
	2019	0	0	4	80	5	100
	2024	0	0	5	100	4	80
	2029	0	0	5	100	4	80
	2034	0	0	4	80	4	80
	2039	0	0	5	100	4	80
	2044	0	0	4	80	4	80
	2049	0	0	5	100	4	80
	2054	0	0	5	100	5	100
	2059	0	0	0	0	0	0
1) Education & Research	2009	0	0	0	0	0	0
O1C3: Area in Reserve: >=10% of total forest area	2014	0	0	0	0	0	0
	2019	0	0	0	0	0	0
	2024	0	0	0	0	0	0
	2029	0	0	0	0	0	0
	2034	0	0	0	0	0	0
	2039	0	0	0	0	0	0
	2044	0	0	0	0	0	0
	2049	0	0	0	0	0	0
	2054	0	0	0	0	0	0
	2059	0	0	0	0	0	0

3) Sustainable Timber Supply	2009	0	0	0	0	0	0
O3C1: Harvest Removal: w/in 20% of average in each period	2014	1	100	1	100	1	100
	2019	1	100	0.5	50	1	100
	2024	1	100	1	100	1	100
	2029	1	100	1	100	1	100
	2034	1	100	1	100	1	100
	2039	0.5	50	1	100	0.5	50
	2044	1	100	1	100	1	100
	2049	1	100	0.5	50	1	100
	2054	0.5	50	1	100	0.5	50
	2059			NA	NA	1	100
3) Sustainable Timber Supply	2009	1	100	1	100	1	100
O3C2: Standing Volume (large DBH WP): w/in 20% of current levels in each period	2014	1	100	1	100	1	100
	2019	1	100	1	100	1	100
	2024	1	100	1	100	1	100
	2029	1	100	1	100	1	100
	2034	1	100	1	100	1	100
	2039	1	100	1	100	1	100
	2044	1	100	1	100	1	100
	2049	1	100	1	100	1	100
	2054	1	100	1	100	1	100
	2059	1	100	1	100	1	100
3) Sustainable Timber Supply	2009	3	75	2	50	2	50
O3C3: Diversity of size classes: 4 categories, all >= 15% in all periods	2014	3	75	2	50	2	50
	2019	3	75	2	50	2	50
	2024	3	75	2	50	2	50
	2029	3	75	2	50	2	50
	2034	2	50	2	50	2	50
	2039	2	50	3	75	3	75
	2044	2	50	3	75	3	75
	2049	2	50	3	75	3	75
	2054	2	50	3	75	3	75
	2059	2	50	3	75	3	75

6) Recreation & Aesthetics	2009	0	0	0	0	0	0
O6C1: <=75 acres of HRV stands harvested per period	2014	0	0	1	100	1	100
	2019	0	0	1	100	1	100
	2024	0	0	1	100	1	100
	2029	0	0	1	100	1	100
	2034	0	0	1	100	1	100
	2039	0	0	1	100	0	0
	2044	0	0	1	100	1	100
	2049	0	0	1	100	1	100
	2054	0	0	1	100	1	100
	2059	0	0	1	100	1	100
6) Recreation & Aesthetics	2009	0	0	0	0	0	0
O6C2: Exclude OSR and CC treatments in HRV stands	2014	0	0	1	100	1	100
	2019	0	0	1	100	1	100
	2024	0	0	1	100	1	100
	2029	0	0	1	100	1	100
	2034	0	0	0	0	0	0
	2039	0	0	0	0	1	100
	2044	0	0	0	0	1	100
	2049	0	0	1	100	1	100
	2054	0	0	1	100	1	100
	2059	0	0	1	100	1	100
7) Forest Health & Protection	2009	0	0	0	0	0	0
O7C1: Wind Susceptibility Ratings: <=20% of forest with high/severe rating	2014	0	0	0	0	0	0
	2019	0	0	0	0	0	0
	2024	0	0	0	0	0	0
	2029	0	0	0	0	0	0
	2034	0	0	0	0	0	0
	2039	0	0	0	0	0	0
	2044	0	0	0	0	0	0
	2049	0	0	0	0	0	0
	2054	0	0	0	0	0	0
	2059	0	0	0	0	0	0

7) Forest Health & Protection	2009	1	100	1	100	1	100
O7C2: HWA Susceptibility Ratings: <=20% of forest with high/severe rating	2014	1	100	1	100	1	100
	2019	1	100	1	100	1	100
	2024	1	100	1	100	1	100
	2029	1	100	1	100	1	100
	2034	1	100	1	100	1	100
	2039	1	100	1	100	1	100
	2044	1	100	1	100	1	100
	2049	1	100	1	100	1	100
	2054	1	100	1	100	1	100
	2059	1	100	1	100	1	100
7) Forest Health & Protection	2009	1	100	1	100	1	100
O7C3: SBW Susceptibility Ratings: <=20% of forest with high/severe rating	2014	1	100	1	100	1	100
	2019	1	100	1	100	1	100
	2024	1	100	1	100	1	100
	2029	1	100	1	100	1	100
	2034	0	0	1	100	1	100
	2039	0	0	0	0	0	0
	2044	0	0	0	0	0	0
	2049	0	0	0	0	0	0
	2054	0	0	0	0	0	0
	2059	0	0	0	0	0	0

Appendix D: Regeneration Information

Matrix Description

Richard Morrill
7-Mar-10

Site Index	WP = 55 =SM= 47
	WP = 65 =SM= 57

Access Query Classes

BA		Site Index (SM values) ≤47	Site Index (SM values) >47 and <56	Site Index (SM values) ≥56
≤50	1	1	2	3
>50<100	2			
≥100<150	3			
≥150	4			

BA	Site Index (SM values) ≤47	Site Index (SM values) >47 and <56	Site Index (SM values) ≥56
≤50	A	B	C
>50<100	D	E	F
≥100<150	G	H	I
≥150	J	K	L

The letter codes in red are noted in the comment line of the "DBD_rgn1.key" file in the DBD2010 LMS portfolio folder. This matrix represents the "binning" of stand attributes. Basal area and Site index. Each stand polygon can be classified by LMS as falling in one of these catagories. Each letter represents a tree list of regeneration that will be "planted" each projection period. Which tree list LMS selects to plant is determined by the bin (letter code) in which the stand polygon falls at the start of that period. SI will clearly not change by BA can be altered by harvest or simulated mortality.

Number codes 1, 2, 3, 4 in red indicate the BA or SI class that was created in access queries in the database LMS_2008_Modeling_2 (see scrnshot below). Those classes were used in a final "Binning" query that created the A-I maxtrix.

Rgn Tree lists created in Access Database
Named: LMS Modeling 2
Primary Query used named: Rgn Matrix sample BA A2

Regeneration Key File

```
DBDregen4_16mar10.key - Notepad
File  Edit  Format  View  Help
COMMENT
KEYWORD     111111111 222222222 333333333 444444444 555555555 666666666 777777777
END
COMPUTE
SDI = BTPA * ( BADBH / 10.0 ) ** 1.604
END

MORTMULT           1        ALL       1.5       0.0        12
COMMENT
SDIMAX                                                               100
END

COMMENT
KEYWORD     111111111 222222222 333333333 444444444 555555555 666666666 777777777
END

NOTRIPLE

COMMENT
A
END
IF
SITE LE 47 AND BBA LE 50 AND BTPA LT 600
THEN
ESTAB
NATURAL                      EH        30                            1.2
NATURAL                      BF        25                            1.4
NATURAL                      QA        40                            1.6
NATURAL                      WP        115                           1.4
NATURAL                      RS        25                            1.0
NATURAL                      WC        10                            1.2
NATURAL                      RM        30                            1.6
NATURAL                      AB        20                            1.0
NATURAL                      BT        5                             1.5
NATURAL                      GB        5                             1.6
NATURAL                      OH        90                            1.4
OUTPUT             1
END
ENDIF
```

Appendix E: Area Control Worksheets

Scenario 2: More Intensive

DBD Area Control Worksheet

	Acres
Total Managed Acres	1485
Percent Even	0.75
Percent Uneven	0.25
Rotation Age Even	80
Rotation Age Uneven	80
Years per Period	5

Values to use	Intensive	Moderate
	Scn2	Scn3
Rotation Age Even	80	100
Rotation Age Uneven	80	100

Enter values for each scenario in yellow cells.

	Even	Uneven	Totals
Total Acres	1114	371	1485
Acres Regen / Year	14	5	19
Acres Regen / Period	70	23	93

Plug these calculated values into the harvest scheduling spreadsheet to guide how many acres to **regenerate** each period with OSR and selection harvests

Total Acres Regened/Prd	93	
Total Acres to Treat/Yr	35	Staff Capability
Total Acres to Treat/Prd	**175**	
Total Acres to Treat w/ Tending/Prd	82	
Total Acres to Treat w/ Tending/Year	16	

Values calculated for acres to treat with shelterwood establishment or commercial thinning treatments by period and year. Plug these calculated values into the harvest scheduling spreadsheet to guide how many acres to treat with either treatment each period

Scenario 3: Moderate

DBD Area Control Worksheet

	Acres
Total Managed Acres	1485
Percent Even	0.75
Percent Uneven	0.25
Rotation Age Even	100
Rotation Age Uneven	100
Years per Period	5

Values to use	Intensive	Moderate
	Scn2	Scn3
Rotation Age Even	80	100
Rotation Age Uneven	80	100

Enter values for each scenario in yellow cells.

	Even	Uneven	Totals
Total Acres	1114	371	1485
Acres Regen / Year	11	4	15
Acres Regen / Period	56	19	74

Plug these calculated values into the harvest scheduling spreadsheet to guide how many acres to **regenerate** each period with OSR and selection harvests

Total Acres Regened/Prd	74	
Total Acres to Treat/Yr	35	Staff Capability
Total Acres to Treat/Prd	175	
Total Acres to Treat w/ Tending/Prd	101	
Total Acres to Treat w/ Tending/Year	20	

Values calculated for acres to treat with shelterwood establishment or commercial thinning treatments by period and year. Plug these calculated values into the harvest scheduling spreadsheet to guide how many acres to treat with either treatment each period

Appendix F: Harvest Scheduling Worksheet

Targets:					
	56ac	EA Ac. Regenerated OSR,CC	57.62843	1	thin stands ie 15 yrs +
	19ac	MA Ac. Regenerated SEL	20.67149	2	15 yrs after
	56ac	EA & MA Ac SWest	55.11387	3	20 yrs after
	25ac	EA & MA Ac Thin	23.72813	4	40 yrs after
	3ac	EA & MA Ac. PCT	11.28614	5	

Stand_ID	Current_YR	Last_Op	Last Treat	Time Past Op	Suggest Treat	Silvi_Sys	Cd_ac	GIS_Ac	Treatment Code	Treatment
E27_250	2054				?	MA	68.53137	1.524988		
K155	2054	2024	SEL	30	sel	MA	61.467265	7.329123	2	SEL
D29_250	2054				?	MA	55.191571	5.232765		
K153	2054	2024	SEL	30	sel	MA	49.643527	4.265662		
D31_250	2054				?	MA	48.998462	8.060287		
D31a	2054				?	MA	47.882619	4.795165		
E19_250	2054	2019	SEL	35	sel	MA	47.613741	3.052921	2	SEL
B40	2054				?	MA	45.004033	2.260118		
B40_250	2054				?	MA	45.004033	1.551886		
D30_250	2054				?	MA	44.493936	1.075994		
K171	2054	2014	SEL	40	sel	MA	44.341566	10.28945	2	SEL
F5	2054				?	EA	44.107177	0.832129		
K166	2054	2024	SEL	30	sel	MA	43.302154	5.36662		

Appendix G: Strata Components

Strata_Name	Strata ID	Name	Code	Description
Site Class	1	High	1	Highest site class based on white pine SI value using drainage class from NRC soils GIS layer
Site Class	1	Med	2	Medium site class based on white pine SI value using drainage class from NRC soils GIS layer
Site Class	1	Low	3	Lowest site class based on white pine SI value using drainage class from NRC soils GIS layer
Development Class 2	2	Seed	A	Stand BA dominated by seedling sized trees (those <1 in DBH)
Development Class 2	2	Sapling	B	Stand BA dominated by sapling sized trees (those >1" and <5" in DBH)
Development Class 2	2	Intermediate	C	This is the catch all class but is defined as a stand dominated by pole sized trees with DBH >5" and < an upper diameter limit based on habitat type.
Development Class 2	2	Large	D	If the species in hab type 5 with a DBH >12" and <16" have a total BA >30ft^2
Development Class 2	2	Large	D	If the species in hab type 6 with a DBH >9" and <12" have a total BA >30ft^2
Development Class 2	2	Large	D	If the species in hab type 3 or 4 with a DBH >12" and <20" have a total BA >30ft^2
Development Class 2	2	Large	D	If the species in hab type 1 or 2 with a DBH >12" and <16" have a total BA >30ft^2
Development Class 2	2	Very Large	E	If the species in hab type 5 with a DBH >16" have a total BA >30ft^2
Development Class 2	2	Very Large	E	If the species in hab type 6 with a DBH >12" have a total BA >30ft^2
Development Class 2	2	Very Large	E	If the species in hab type 3 or 4 with a DBH >20" have a total BA >30ft^2
Development Class 2	2	Very Large	E	If the species in hab type 1 or 2 with a DBH >16" have a total BA >30ft^2
FSF Habitat	3	Aspen Birch	1	If sum of BA of hab type 1 > than that of all other individual hab types then class 1 selected
FSF Habitat	3	N. Hardwoods	2	If sum of BA of hab type 2 > than that of all other individual hab types then class 2 selected
FSF Habitat	3	Oak-Pine	3	If sum of BA of hab type 3 > than that of all other individual hab types then class 3 selected
FSF Habitat	3	Hemlock	4	If sum of BA of hab type 4 > than that of all other individual hab types then class 4 selected
FSF Habitat	3	Spruce-Fir	5	If sum of BA of hab type 5 > than that of all other individual hab types then class 5 selected
FSF Habitat	3	N. W. Cedar	6	If sum of BA of hab type 6 > than that of all other individual hab types then class 6 selected
FSF Habitat	3	Riparian	7	Spatially derived non quantitative selection process
FSF Habitat	3	Vernal Pool	8	Spatially derived non quantitative selection process
FSF Habitat	3	Forested Wetland	9	Spatially derived non quantitative selection process
*FSF Habitat 2	3a	Non-Pine softwoods	11	A combination of hab types 4, 5, and 6 to simply the number of types, used when combining all strata
*FSF Habitat 2	3a	Non-Oak hardwoods	12	A combination of hab types 1 and 2 to simply the number of types, used when combining all strata
Canopy Cover	4	Closed	c	If canopy closure value is >70%
Canopy Cover	4	Medium	m	If canopy closure value is >40%
Canopy Cover	4	Open	o	If canopy closure value is <40%

Strata_Name	Strata ID	Name	Code	Quantitative Derivation
Site Class	1	High	1	IIf([WP_SI_09]>65,1
Site Class	1	Med	2	Otherwise "2"
Site Class	1	Low	3	,IIf([WP_SI_09]<55,3
Development Class 2	2	Seed	A	IIf([sumofba5]<10,"A",
Development Class 2	2	Sapling	B	IIf([sumofba5]<10 And [sumofba1]-[sumofba5]>[sumofba5],"B"
Development Class 2	2	Intermediate	C	If stand does not fit into other classes then it must fit class C (catch all class)
Development Class 2	2	Large	D	IIf([fsf_Hab]=5 And ([sumofba12b]>30),"D"
Development Class 2	2	Large	D	IIf([fsf_Hab]=6 And ([sumofba9]>30),"D"
Development Class 2	2	Large	D	IIf(([fsf_Hab]=3 Or [fsf_Hab]=4) And ([sumofba12a]>30),"D"
Development Class 2	2	Large	D	IIf(([fsf_Hab]=1 Or [fsf_Hab]=2) And ([sumofba12a]>30),"D"
Development Class 2	2	Very Large	E	IIf([fsf_Hab]=5 And ([sumofba16]>30),"E"
Development Class 2	2	Very Large	E	IIf([fsf_Hab]=6 And ([sumofba12b]>30),"E"
Development Class 2	2	Very Large	E	IIf(([fsf_Hab]=3 Or [fsf_Hab]=4) And ([sumofba20]>30),"E"
Development Class 2	2	Very Large	E	IIf(([fsf_Hab]=2) And ([sumofba16]>30),"E"
FSF Habitat	3	Aspen Birch	1	IIf([sumofasp_bir_BA]>[sumofnh_ba] And [sumofasp_bir_BA]>[sumofop_ba] And [sumofasp_bir_BA]>[sumofeh_ba] And [sumofasp_bir_BA]>[sumofsf_ba] And [sumofasp_bir_BA]>[sumofwc_ba],1
FSF Habitat	3	N. Hardwoods	2	IIf([sumofnh_BA]>[sumofasp_bir_ba] And [sumofnh_BA]>[sumofop_ba] And [sumofnh_BA]>[sumofeh_ba] And [sumofnh_BA]>[sumofsf_ba] And [sumofnh_BA]>[sumofwc_ba],2
FSF Habitat	3	Oak-Pine	3	IIf([sumofop_BA]>[sumofnh_ba] And [sumofop_BA]>[sumofasp_bir_ba] And [sumofop_BA]>[sumofeh_ba] And [sumofop_BA]>[sumofsf_ba] And [sumofop_BA]>[sumofwc_ba],3
FSF Habitat	3	Hemlock	4	IIf([sumofeh_BA]>[sumofnh_ba] And [sumofeh_BA]>[sumofop_ba] And [sumofeh_BA]>[sumofasp_bir_ba] And [sumofeh_BA]>[sumofsf_ba] And [sumofeh_BA]>[sumofwc_ba],4
FSF Habitat	3	Spruce-Fir	5	IIf([sumofsf_BA]>[sumofnh_ba] And [sumofsf_BA]>[sumofop_ba] And [sumofsf_BA]>[sumofeh_ba] And [sumofsf_BA]>[sumofasp_bir_ba] And [sumofsf_BA]>[sumofwc_ba],5
FSF Habitat	3	N. W. Cedar	6	IIf([sumofwc_BA]>[sumofnh_ba] And [sumofwc_BA]>[sumofop_ba] And [sumofwc_BA]>[sumofeh_ba] And [sumofwc_BA]>[sumofasp_bir_ba] And [sumofwc_BA]>[sumofsf_ba],6
FSF Habitat	3	Riparian	7	NA
FSF Habitat	3	Vernal Pool	8	NA
FSF Habitat	3	Forested Wetland	9	NA
*FSF Habitat 2	3a	Non-Pine softwoods	11	IIf([FSF_Hab]=4 Or [FSF_Hab]=5 Or [FSF_Hab]=6,"SW"
*FSF Habitat 2	3a	Non-Oak hardwoods	12	IIf([FSF_Hab]=1 Or [FSF_Hab]=2,"HW"
Canopy Cover	4	Closed	c	IIf([cc]>70,"c"
Canopy Cover	4	Medium	m	IIf([cc]>40,"m"
Canopy Cover	4	Open	o	otherwise "o"

Strata_Name	Strata ID	Name	Code	Iff Statement Sequence	Comment
Site Class	1	High	1	1	
Site Class	1	Med	2	3	
Site Class	1	Low	3	2	
Development Class 2	2	Seed	A	2	
Development Class 2	2	Sapling	B	1	
Development Class 2	2	Intermediate	C	11	(catch all class)
Development Class 2	2	Large	D	7	
Development Class 2	2	Large	D	8	
Development Class 2	2	Large	D	9	
Development Class 2	2	Large	D	10	
Development Class 2	2	Very Large	E	3	
Development Class 2	2	Very Large	E	4	
Development Class 2	2	Very Large	E	5	
Development Class 2	2	Very Large	E	6	
FSF Habitat	3	Aspen Birch	1	1	*Red Maple is not included in any of these classes
FSF Habitat	3	N. Hardwoods	2	2	
FSF Habitat	3	Oak-Pine	3	3	
FSF Habitat	3	Hemlock	4	4	
FSF Habitat	3	Spruce-Fir	5	5	
FSF Habitat	3	N. W. Cedar	6	6	
FSF Habitat	3	Riparian	7	NA	
FSF Habitat	3	Vernal Pool	8	NA	
FSF Habitat	3	Forested Wetland	9	NA	
*FSF Habitat 2	3a	Non-Pine softwoods	11	NA	
*FSF Habitat 2	3a	Non-Oak hardwoods	12	NA	
Canopy Cover	4	Closed	c	1	WHERE: carea: Sum((3.14159265359*([mcw]/2)^2)*[Tpa]) and cc: 100*(1-Exp(-0.01*(100*(crwncov_A.carea/43560))))
Canopy Cover	4	Medium	m	2	WHERE: carea: Sum((3.14159265359*([mcw]/2)^2)*[Tpa]) and cc: 100*(1-Exp(-0.01*(100*(crwncov_A.carea/43560))))
Canopy Cover	4	Open	o	3	WHERE: carea: Sum((3.14159265359*([mcw]/2)^2)*[Tpa]) and cc: 100*(1-Exp(-0.01*(100*(crwncov_A.carea/43560))))

Appendix H: FVS Species Codes- Northeast Variant

AB American beech
AC American chestnut
AE American elm
AH American hornbeam
AI Ailanthus
AP Apple species
AS Ash species
AW Atlantic white-cedar
BA Black ash
BB Birch species
BC Black cherry
BE Boxelder
BF Balsam fir
BG Blackgum/black tupelo
BH Bitternut hickory
BI Black hickory
BJ Blackjack oak
BK Black locust
BL Black willow
BM Black maple
BN Butternut
BO Black oak
BP Balsam poplar
BR Bur oak
BS Black spruce
BT Bigtooth aspen
BU Buckeye/horsechestnut
BW American basswood / basswood species
BY Baldcypress
CA Catalpa
CB Cherrybark oak
CC Chokecherry
CH Commercial hardwoods
CK Chinkapin oak
CO Chestnut oak
CT Cucumbertree
CW Cottonwood species
DM Diamond willow
DO Delta post oak
DW Flowering dogwood
EC Eastern cottonwood
EH Eastern hemlock
EL Elm species
FM Florida maple
FR Fir species
GA Green ash
GB Gray birch
HA Silverbell
HB Hackberry species
HH Eastern hophornbeam
HI Hickory species
HK Hackberry
HL Honeylocust
HM Hemlock species
HS Select hickory
HT Hawthorn species
HY American holly
JP Jack pine
JU Juniper/Redcedar species
KC Kentucky coffeetree
LB Loblolly-bay
LK Laurel oak
LL Longleaf pine
LO Live oak
LP Loblolly pine
MA American mountain-ash
MB Mulberry species
MG Magnolia species
MH Mockernut hickory
ML Bigleaf magnolia
MM Mountain maple
MS Southern magnolia
MV Sweetbay
NC Non-commercial hardwoods
NK Nuttall oak
NP Northern pin oak
NS Norway spruce
OB Ohio buckeye
OC Other cedar species
OH Other hardwoods
OK Other oak species
OL Other lowland species
OO Osage-orange
OP Other pine species
OS Other softwoods
OT Other species
OV Overcup oak
PA Pumpkin ash
PB Paper birch
PC Pondcypress
PD Pond pine

PE Pecan
PH Pignut hickory
PI Spruce species
PL Plum, cherry species
PN Pin oak
PO Post oak
PP Pitch pine
PR Pin cherry
PS Common persimmon
PU Sand pine
PW Paulownia
PY Swamp cottonwood
QA Quaking aspen
QI Shingle oak
QS Shumard oak
RA Redbay
RB River birch
RC Eastern redcedar
RD Eastern redbud
RE Rock elm
RL Slippery elm
RM Red maple
RN Red pine (natural)
RO Northern red oak
RP Red pine (plantation)
RS Red spruce
SA Slash pine
SB Sweet birch
SC Scotch pine
SD Sourwood
SE Serviceberry
SG Sugarberry
SH Shagbark hickory
SI Siberian elm
SK Southern red oak
SL Shellbark hickory
SM Sugar maple
SN Swamp chestnut oak
SO Scarlet oak
SP Shortleaf pine
SR Spruce pine
SS Sassafras
ST Striped maple
SU Sweetgum
SV Silver maple
SW Swamp white oak
SY Sycamore
TA Tamarack
TL Tupelo species
TM Table mountain pine
TO Turkey oak
TS Swamp tupelo
UA Blue ash
UH Other upland hardwoods
VP Virginia pine
WA White ash
WB White basswood
WC Northern white-cedar
WE Winged elm
WH Water hickory
WI Willow species
WK Water oak
WL Willow oak
WN Black walnut
WO White oak
WP Eastern white pine
WR Water birch
WS White spruce
WT Water tupelo
YB Yellow birch
YP Yellow-poplar
YY Yellow buckthorn

Continued next

Appendix I: Draft Planning Document (Objectives & Criteria)

Demeritt Forest & University Forest
Management Planning Process Outline

Document created By Rick Morrill (RM) on 8sep09.
Document modified: RM on 15sep09; 29sep09, RM on 25Mar2010, RM on 7Apr2010

1. Determine/define **management objectives**. (Broad and general desired condition of forest resource)
   a. Assess the objectives outlined in existing Demeritt Forest management planning documents and records.
   b. Consider the potential objectives of forest user groups (broader community) (forestry faculty, campus recreation, researchers, teaching faculty utilizing the forest, local public officials, and campus organizations.)

2. Define data requirements and principle management questions as part of **upfront Analysis.** (Serves as a "check list" for necessary actions to be taken in the initial stages of planning.)

3. Define **criteria** with which to **measure achievement of objectives**. (Specific action or attribute that can be **measured** or assessed to determine **achievement** of Objective)

   Two Types of Criteria
   a. Criteria measurable in both **current field inventory** as well as **modeling outputs.** (Constitutes the bench marks by which modeled scenarios are evaluated and compared, generally quantitative in nature.)
   b. Criteria to be part of **adaptive management approach.** The elements of this criteria should be monitored closely over the life of the 2009/10 Plan**.** The results of assessments should be integrated into constant updates to the planning document. (Highlights the criteria to be evaluated in the future to assess success of management actions)

4. Conduct **assessment** of **current** resource conditions. (INV, GIS, MNAP/IF&W/Archeological, recreational)

5. Develop **different** management **scenarios** using G&Y models and optimization software.
   a. Initial LMS (**fine** scale approach) assessment of management scenario options.
   b. **Woodstock** (**coarse** scale approach) **optimizing** for different values.
   c. **LMS** (**fine** scale approach) **validation** of Woodstock optimal outputs.

6. **Evaluate** scenario results based on **management objective criteria**.

7. Select scenario that best satisfies management objectives.
8. Develop a written document reflecting both planning process and scenario selection.
9. Submit draft of written plan to key user groups for review.
10. Utilize adaptive management approach to integrate future outcomes into planning update process.

Mission Statement

THE DEMERITT FOREST AND ADJACENT UNIVERSITY FORESTS WOODLANDS SHALL BE MANAGED WITH PRIMARY EMPHASIS ON ITS EDUCATIONAL, RESEARCH, DEMONSTRATION, AND RECREATIONAL VALUE TO FIRST, THE SCHOOL; SECOND, THE COLLEGE; THIRD, THE UNIVERSITY; AND FOURTH, THE PUBLIC. THE FORESTS SHALL ALSO PROVIDE INCOME FROM THE SALE OF THE FOREST PRODUCTS TO HELP SUPPORT THE PROGRAM AND FACILITIES; AND TO MAINTAIN THE REALISM OF THE FOREST MANAGEMENT DEMONSTRATIONS; AND TO PROVIDE FINANCIAL ASSISTANCE AND EXPERIENCE FOR STUDENTS THROUGH EMPLOYMENT. *(Language adapted from document entitled, "Management Policy, Objectives and Practices on the University Forests." March 15th, 1987. Page 1)*

Suggested Objectives and Criteria

Management Objectives Categories

1. **Education & Research**
2. **Sustainable Timber Supply**
3. **Income Generation**
4. **Biodiversity, Habitat, & Areas of Special Concern**
5. **Recreation & Aesthetics**
6. **Forest Health & Protection**
7. **Water & Soil Quality**
8. **Non-Timber Products**
9. **Historic and Cultural Resources**

Upfront Analysis Information Needs

→ Assessment of current forest attributes including: species composition, diameter range, structure, age, and site capability is conducted
→ Assessment of current timber volumes across species and size classes is conducted
→The current use of the forest, of all types, by all user groups, is considered as part of planning process
→Plans exist for road maintenance and construction of additional roads that provide access for education, research, and demonstration activities
→The current and future income requirements of the University Forests office are estimated
→Unique areas are identified and mapped as part of planning process and integrated into spatially models
→Recommended management practices for unique areas are incorporated in planning and modeling actions

→Identify important historic and/or cultural resource areas to be incorporated into planning and modeling
→Trails and other high recreational use areas are identify and incorporated into modeling actions
→The current presence and/or extent of potentially harmful species is documented
→The current susceptibility of the forest to disturbance events is evaluated
→The current condition of the forest property boundaries is evaluated
→Areas with special and/or significant influence on water quality are identified
→Areas with significant influence on water quality are identified
→Appropriate harvest seasons for polygons are identified
→Recommended best management practices (BMPs) are identified
→Current conditions of sugarbush stands are inventoried

Objectives and Inventory/Modeling Criteria

O1C1 = Objective 1, Criteria 1

1. Education & Research

Objective: Provide diverse and continuous opportunities for education, research, and demonstration

Criteria Measurable (Inventory/Model):

O1C1→Diversity of stand compositions and structures: 24 categories (a. X b. X c.) ≥1% in each category in all planning periods.
a. Vertical Strata (S,MS) (single, multi-strata)
b. Size (S,M,L,XL) (small, medium, large, and extra large)
c. Type (H,OP,S) (other hardwood, oak-pine, other softwood)

O1C2→Silvicultural Treatments: ≥10ac per planning period (exception planting ≥2ac).
a. Intermediate (thinning)
b. Clearcut
c. Shelterwood Establishment
d. OSR (overstory removal)
e. Multi-Age System (SingleTreeSel, GroupSel, IrregularGroupShelterwood)

O1C3→Control/Reserve: ≥ 10% of the total forest area (75ft SLZ buffer zones may not be included in this total acreage) in each planning period.

2. Forest Structure & Forest Species Composition **(see objective and criteria for Objective 1.)**

3. Sustainable Timber Supply

Objective: Manage for a sustainable supply of high quality timber over the long term* (*Defined generally as the length of a normal rotation period). *(These criteria **apply only** to the **stands under management** (Mgt. Stands) of the University Forests. Stands designated for research purposes are not to be incorporated into harvest scheduling or harvest volume planning assessment.)*

Criteria Measurable (Inventory/Model):

O3C1→Harvest Volumes: Harvest removals in any one planning period are within 20% of the average for the entire projection period.
O3C2→Standing Volumes: The standing volume of large diameter WP (WP>12inDBH) is within +or- 20% of the current percentage that WP represents of the forest.
O3C3→Diversity of size/age classes: ≥15% of area in each of 4 categories, in all planning periods.
a. Size (S, M, L, and XL) (small, medium, large, and extra large).

4. Income Generation

Objective: Provide income to support management activities of the University Forests.

Criteria Measurable (Inventory/Model):
O4C1→Income from forest management activities ranges from $325,000 to $385,000 (2009 Dollars) in each 5 year planning period.

5. Biodiversity, Habitat, & Areas of Special Concern

Objective: At the landscape level, consider biodiversity enhancement during planning activities and protect critical habitats and unique areas.

Criteria Measurable (Inventory/Model):
O5C1→Harvests are excluded from SLZ 75 buffers, Vernal Pool 100ft zones, Reserves/Controls, and other harvest exclusion polygons (TBA).
O5C2→Harvests are reduced in SLZ 250ft polys and in polys designated as unique areas subject to harvest reductions.
O5C3→Reserve/Scientific Control areas are excluded from harvest (see criteria in #1).

6. Recreation & Aesthetics

Objective: Accommodate safe, sustainable, diverse, and attractive recreational experiences.

Criteria Measurable (Inventory/Model):
O6C1→Restrict harvest in areas identified as having high recreational (HR) value to ≤75ac per planning period
O6C2→Restrict treatments in stand polygons identified as having high recreational (HR) value to:
a. Intermediate (thinning)
b. Shelterwood establishment.
c. Multi-Age System (SingleTreeSel, GroupSel, IrregularGroupShelterwood)
d. Plant
e. PCT

7. Forest Health & Protection

Objective: The forest resource will be protected from native/non-native diseases and pests (including white tailed deer), invasive vegetation, wildfire, and unlawful trespass

Criteria Measurable (Inventory/Model):

O7C1→Susceptibility Indexes: ≤20% of forest receives hazard rating of "high"/"Severe"

a. Wind
b. Hemlock Wooly Adelgid
c. Spruce Budworm

8. Water & Soil Quality

Objective: Waterbodies are protected from potential pollution sources and soil productivity is preserved and/or enhanced through management actions

Criteria Measurable (Inventory/Model):

O8C1→Harvests are excluded from SLZ 75 buffers

O8C2→Harvests are reduced in SLZ 250ft buffers as well as other polygons with important water or soil quality value

9. Non-Timber Products

Objective: Non-timber resources are appropriately cultured

Criteria Measurable (Inventory/Model):

O9C1→Restrict treatments in Sugarbush polygons to:

a. Intermediate (thinning)
b. Plant

10. Historic and Cultural Resources

Objective: Resources of historic and/or cultural value are appropriately identified and managed

Criteria Measurable (Inventory/Model):

O10C1→Harvests are excluded from designated harvest exclusion polygons (TBA)

O10C2→Harvests are reduced in designated polygons (TBA)

Adaptive Management Criteria: **These criteria will be updated as the planning process unfolds

→Evaluate model results against updated field inventory data

→Use for education, research, and demonstration activities increases or is consistent through time

→Evaluate model results against updated inventory data

→Forest land base remains consistent through time

→Evaluate income projections against actually income generation

→Monitor forest biodiversity indicators

→Evaluate influences of management actions on critical habitats and unique areas

→Monitor user reactions to management actions

→Monitor presence and/or spread of potentially harmful species

→Property boundaries are consistently and properly maintained

→Water quality BMPs are consistently and properly implemented
→Monitor health and productivity of non-timber resources
→Monitor site conditions of historic and/or cultural resources map additional sites as needed

Example of objectives, criteria, and evaluation of scenario results

Education & Research
Objective: Provide diverse and continuous opportunities for education, research, and demonstration

Criteria Measurable (Upfront Analysis):
→ Assessment of current forest attributes including: species composition, diameter range, structure, age, and site capability is conducted

Criteria Measurable (Inventory or Model):
→≥20% of the forest in each of 3 Size classes (S,M,L) (small, medium, large)

Criteria Adaptive:
→Evaluate model results against updated inventory data

Score card

Age Class	Scenario 1	Scenario 2	Scenario 3
Small	Y	Y	N
Medium	Y	Y	Y
Large	N	Y	Y
SCORE	2	3	2

Measurement Criteria
≥20% of the forest in each of 3 Size classes (S,M,L) (small, medium, large)

Appendix J: Inventory Protocols

2006 D.B. Demeritt Ten Year Inventory Cruise

The D.B.D. Inventory Cruise should take place every ten years. The following discusses the equipment needed for the cruise as well as the methods that were used in the 2006 cruise.

Equipment Needed

PPE: Hard hat and safety glasses
Diameter calipers: up to 36"
Logger's tape: Feet in tenths on one side and diameter on the other
Compass with properly set declination
20 BAF Prism
Hip Chain (to calibrate pace)
Haglof Vertex III or similar device to measure tree heights
Clinometer (backup for Haglof)
GPS (non survey grade)
Chalk, Paintstick, or lumber crayons
Bug nets
Flagging (to mark plot center)
DBH stick (cut to 4.5', used to accurately measure DBH)
Data Sheets
Pencils
Sharpie

INVENTORY METHODS:

1) Navigate via compass, GPS, and hip chain (pacing once your pace is accurate) to each point. Upon arriving at the point conduct the following steps.
2) Mark the point center (w. trekking pole, stick, or stake)
3) Flag the location of point center
4) Determine which direction is North
5) Enter a waypoint with the GPS
6) Starting from North and working clockwise, determine which trees are to be measured (Use a 20 BAF prism)
7) Mark the first tree with paintstick, chalk, or lumber crayon (to ensure no trees are missed/repeated)
8) Record Species (use the attached species list and corresponding code)
9) Record DBH (measure with calipers with the points facing away/facing toward plot center (rays)
10) Record Crown Class (use the attached code list)
11) Record Height to base of crown
12) Record Total height

13) Record Quality-only for the first 16’ of white pine trees! (use the attached code list)
14) Record Notes-include anything that you think may be important to note
15) Conduct Sapling Tally (SEE SECTION BELOW FOR SPECIFICS)
16) Determine Stand Type (SEE SECTION BELOW FOR SPECIFICS)

Determining an “in” tree

Holding the 20 BAF prism over plot center, look at the tree (at DBH) to determine if it should be measured. There are three possibilities: a countable tree, a not countable tree, or a borderline tree. A countable tree will have overlap of the tree in the prism, while a non-countable tree will not have overlap. A borderline tree appears to have the right edge of the tree in the prism parallel with the left edge of the tree. (See sketches below for a better representation.) For the marginal trees, measure the distance from the plot center to the face of the tree and use the corresponding limiting distance to determine if the tree should be counted. If the tree falls within the limiting distance, then it shall be measured. All trees larger than 4.6” DBH must be tallied. Dead trees (snags) shall be tallied if they are greater than 12” at DBH, and 20’ tall.

More information about the Inventory Sheet:

Tree ID: This is a number that is given for each tree starting at 1 (one) and continuing sequentially until all trees counted are assigned a number. At each point, the first tree is labeled as one (01).

Species: This is the species of tree which is tallied. Abbreviations are listed in Appendix A.

Crown Class: This is the crown class for each tree tallied. Abbreviations are noted below. D=Dominant
C=Codominant
I=Intermediate
O=Overtopped
- Dominant trees have crowns that extend above the general level of the main canopy (or in uneven-aged stands, above the crowns of the adjacent trees and receiving full sunlight from above and partial light from the sides).
- Codominant trees have crowns that form the general level of the main canopy (or in uneven-aged stands, receive full sunlight from above and little side light).
- Intermediate trees have crowns that extend into the lower level of the main canopy (or in uneven-aged stands, receiving little direct light from above and none from the sides).
- Overtopped trees have crowns that are below the level of the main canopy.
- Emergent trees are those that have crowns completely above the level of the main canopy and receive full sunlight from above and the sides. This should be noted in the Notes Column.

Diameter: This is the diameter at breast height (4.5') of each tree tallied. DBH shall be measured with English calipers with the two caliper points radiating from plot center. All measured DBH's should be reported to the tenth of an inch. DBH shall be measured on the uphill side of the tree. If there is a deformity at DBH, then the diameter measurement should be made above the deformity and noted in the notes column. If there is a branch at DBH, the measurement should be made above the branch and noted in the notes column. If the tree has a double trunk at stump level, each tree should be measured individually and noted in the notes column. (ADDITIONAL INFORMATION CAN BE FOUND FROM THE FS TIMBER CRUISING HANDBOOK.)

Height to crown base: This is the measured height of the lowest live branch whorl with live limbs on at least two sides of the tree. The live limbs must not be epicormic branches and they must be continuous with the main crown. Measurement should be taken with Haglof.

Total height: This is the measured height of the total tree height. Record in feet using the Haglof. *Note: If the top of the tree is dead, first take the height to the highest whorl of live branches and then the top height. This is done to ensure that the proper LCR is computed.

LCR: "Live Crown Ratio". This is determined by subtracting the Height to crown base from the total height, and then dividing by the total height. This can be calculated during rests, lunch, or in the office.

Quality: This refers only to the butt log (16') of White pine trees or the trees that are Cull or snags. The following notation shall be used.

Cu=Cull (50% is unmerchantable)
Sn=Snag (standing dead)
P=Possibly Pruned
1=Tree Grade #1
O=Other (Tree Grades #2, #3, #4)

*Note: Multiple codes can be used for one tree (an example would be a pine that was pruned but does not have a tree grade of 1 would be coded as PO).
See Appendix B for the full specifications

Notes: Any additional information can be noted here (i.e. if tree height is estimated put "H-Est").

SAPLING TALLY METHODS:

Upon completion of the prism tally, a sapling tally should commence. A 1/100th acre (Radius=11.778') shall be done on plot center. Measure 11.778' (or 11.8') out from the plot center, starting from the north. Using a dot tally, count the number of saplings in, noting the species, diameter and estimated height. Heights should use the following height classes (4.5' to 9.9'; 10' to 14.9'; 15' to 19.9'; 20'+) and DBH should be 0.6" to 1.0"; 1.1" to 2.0"; 2.1" to 3.0"; 3.1" to 4.6" classes.

FTY 476 Fall 2009 Planning Inventory for Demeritt Forest Compartment K
INV_Project_ID = 9
Inventory Protocol Created 24sep09 by Rick Morrill (RM)
Updated on: 29sep09 RM

Point Center Location:
All point centers have been established in GIS and uploaded to Garmin GPS units. Centers are to be located using the GPS unit. This should be done in an "unbiased way" by keeping one's head down while following the GPS azimuth directions until the unit displays 2 meters or less as the distance from the target waypoint. NOTE: true point center locations in the field DO NOT need to be GPS recorded. The point center should be marked with the Haglof transponder pole at the point center. The center should also be flagged as close to the center as possible with the Sample_ID and the Stand_ID recorded on the flag. ***All plot locations have been recorded using UTM coordinates in meters for UTM Zone 19N with reference to the North American Datum for 1983 (NAD83).

The point centers have been distributed on a **stand by stand basis** in each stand polygon with ArcGIS using a random point distribution tool (Hawths Tools). Thus each point is tied to a specific stand and thus measurements taken on that point should be of the desired stand. In the event that a point center falls **outside** the specified stand that point center should be moved **20 feet** into the stand from the **nearest** edge of that stand. For plots located along the edge of a stand, the "**walk through method**" should be used to "double count" those trees that qualify under the correction method (SEE the attached PPT slides from A.W. FTY266). In the case of a **"hard"** edge (ex. plantation vs. natural forest or a boundary line) the edge of the stand will be clear and the correction can be properly applied. For stand boundaries that are **"soft"** (ex. Mixed-wood trending to higher % softwood) making a boundary determination, for the purpose of using the walk through method, is not necessary. In this case the edge of the stand is not significantly different enough to warrant precise delineation and therefore correcting for edge bias has been deemed unnecessary.

For plots located outside Forest boundary, in an area of open water, or a location otherwise deemed totally unsuitable (a point center landing in a harvesting trail **shall NOT be re-located**), a new plot center and a new waypoint will have to be created and recorded with a minimum of 100 averaged readings. The new waypoint X and Y coordinates should be recorded in the comment field for the point, (Using NAD 83 UTM 19 coords) to update current maps.

Sample Structure:

Type/Size:	Overstory:	BAF 20 Variable Radius Point Sample BAF 75 Height and softwood species Age sampling only (point)
	Sapling:	1/100 acre fixed radius circular plot, 11.8' radius. To be nested on the same plot center.

Seedling: 1/1000 acre fixed radius circular plot, 3.724' radius. To be nested on the same plot center.

Key Tasks to Complete:

1. **Each PDA records and or tally sheet *must have the Sample ID recorded on it!* Without this information the data collected is TOTALLY USELESS! …(And you will be fired!!)**
2. **The Haglof must be calibrated at the start of each day and potentially in the midday as the air temperature changes. Calibrate at 10 meters (32.8 feet, 32feet and 9.5 inches)**
3. **Limiting distances for all borderline trees <u>must be checked</u>! This is done using the Haglof with the BAF preset to 20 so it calculates the Minimum DBH the tree. There is no excuse for not doing this as this technology makes it way to easy! Bad data is actually worse than no data at all! If the units fail to function the limiting distance can be read off the cheat sheet on the clip boards or calculated using the formula DBH X PRF of 1.944= limiting distance.**
4. **A plot with no vegetation to be tallied must be given a record and a <u>species code of No Tally</u>**

Overstory Point Sample Data:

<u>Trees: BAF 20 Tally</u>

Information will be taken of all live trees 3.6 inches DBH and greater. Trees should be recorded beginning with the 1st tree due north of the point center and proceeding in a clockwise direction. The following information will be recorded for each live "IN" tree -

- Point Center ID
- Tree Number (i,e: 1,2,3….)
- Species, (FVS code list see clip board.)
- DBH, to the nearest 1 inch class, (rounding down for trees at DBH class midpoint ie. 5.5" = 5", 5.6" = 6") To be recorded with DBH Tape.
- Quality: **AGS** = acceptable growing stock (tree must be have be capable of producing a sawlog product) *Note this is not a measure of whether the tree should be harvested based on a silvicultural objective, rather it is just a classification of the trees product quality. **UGS** = unacceptable growing stock (Tree does not meet the qualifications of an AGS tree but it is still alive. **Snag** = Any dead but standing tree, can be given a species if known.

BAF 75 Tally: Trees that are "in" with the 20BAF as well as a 75BAF will have the total height as well as height to crown base recorded.

- Total Height **(TH)** (ground to tip), heights will be taken.
- Height to Crown base **(HCB)** ("average" of the lowest live crown, not the lowest live branch, but the cruisers estimation of the average crown base.)

Dead Trees: Dead trees "SNAGS" **will be** recorded as part of this inventory. (see section on quality above)

Tree Age and Growth Data:
Softwood species in the overstory point tally, on which height data is recorded (those in with the BAF 75), shall be cored **to the tree center** with an increment borer. **********<u>**SOFTWOOD SPECIES ONLY*********</u>** Core location shall be taken as low on the trunk as possible **(<u>NOT</u> AT DBH).** A separate data entry form is provided for associated data. Even though much of the data for age trees will already be recorded in the PDA it strongly recommended that the data be duplicated (on the paper tally) for age trees to ensure the extra work of taking a tree core is not wasted due to lost data. **It is critical to note if the tree has been free to grow over its entire life and therefore a good indicator of site index. If the tree shows signs of suppression, (ex. Cluster of branches midway up stem) then record "NO" for the column "Free to grow for life span". Please glue the tree core into the core board and label the space above the core with: the Sample_ID and the Tree No. This will insure that you can match the core up with the tree's other attributes, recorded on the paper form.**

Sapling Plot:
The sapling plot will be located at the same plot center as the tree plot. The DBH and species of all live trees >0.6 inch and $\leq$ 3.5" will be recorded starting from north and continuing clockwise. Plot radius can be established using the Haglof hypsometer or it can be measured with a 100' tape or with a pre-measured plot cable (RED colored cables are 1/100ac).
The following information will be recorded for each live tree within the plot boundary using a dot tally method

- Species, (FVS code list see clip board.)
- DBH using the tree forks of all live trees >0.6" and $\leq$ 3.5" inches.
- Total tree heights shall be recorded for 1 tree in each size of the 3 classes for each species present on the plot. (See tally sheet for proper recording method.) Note taker will determine which tree to provide heights for without looking at the trees to be tallied. Heights should be recorded on only those trees that fall within the plot boundary.

Seedling Plot:
Fixed radius seedling plots will also be measured. All plots will be 1/1000ac plots or 3.724 ft radius. Seedlings will be placed in 1 of 5 height classes. **Class descriptions** 1ft= >0.5ft---≤1.5ft tall; 2ft = >1.5ft---≤2.5ft … 5ft = > . Heights should be determined using the of DBH/height stick which has the classes clearly marked on making the tally very easy . If the seedling has a DBH in the 1 inch class it should be in the sapling tally. All seedlings ≤ 0.5" shall not be tallied, (Do not tally the millions of pine seedlings less than 6 inches tall that are out there right now!)

USING the Trimble Recon and the Sprint DBpro Database Form.
A simple data entry form has been developed by Aaron Wieskettal and Rick Morrill for use on the Trimble Recon PDA's. It is a database based form and all the data recorded is automatically saved to a MS Access ready set of tables. Important** The data entered is automatically saved so don't look for a save button. The unit has a back up battery so even if the main battery dies the data will not be lost. When moving between points the

screen can be turned off to prevent accidental entries. This is done by hitting the round button in the lower right **just once**.

*****DO NOT HOLD IT DOWN TO RESET THE UNIT as this may result in LOST DATA.**

User Instructions:

1. Open the Sprint DB program on PDA. (start menu dropdown)
2. Choose File > open >select the Form named **UF_INV_S** in My Documents on the PDA.
3. The Form will automatically open and default to the sample table. (tabs at top)
4. All the tabs include one record to start out with, this is necessary for the form to work correctly and allow new records to be added. (a funny quirk of the program)
5. When a new sample, tree or sap, is to be recorded **first hit the ADD button at the top** which adds a new record, to the current tab, and is ready for data entry. *Note the existing record is tagged as a test record and can be **ignored**, it will be deleted from the resulting tree list back in the office.
6. The triangular button on the bottom right of the PDA screen brings up the keyboard.
7. When starting a new sample point choose the sample tab and enter the appropriate data.
8. Both the Tree, Sap, And Seed tabs include a dropdown menu for the sample ID that will include only those sample ID values that have been entered in the Sample tab. (In order for the drop down to be populated with the most recent entry you must close the form and then re-open it, after which the drop down will show the new sample_ID value.)
9. If a Tree needs to be double counted using the walk through method, the copy (COP) button at the top should be used to copy the selected tree record. This will result in the tree appearing twice in tree list.
10. The sapling tab has buttons that allow you to add individual trees to a record in 1 of three DBH classes. This is meant to replace a Dot tally method**. **Note**: there is no delete button, so if you add a sapling in error to one of the classes you have **two** options. Delete the entire record and re-enter the correct values (make sure to note the numbers of trees in each of the three DBH classes before deleting the record. OR instead add a new record to the list and re-enter the initial information for the incorrect record but select the "minusDBH" line in the Quality drop down menu and then enter the number of trees to delete in each of the DBH classes as appropriate.
11. The seedling tab is similar to the sapling tab in the way seedlings are added. A mistake in recording will be corrected using one of the two methods described in #10.
12. Dates are automatically added to each record.

Equipment list:

1. Tally Sheets

1. Trimble Recon PDA with blank data form loaded (PROVIDED)
2. Backup paper tally sheets

3. Garmin 60 or 76 GPS with spare batteries
4. Clipboards with pencils: pocket knife or pencil sharpener
5. Suunto compass or mirror type sighting compass set for magnetic azimuths
6. 1 Haglof Vertex 4 Hypsometers for tree height and distance: spare batteries (PROVIDED)
7. 1 Haglof Transponder (PROVIDED)
8. 1 Haglof plot center pole and 360 degree mount (PROVIDED)
9. 2 D-tapes
10. 100' Loggers or fiberglass tape or radius cable for sapling plot, as back up for Haglof on sapling plot
11. 1 Diameter Fork (PROVIDED)
12. 1 tree marking crayon
13. DBH/ Seed height stick to ensure correct measurement of DBH, and seedling height class (PROVIDED)
14. Increment Borer (NOT PROVIDED) and Core Board (PROVIDED)
15. Flagging tape (PROVIDED) and sharpie to mark point centers.

Author's Biography

Cassie Vaillancourt was born on December 14, 1987 and grew up in Fort Kent, Maine. She graduated from Fort Kent Community High School in June of 2006. Cassie's love and passion for the outdoors led her to earn a B.S in Forestry from the University of Maine, where she graduated in May of 2010. During her undergraduate career, Cassie was an active member of the Society of American Foresters, the National Society of Collegiate Scholars, Xi Sigma Pi Forestry Honor Society, and All Maine Women. She will be continuing her education at The University of Maine in the fall of 2010 where she will work towards earning her Masters of Business Administration (MBA). Once she is finished school, Cassie plans to work for a private land management company as a field forester, earn her forestry license, and hopefully one day earn a management position within a forest management company.