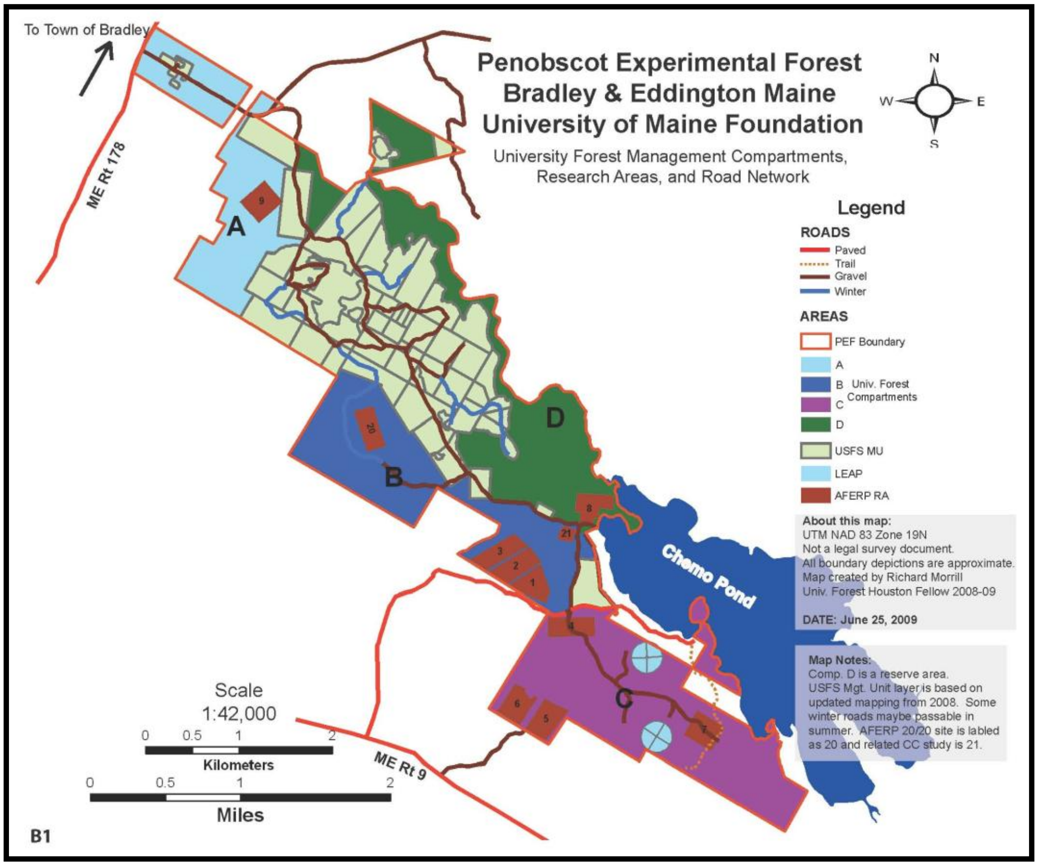
Penobscot Experimental Forest

Forest Management Plan

University of Maine Foundation Ownership

University Forests Management Area



October 23, 2009

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Foreword & Acknowledgments

This written plan represents the culmination of many months of labor both in the field and the office. The document has been formatted for "hardcopy printing" but the authors feel that it will prove most useful in electronic form, so the reader can take full advantage of built in links to supporting documents, websites, and maps. Hyperlinks embedded throughout the text allow one to, with just a button click, "flip" to supporting material and then back to the plan, creating a reading experience akin to having all the appendix information neatly organized on a giant desk immediately available to the reader. This plan is also meant, like the forest ecosystems it describes, to be dynamic and constantly developing with advances in scientific knowledge, management understanding, and forest change. While the next official update to the plan will come in 2019, this electronic format will enable intermediate updates and revisions, thus elevating the document to a working manual for the management of the PEF that will be consulted routinely.

This management plan is the result of contributions from a diverse group of faculty, staff, and students from within the School of Forest Resources (SFR) as well as professionals from outside the halls of Nutting. The Research Operations Team (ROT) members: John Brissette(USFS), Laura Kenefic(USFS), Robert Seymour(SFR), and Jeremy Wilson(SFR) reviewed drafts of this document, and contributed significant direction to the planning process. Jeremy Wilson and Robert Seymour deserve special recognition for their key contributions to the development of management simulations and analysis using modern techniques and technology. Spencer Meyer assisted in building essential database tools and Aaron Weiskittel gave generously of his time and technical expertise in multiple aspects of biometry and modeling. M.S. student Elizabeth Bryce edited multiple sections on invasive vegetation based on her related research in the USFS portion of the PEF. Numerous student workers, too many to list here, assisted in the collection of field data, which made the planning process possible. Several professional foresters provided valuable ideas and feed back relating to FSC principles and forest classification systems, including Robert Byran of Harpswell, Maine and Ross Morgan of Craftsbury, Vermont.

We would like to acknowledge the University of Maine Foundation for accepting ownership of the PEF in 1995 on behalf of the University of Maine, for creating and managing the stumpage account, the research account, and the PEF Endowment. The Foundation, through the Green Endowment Program, was instrumental in securing both the Houston Forest Management Fund that helps support undergraduate interns working on the PEF and the George L. Houston Scholarship Fund that supported Richard Morrill, the first Houston Graduate Fellow, as he worked tirelessly to bring this plan to fruition.

Executive Summary

This document is the comprehensive forest management plan for the Penobscot Experimental Forest located in Bradley and Eddington, Maine, owned in fee by the University of Maine Foundation. This plan pertains to the portion of the forest that is managed by the University Forests and does not govern the management of the USFS research area which resides within the overall forest ownership. The area descriptions in section 3 of this document make clear the parts of the forest to which the plan applies. The planning process and final document have been developed to satisfy American Tree Farm System certification criteria as the PEF is certified under the Tree Farm (ATF) system. In addition, the plan has been crafted to parallel regional Forest Stewardship Council (FSC) certification requirements. While the University Forests Office is not currently pursuing FSC certification it has been determined that FSC guidelines will be incorporated into University Forest management planning activities where possible.

The 2009 planning process has been based on the goal of orchestrating management activities at the landscape level. Individual stand prescriptions and harvest schedules result from planning that seeks to balance current and future stand level forest conditions with the "big picture", the conditions across the entire management area. The first section of the document outlines the management objectives and specific criteria against which achievement of the objectives will be measured. The primary objectives include managing for a sustainable supply of forest products, fostering research and educational opportunities, and protecting unique ecological features and managing to conserve and/or enhance forest biodiversity.

Section 2 describes key elements of the property deed and the memoranda (updated in 2007) which govern the forest and originated with the transfer of the property to the University of Maine Foundation. Part 3 provides a detailed analysis of the current forest conditions as they existed in 2008 on the ownership. The forest can be characterized as generally mature, dominated by sawlog sized overstory trees, often with a developed sapling to small pool strata of shade tolerant species. About 2/3 of the forest is classified as mixed-wood with the other third split between hardwood and softwood types. Invasive species, both vegetation and pest/disease are uncommon, however their presence around the forest boundaries and in the region are cause for concern and necessitate vigilant monitoring. Almost 20% of the forest is subject to shoreland zoning regulation. Roughly 10% of the

upland forest has been designated as ecological reserve or research project controls and will not be subject to harvesting. Of the total ownership area just under 50% (roughly 1260ac) is open to management activities directed by the University Forests.

The 2009 management planning process employed the Landscape Management System, a forest modeling software package capable of manipulating multiple stands simultaneously. Current inventory data was used to build a forest "portfolio" comprising over 150 stands. Harvest treatments were designed and implemented in the model and forest conditions were projected 50 years into the future. Out of the modeling process emerged a single management scenario, developed to balance the planning objectives and achieve a robust and practical harvest schedule. Based on the scenario about 25% of the stands will be managed using an uneven-age system with the remaining 3/4 under an even-age system. Analysis of the forest conditions resulting from the management scenario indicate a gradual draw down of standing volume over 50 years in keeping with an intended area regulation approach to managing the resource. Harvest volumes fluctuate over the period, as does the area regenerated.

Stand classifications based on the Maine Audubon Focus Species Forestry manual show an increase in the percent of young forest due to management actions, as well as a slow increase in the area classified as late successional under the 50 year harvest scenario. Habitat types appear to remain constant over the projection period, however the model portrays a gradual disappearance of the Northern White Cedar type, indicating that this forest type must be monitored closely. Section 7 outlines the attention paid to ecologically unique features and the steps being taken to ensure their integrity over time. The most important element in this regard is the accurate and organized mapping of these critical areas and features. A variety of maps depicting unique habitats as well as numerous other forest attributes are included in Appendix B of this plan.

In Summary, analysis of the model outputs describe a sustainable harvest schedule that satisfies multiple management objectives including a sustainable timber supply, maintenance of a variety of forest conditions available to research and educational activities, and attention to principles of biodiversity. This comprehensive forest management plan provides details, analysis, and recommendations pertaining to the management of the Penobscot Experimental Forest. The authors have designed the documents electronic format to function dynamically, enabling the content to serve as a reference materials that managers can turn to for guidance on all aspects of managing the forest resource.

1. Management Objectives

MAINTAIN AND ENHANCE A HEALTHY, PRODUCTIVE FOREST FOR THE LONG TERM UNDER THE CONDITIONS OF THE DEED AND MEMORANDA THAT GOVERN THE FOREST AND ITS MANAGEMENT.

These management objectives inform both a strategic planning process focused on a long term time horizon (0-50yrs) as well as short term tactical planning (0-10yrs). Objectives are broad goals developed to guide the planning process, while criteria are specific measures against which model outputs and future outcomes can be compared.

1.1 Timber Supply

Objectives: As set forth in the deed and Memoranda of Understanding (MOU) to the property, the forest will yield a sustainable supply of timber and associated income to satisfy scholarship, research, and management goals. In addition management actions will achieve reasonable regulation of acreage and volumes harvested over the long term. The forest will be managed for a diversity of structural conditions using a variety of silvicultural systems. A robust timber resource will be protected from diseases, pests, invasive species, wildfire, and unlawful trespass. Appropriate monitoring programs will be maintained and improved to provide essential feed back for management decision making.
Criteria: Modern forest simulation software is used to create multiple management scenarios, the results of which are compared both spatially and temporally. Sustainable harvest estimates, derived from modeling, are integrated into harvest planning in association with practical field-based knowledge. Data from the continuous forest inventory system (CFI) on the PEF is regularly integrated with simulation software to enable localized calibration of model outputs. Additional monitoring in the form of future planning inventories and CFI measurements are compared to model predictions as part of an adaptive management approach.

1.2 Research and Education

Objective: Continue support of current research projects and provide opportunities for new projects in the future. Fulfill obligations, as outlined in the MOU, of annual contributions to research and scholarship funds. Provide venue and support for field demonstration and tours open to students, forestry professionals, and the public.
Criteria: Monitor the number of research cooperators and projects as well as the level of financial support for research and scholarship funds provided by timber harvesting related income. Track the use of the forest by SFR courses and other events.

1.3 Biodiversity/Habitat/Areas of Special Concern

Objective: A diversity of vegetation species, development stages, and structures are present across all management compartments. Diverse and unique habitat types, significant to a broad spectrum of plant and animal species, not just traditional "game" species, are also maintained and enhanced where appropriate. Unique habitats and imperiled species are protected. The preceding qualities and features are protected and/or cultured across all compartments in accordance with a landscape perspective that considers the immediate forest as well as the area beyond the property boundaries. Appropriate monitoring programs are constantly improved.
Criteria: Based on Focus Species Forestry forest development classifications, management will strive to develop and maintain forest areas approximate to the following percentages: 5-

30% regeneration/sapling; ≥20% intermediate; ≥20% mature; ≥15% late successional. An additional goal of maintaining a minimum of 5% of the forest in each of 6 Focus Species Forestry habitat classes: Aspen/Birch; N. Hardwood; Oak/Pine; Hemlock; Spruce/Fir; and N. White Cedar. Simulation software should be utilized to predict and evaluate the implications of management actions on forest biodiversity and habitat. GIS maps are adequately maintained, depicting both areas of interest as well as general forest conditions. Proper State agencies and non-governmental organizations are engaged to evaluate the status of these qualities within the forest.

1.4 Water and Soil Quality

Objective: Water quality, of the highest level, is maintained through appropriately planned and executed road construction, harvest operations, and silvicultural prescriptions. Soil quality is maintained and where possible improved through attention to appropriate silvicultural and operational principles. Under no circumstances should future soil productivity be compromised in the name of short term profit or expedience.
Criteria: All harvest operations follow **State water quality BMPs**. Management planning considers the impact of whole-tree harvesting on soil nutrient cycles.

1.5 Recreation

Objective: Safe recreational experiences are available to a variety of users. A variety of uses are made possible through road and water access routes and points. Where appropriate, the aesthetic implications of management actions such as harvesting are considered. Recreation use does not compromise other landowner objectives.
Criteria: Conflicts with and among users are minimized.

1.6 Historic and Cultural Resources

Objective: These qualities are maintained in the managed forest and especially in the reserve areas. Up to date mapping of, and details about known resources are integrated into the management planning process whenever possible.
Criteria: Work with state agencies and university departments to evaluate status of these features within the property.

2. General Property Administration

2.1 Property History

The history of the PEF before 1950 is not well documented. It is known that by 1859 there were (in Bradley village alone) fourteen single board mills, three mills with gangs of saws, four clapboard mills, four lath machines, and three shingle mills (Town of Bradley History). Only a small portion of the PEF was cleared for agriculture or grazing, and most of the area was cut lightly in the 20 to 40 years before 1950 for pine, hemlock, and spruce sawlogs. Earlier cutting may have been heavier. The presence of charcoal and old burned stumps in some areas, indicate fires following the cutting of pine stands. In 1950, stands on the PEF were 60 to 100 years old with a few older individual trees scattered throughout the area (USFS PEF History).

The Penobscot Experimental Forest was established in 1950 when nine Maine timberland owners (International Paper Company, Great Northern Paper Company, Penobscot Development Company, Eastern Corporation, Oxford Paper Company, Dead River Company, S.D. Warren Company, St. Regis Paper Company, and Hollingsworth and Whitney Company) jointly purchased 3800 acres of forest land in Bradley and Eddington, Maine and then leased it for 99 years to the Northeastern Forest Experiment Station of the USDA Forest Service for long term forest management research in a mixed northern conifer forest.

In 1984, each of the then 12 private firms that owned the PEF (in common, undivided ownership) deeded their respective interest in about 225 acres surrounding the historic Leonard's Mills dam to the Maine Forest & Logging Museum, Inc. All of those deeds reserved rights of way over and across Government Road and what is now known as the IP Road (66 foot ROW).

In 1991, each of the 12 owners deeded their respective interest in the PEF to Penobscot Experimental Forest, Inc. and then in 1994, the PEF was donated by Penobscot Experimental Forest, Inc., to the University of Maine Foundation. Both the deed and a subsequent memorandum of agreement (MOA) contained specific language outlining the mission of the PEF and its governance.

2.2 Deed Conditions

The PEF was donated to the University of Maine Foundation with specific conditions for its use. The property is to be used for "*educational, research and forestry purposes* *connected with the University of Maine at Orono's forestry and natural resources educational institutions."* Other conditions of the deed focus on the use of the property as a research and educational forest that will continue to produce forest products. "*The property shall be managed and operated in a manner which provides for the continued production of trees to be harvested for commercial use."*

The deed also established an annual "**Penobscot Experimental Forest Scholarship"** which included full undergraduate in-state tuition for one year. Income derived from the property is required to first fund the scholarship and then go towards management and maintenance of the property and educational or research purposes.

Thus was set in motion the management and use of the PEF by the University of Maine's College of Natural Sciences, Forestry and Agriculture.

2.3 Original MOA Conditions

Since the USFS held a 99-year lease to conduct research on the PEF, an agreement was executed in August, 1995 between the College of Natural Sciences, Forestry and Agriculture and the Northeastern Forest Experiment Station of the USFS that clarified the roles of both the USFS and NFA. This Memorandum of Agreement (MOA) established a protocol for operation of the PEF.

The MOA identified the primary mission of the PEF *"to provide a location where long-term research, developmental activities and demonstrations of forest ecosystems may be carried out".* It went on to say *"All forestry operations will be planned and executed in such a way that research needs are given priority."* The MOA future defined the role of the PEF to educate students, professionals and the general public was also identified. This MOA was to remain in effect for 50 years, with periodic reviews every five years.

The original MOA gave the USFS "*full administrative control over all PEF areas containing ongoing research or demonstrations installed prior to the date of this memorandum of agreement".* A **Research Operations Team** (ROT) was formed consisting of one representative from NFA appointed by the Dean, one representative from the Maine Agricultural and Forestry Experiment Station (MAES) appointed by the Director, and two representatives from the USFS appointed by the Director of the Northeastern Forest Experiment Station. Chairing of the ROT alternates annually between NFA and USFS personnel. The ROT has authority to set policies for the PEF and works with the Woodlands Manager of the University of Maine to carry out the day-to-day activities on the forest.

The MOA establishes a format by which management planning occurs and is carried out on the PEF. It also further defined roles of both the ROT and Woodlands Manager in that context. The MOA reiterates the deed condition that "*any income derived from the PEF, less reasonable expenses, available after funding the PEF Scholarship shall be available to the PEF Woodlands Manager and the PEF Research Operations Team for maintenance and management of the property and for educational and research purposes outlined in the covenant".*

2.4 Administration and Finance

The PEF is owned by the University of Maine Foundation but is not part of the SFR Green Endowment Program. The administration of the PEF is instead, governed by the 1994 deed from Penobscot Experimental Forest, Inc. to the University of Maine Foundation. The administration is further clarified in the Memorandum of Understanding (MOU) between the Northern Research Station of the USFS and the School of Forest Resources of the University of Maine that was signed in 2007. This MOU is for 5 years and supersedes the original MOA that was signed in 1995. The PEF Woodlands Manager and the Chair of the PEF Research Operating Team are responsible for the day-to-day operations of the PEF. The PEF Woodlands Manager is the SFR employee responsible for all day-to-day, non-research management activities on the PEF.

The salary and operating costs of the PEF Woodlands Manager are paid by the SFR from accounts managed jointly by the Manager of Funded Accounts in the SFR and the Financial Administrator of the MAFES. Income flows to those accounts from stumpage sales at the PEF and earnings from the PEF Endowment. The PEF endowment was created by the Foundation using funds from the sale of camps lots along the south shore of Chemo Pond. As stipulated in the Deed, income derived from the property is required to first fund the annual PEF Scholarship and then may go towards management and maintenance of the property and educational or research programs conducted on the property.

Earnings from the Endowment are deposited twice each year (September and January) by the University of Maine Foundation into the PEF Gift Account. Timber sale income is delivered to the University of Maine Foundation by the University Forests Operations Manager as those monies come in and are deposited in the Stumpage Account at the Foundation. Once harvest operations cease in the spring, and before the end of the fiscal year for the PEF Gift Account (June 30), the PEF Woodlands Manager, the Chair of the PEF

Research Operating Team, and the Chief Financial Officer for the University of Maine Foundation meet to disburse the year's stumpage income. Despite being the landowner, the Foundation only retains 10% of the funds. The remaining income is divided between the PEF Research Account (interest bearing account managed by the Foundation and the Chair of the PEF Research Operations Team) and the University Forests Office. That division was recommended by the Dean of the College and voted on by the ROT in March of 2000. The division approved allocates 40% to research, 40% to the University Forests Office, with the remaining 20% being discretionary. Initially this division was applied to the net income from timber sales after the University Forests Office deducted the year's expenses. When the School of Forest Resources was created in 2005, administration of the University Forests Office moved from MAFES to the School. At that time, Steve Reiling (Interim Director of the School of Forest Resources) clarified this policy and stipulated that the division was always intended to be applied to the gross income. In years when the discretionary dollars have not been allocated to significant infrastructure expenses, they have typically been deposited in the interest bearing research account with the understanding that a cushion will be kept in that account to cover unexpected costs arising from the operation and management of the property.

3. Resource Assessment

3.1 Area Description

The PEF is located northeast of Bangor, Maine. Access is from either Maine Route 9 traveling east from Brewer to the Chemo Pond Road, or traveling north on Maine Route 178 to the main entrance in Bradley. From the main entrance a gravel road, Government Road, traverses the forest for 5mi to the Chemo Pond Road; a gravel road continues southerly across the remaining area another 1.5mi. Along Government Road there are multiple side

Table 3.1 Acres of forest features and attributes

	USFS Research Area	Non-USFS Research Areas	Non-Forested Wetlands	Roads & Landings	Non-Wetland Reserves	SLZ 75ft Buffer	No Current Access	Forest Land Under Management	Grand Total Acres
Comp A	**NA**	26	70	5.86	0	**27**	87	244	460
Comp B	**NA**	105	0	15.53	0	**4**	0	495	620
Comp C	**NA**	148	109	11.47	55	**69**	0	521	890
Comp D	**NA**	23	424	1.94	203	NA	NA	0	629
Total Acres	**1257**	**302**	**603**	**35**	**258**	**100**	**87**	**1260**	**2598**
% Total Acres	**NA**	12%	23%	1%	10%	4%	3%	48%	100%

roads that provide access to various parts of the forest. In 2009 the PEF contains 3,855ac[1] in the towns of Bradley and Eddington, Maine, on the east side of the Penobscot River.

The USFS long-term research area is located approximately in the middle of the forest and covers 1,257ac. For management purposes, the remaining forest is divided into 4 Compartments (Table 3.1). Compartments A, B, and C are under forest management and D is designated as reserve (B1). Two University of Maine sponsored programs, the Acadian Forest Research Program (AFERP) and Land-Use Effects on Amphibian Populations (LEAP), conduct research on the forest separate from the USFS station. These two programs occupy 302ac across the 4 compartments. As of October 2009 the two LEAP arrays on the PEF are in the process of being removed from the study project (Appendix A2 has more information about this process).

Non-forested wetlands total 603ac and are distributed across compartments A, C, and D, 70% of which are in compartment D. A total of 35ac, for all compartments, are taken up by roads or log landings. All of compartment D was classified as a reserve area in the 1999 PEF forest management plan. More information about each of these areas and classifications can be found in subsequent sections of this plan, maps in Appendix B provide a spatial context.

Table 3.2 Soil attributes by series

								SITE INDEX		
Series	Acres	% Area	Drainage	Txt	Depth(in)	Parent Material	Briggs	Briggs BF	NRCS S-F	NRCS WP
Plaisted	183	16%	WD	GL	48	Till	1	60	58	66
Thorndike	150	13%	WD	VRSIL	24-48	Till	1	60	55	63
Suffield	21	2%	MWD	SIL	48	Marine/Lacustrine	2	60		
Howland	189	17%	SWPD	GSL	30	Till	3	55	54	64
Scantic	45	4%	PD	SIL	72	Marine/Lacustrine	4	48	60	58
Monarda	189	17%	PD-VPD	GSL	30-48	Till	4	48	40	66
Buxton	139	12%	VPD	SIL	20-40	Marine/Lacustrine	4	48	55	65
Biddeford	61	5%	VPD	Muck o/ SIL	40	Marine/Lacustrine	4	48	48	54
Muck	48	4%	VPD	na	72	Organic	4	48	30	na
Saco	24	2%	VPD	SIL	30	Alluvium	4	48	na	55

3.2 Forest Soils

The soil survey published by NRCS for Penobscot County (SCS 1963) includes a general soil map of Penobscot County that shows the vicinity of the PEF as being covered by three distinct soil associations. These three associations are arranged from NW to SE and from the shores of the Penobscot River to the shores of Chemo Pond. The association that lies along the Penobscot River is the Suffield-Buxton-Biddeford association described as

[1] Most acreages quoted in this document are based on GIS analysis using a combination of photo interpretation and GPS technology. These are not survey acres and this document does not intend to represent them as such.

silty, well-drained to very poorly drained soils on rolling and depressional topography that developed in the fine-textured lacustrine or marine materials deposited when the glaciers sunk Maine's coastline. Soils of marine origin are found along the Penobscot River at least to Passadumkeag and up the Passadumkeag River nearly to Saponac Lake. Further from the river, the Plaisted-Thorndike-Howland association is characterized by moderately well to well drained, stony and ledgy, deep to shallow, granitic and slaty soils that developed in the glacial tills of the upland. The Monarda-Burnham-Dixmont association surrounding Chemo Pond is comprised of wet, dominantly very stony soils that also developed in the glacial tills of the uplands. This sort of coarse overview is useful to put soils into a landscape context.

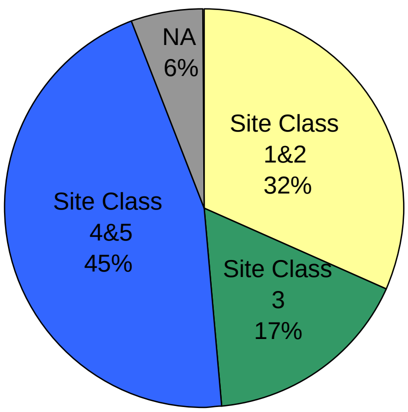

Figure 3.1 Percent of area in 5 Briggs classes

Figure 3.1 shows the distribution of the soils in the PEF taken from the NRCS 1963 soil survey by drainage class (B4). Table 3.2 gives the acres for each soil series along with some of the basic characteristics for each soil. The table indicates that 62% of the acres included in this management plan are somewhat poorly, poorly, or very poorly drained. Another 13% are well drained but very shallow to bedrock leaving only 18% that are deep and either well drained or moderately well drained.[2] [3] [4] [5]

3.3 Management and Harvest History

The 1999 management plan outlined harvest activities to be initiated for the 10 year period following the plans start date. Several harvests were implemented from 2001 to 2005 in compartments A, B, and C. These operations utilized a variety of equipment systems from cable skidders to whole tree systems. The 591ac harvested in the period (Table 3.3) represents about 47% of the area currently under management as described in section 3.1 and Table 3.1

Table 3.3 Harvest actions between 2001 and 2005

Comp	Thinned	OSR	Total Ac Harvested	Harvest System
A	49	0	49	CTL
B	82	166	248	CS or WTH
C	206	88	294	CTL or CS or WTH
Total	337	254	591	

[2] http://www.mapss.org/pdf/DRAINAGEkey.pdf
[3] http://www.mapss.org/pdf/DRAINAGEkey2.pdf
[4] ftp://ftp-fc.sc.egov.usda.gov/ME/tech/07CatenaKey11_08.htm
[5] http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx

represents about 47% of the area currently under management as described in section 3.1 and Table 3.1

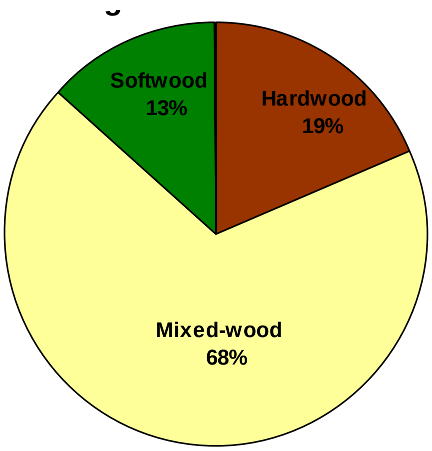

Figure 3.2 2008 Forest types percent of managed forest area 1260ac

3.4 Forest Types, Timber, Vegetation, and Health

The character of the forest varies across the three managed compartments, but general classifications using attributes such as structure, size class, and volume can be made. The following descriptions are based on both 2006 and 2008 planning inventory data, as well as anecdotal field observations. These descriptions do not include Compartment D but do include all stands regardless of current accessibility, as well as those areas within 75ft Shoreland Zoning buffers. Area estimates using Geographic Information System (GIS) mapping and 2007 ortho-photo imagery show that just over 1/10 of the area is non-operable wetland as classified by the National Wetland Inventory (NWI), forested wetlands occupy an area about half that size, and upland forest accounts for the remainder.

A mixture of forest types, ages and size classes occur across the PEF. The area is currently dominated by mixed-wood stands of mature timber, typically with abundant regeneration, of tolerant species, in the understory (Figure 3.2). These forest conditions reflect the fact that these compartments saw limited or no harvesting during much of the last century and the only disturbance events were primarily small scale and natural. Prior to 2000 management focused on the USFS designated research units and compartments. The mixed-wood classification includes stands containing between 25% and 75% hardwood species by basal area (B3). The dominant overstory species in 2009 include eastern white pine, eastern hemlock, and aspen species.

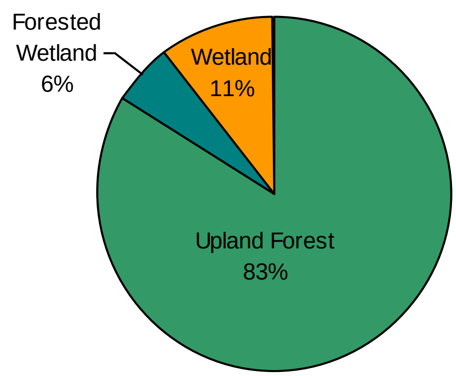

Figure 3.3 Percent area description

The PEF currently contains approximately 25 cords per acre for a total of roughly 30,000 cords across the three compartments. A series of figures helps to illuminate the current species composition and diameter structure of the forest. The percent basal area by species of all stems greater than 1 inch in diameter is dominated by red maple and aspen for hardwoods and balsam fir followed by white pine and hemlock for softwoods ().

However, a different picture of the forest emerges when the % basal area is broken into two diameter classes. Percent basal area by species of stems greater than 6" shows red maple and aspen dominating with white pine and hemlock as the prevailing species rather than fir (Figure 3.5). The reason for this reversal in softwood species is made clear when the same attributes are viewed for stems between 1 and 6 inches (Figure 3.6). Fir makes up a whopping 62% of the total basal area for the smaller size class. These figures are reinforced by a figure showing the total cords by species in the greater than 6 inch size class. The arrangement of hardwood species is unchanged, while softwood numbers indicate white pine makes up 17% of the total volume followed by hemlock, spruce, cedar and lastly fir at only 2% (Figure 3.7).

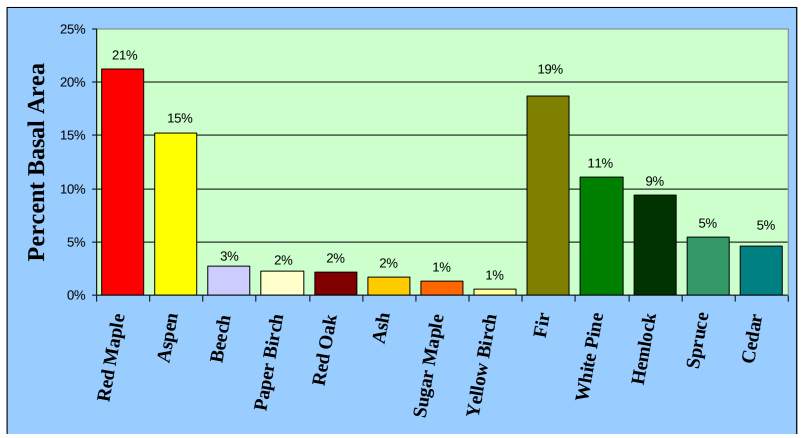

Figure 3.4 Percent basal area by species >1 inch

If broken into three size classes the volume estimates show a forest heavy to saw timber (Figure 3.8). The current forest condition is far from the ideal of a well regulated forest. Management activities begun by the ROT and Forest Manager in 2000 initiated the process of addressing this issue. From

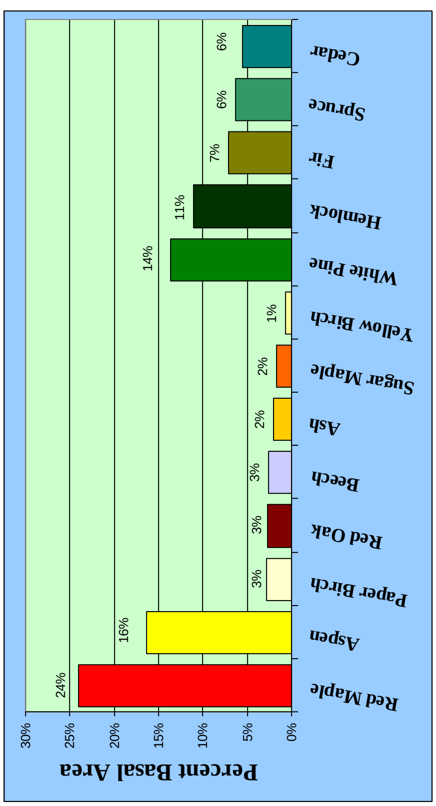

Figure 3.5 Percent basal area by species >6 inch

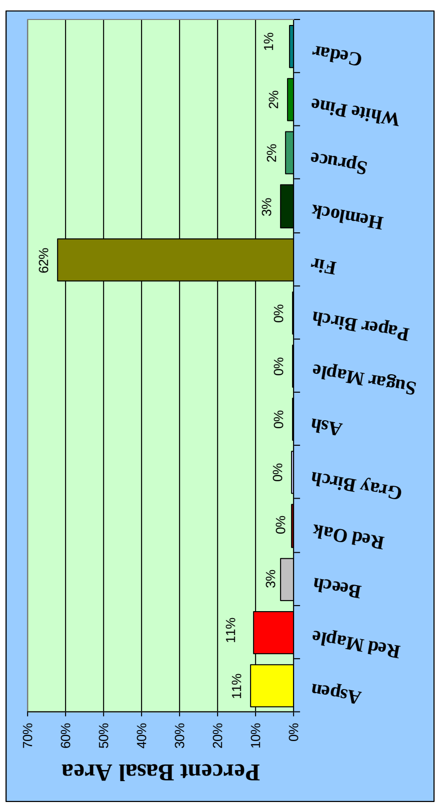

Figure 3.6 Percent basal area by species >1 < 6 inches

2001-04 approximately 250 acres were harvested heavily enough to release or established regeneration. This represents about 20% of the total managed forest area. A table in appendix C1 provides a stand by stand summary of current stand characteristics such as: area, basal area, trees per acre, forest types, and habitat types. This table will help the reader to interpret aspects of this plan which reference specific stands.

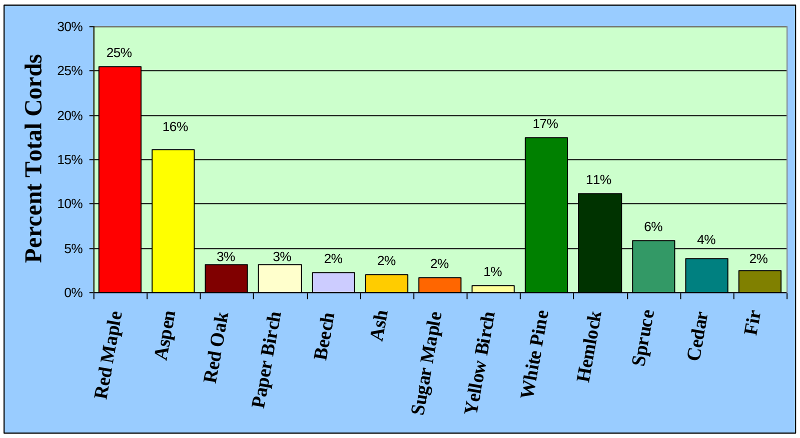

Figure 3.7 Percent volume (cords) by species >6 inch

Forest health concerns for the ownership take many forms. Among the most significant are pests and diseases which reduce commercial timber yields and values. Spruce budworm outbreaks have impacted this forest in the past and some of the spruce fir stands were affected by the 1970's defoliation. One of the measures of forest susceptibility to spruce budworm is the percentage of mature balsam fir present. Based on current inventory numbers a spruce budworm susceptibility index and evaluation tool, created by Prof. Jeremy Wilson, shows that the threat posed by spruce budworm to the forest is very low, again due to the absence of contiguous areas of mature balsam fir. However the percentage of fir in advance regeneration is a cause of concern since a spruce budworm outbreak is likely in the coming decades. The development of this cohort must be monitored closely as it matures.

Figure 3.8 2008 standing volume by size class
(*Pole= >6"<12" *Sawlog= >12"<24" *Large Sawlog= >24")

White pine blister rust is another concern. Evidence of damage and mortality from the fungus is visible on both young and mature white pine in parts of the forest. While a troublesome pest, the current level of damage is not enough to provoke serious concern.

Balsam wooly adelgid is an exotic pest of special concern. This insect has been documented in the USFS management unit 23A. As noted earlier, the predominance of balsam fir in the regeneration size class is significant due to spruce budworm but this new forest pest elevates the level of concern. Mortality due to the adelgid is certain to be an issue in years to come as the percentage of mature fir increases.

Finally, the hemlock wooly adelgid, another exotic pest, is also on the radar for the PEF. Occurrences of the insect in Maine have so far been limited to southern parts of the State that lie closest to the areas in southern New England that have been hard hit by the pest. However, it is likely that the insect will eventual arrive in central and eastern Maine. The high percentage of hemlock in stands across the forest would make an outbreak of this insect highly detrimental. Hemlock is also a critical species in the USFS research areas. Managers must keep abreast of the latest information about this exotic pest and the management strategies that have been developed to deal with an outbreak.

3.5 Biodiversity and Habitat

Managing for biodiversity is a principle element of contemporary forest management. Approaching this issue from a landscape perspective is critical. In the 1999 publication Biodiversity in the Forests of Maine[6], Flatebo, Foss, and Pelletier suggest "a primary goal for biodiversity in Maine's managed forest is to ensure that adequate habitat is present over time across the landscape to maintain viable populations of all native plant and animal species currently occurring in Maine." They emphasize that this objective reaches beyond a focus on a few game species or just the rare, threatened, and endangered species. This approach simultaneously requires an inclusive consideration of habitat for <u>all</u> native species at spatial scales ranging from microsites, to stands, forests, and landscapes and does so through time. The authors list six key concepts that are easy to understand but require commitment to implement:

1. Think of individual stands as part of the landscape in which they are embedded.
2. Within the mosaic of stand types, sizes, and age classes on the landscape, maintain a component of mature and over-mature forest.

[6] Flatebo, G., C.R. Foss, and S.K. Pelletier. 1999. Biodiversity in the forests of Maine: guidelines for land management. Univ. Maine Coop. Extension Bulletin #7147. 168 p.

3. Consider what natural disturbance processes have taught us about tools and mechanisms to maintain biodiversity.

4. Maintain biological legacies within stands.

5. Consider what is left behind during a harvest, as well as what is removed.

6. Understand the importance of special habitats and features on the land and adapt management to maintain them.

These six concepts are listed here for emphasis and for careful consideration as the Forest Manager and the ROT plan management actions, develop management policies, and consider research proposals that support the mission of the forest as spelled out in the deed and MOU. Truly incorporating biodiversity concerns while providing a location for long-term forest ecosystem research, education, and demonstration will require that each action and decision be considered in the broadest possible spatial and temporal context.

To insure that the PEF includes a portion of forest area where no harvesting occurs and natural processes are allowed to happen without human interventions, in accordance with biodiversity and research goals, compartment D is designated as reserve. In addition, a unique 6ac stand in compartment C and the two AFERP control areas RA4 and RA8 have been added to the total reserve acres as part of the 2008-09 planning process (B5). University Forest staff have used a variety of approaches to characterize the current forest conditions as they related to biodiversity values. A management approach developed by Maine Audubon termed Focus Species Forestry[7] (FSF) provides useful criteria for the assessment of habitat types and development stages. Using the inventory described in section 3.3, stands were categorized into habitat types and development classes based on FSF criteria. A diversity of habitat types are represented on the forest with the spruce fir and the oak-pine types making up about 50% of the total forest area in compartments A, B, and C

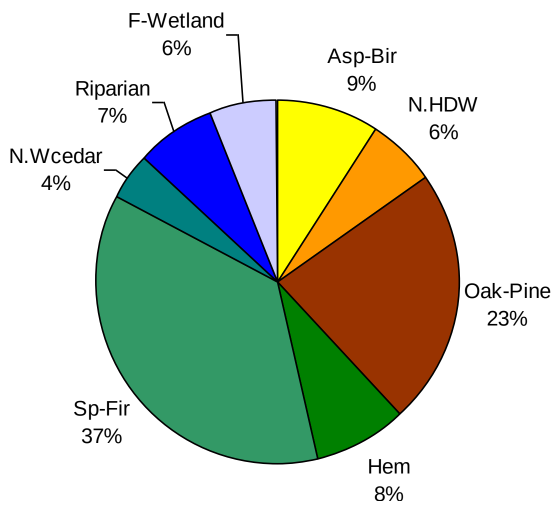

Figure 3.9 2008 proportion of forest in FSF habitat types

[7] Bryan, R.R., 2007. Focus Species Forestry, a Guide to Integrating Timber and Biodiversity Management in Maine. Maine Audubon, Falmouth, ME.

(Figure 3.9). All other habitats, with the exception of N. White Cedar, occupy more than 5% of the forest area. The University Forest has set a goal of maintaining all FSF habitat types at a minimum of 5% of the forest area. Each of these habitats are utilized by a variety of species but management using the FSF model can focus on one or two specific species to help simplify the concept of habitat management. The FSF publication provides useful background information on each habitat class and associated wildlife. This management plan does not single out specific *focal species*, but such an approach could be used in the future.

FSF uses five development classes to describe forest conditions. These classes are based primarily on tree diameter. The PEF is dominated by intermediate (pole sized) and mature (small sawlog) FSF classes (Figure 3.10). Within area managed by the University Forests, there is currently almost no FSF defined late successional forest; defined as stands dominated by trees approximately 16in and larger. There is also a deficiency of regeneration classes on the forest. Section 6.3 of this plan describes how projections of future management actions predict an increase in the proportion of both of these development classes on the PEF. The current percentages for both habitat and development classes are based on the inventory of compartments A, B, and C, and do not include the forest area of compartment D. An assessment of this important component of the PEF is a noted deficiency that must be addressed in the future.

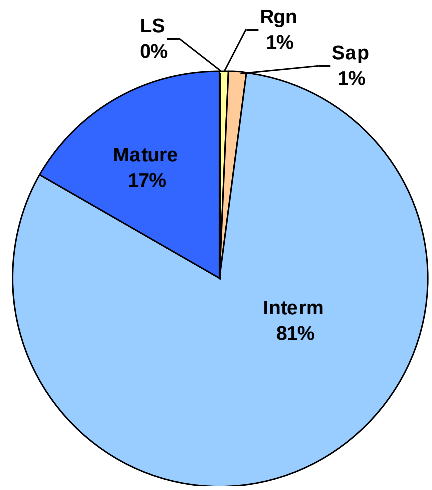

Figure 3.10 2008 Proportion of forest in FSF development stages

Habitat conductivity is a critical concept, though it is difficult to define and its value is debated by some.[8] Riparian corridors can provide important linkages among habitats and Shoreland Zoning (SLZ) buffers help insure the retention of these corridors. Some specific considerations regarding connectivity on the PEF include stand that border reserve areas as well as areas in compartment B that border USFS management units 51, 18, and 19. An anecdotal review of 2007 ortho-photos reveals contiguous patches of mature forest in these

[8] Flatebo, G., C.R. Foss, and S.K. Pelletier. 1999. Biodiversity in the forests of Maine: guidelines for land management. Univ. Maine Coop. Extension Bulletin #7147. p113-117.

USFS management units and University Forests managed stands to the west. Issues relating to conductivity between these areas and similar ones should be considered in the management planning process. A series of wildlife patch-cuts were installed in compartment C during the 1970's as part of a UMaine Dept. of Wildlife Ecology research project.[9] These areas are somewhat unique on the forest and provide important habitat for early successional species. These cuts are almost 40 years old in 2009 and may be due for harvest again as part of a habitat maintenance approach. Several types of significant or essential habitat as defined by Maine Inland Fisheries and Wildlife Dept. occur in the PEF. Section 7 of this plan describes these areas and related management considerations in detail.

3.6 Water Resources

About 6.5 miles of the PEF property boundary falls along Blackman Stream and Chemo Pond. The pond, the stream, their tributaries, and several hundred acres of associated wetlands (both forested and non-forested) contribute to the beauty, diversity, and habitat value of the forest. The many wetlands adjacent to and flowing into Blackman Stream and Chemo Pond from the PEF afford locally and regionally significant habitat for a host of game and non-game species. Wood ducks, otters, mink, turtles, and frogs are abundant in these wetlands. Moose, beaver, great blue herons, black ducks, loons, and eagles are often seen by those enjoying the winding, flat water paddling upstream on Blackman Stream from Leonard's Mills to Chemo Pond.

Chemo Pond is a large, predominantly shallow (maximum depth 24 feet), warm-water pond. Anglers enjoy fast action for white perch, yellow perch, chain pickerel, and small-mouthed bass in both winter and summer. Chemo Pond has slightly below average water quality. The surrounding peatlands and wetlands contribute phosphorous responsible for the tea-like color of the water. The Pond has a number of seasonal and year-round homes that ring the shore on all but the PEF frontage. These homes are accessed from Route 9 easterly via the private Chemo Pond Road, or northerly via Bruckoff, Scott Point, and Getchell Roads or westerly via Yawaca Road. There is a commercial campground and boat launch, Dean's Landing, located where the Chemo Pond Road meets the pond shore. The

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[9] Bailey, Michael E. 1977. Production and Deer Utilization of Vegetation on Small Clearcuts in Central Maine. MS Thesis, Unpublished Manuscript. Graduate School University of Maine Orono May 1977

stream and pond are thus important recreational resources for people living along them as well as for visitors from the entire region.

Blackman Stream and Chemo Pond are currently priority waters in the forefront of a major collaborative effort to improve passage for sea-run fish to their original habitats in several major watersheds in New England. The hope for Blackman Stream is to reestablish the impressive spawning runs of alewives that have been impossible since the construction of the first timber crib dams at Veazie and Great Works in the 1830's (Watts, D. H. 2003, pp.35-41). Currently the Penobscot River Restoration Trust is working to enhance energy production at the dams in Stillwater, West Enfield, and Medway so that the Veazie and Great Works dams can be breached or removed to allow passage for Atlantic salmon, alewives, herring, sturgeon and eels. In addition, they hope to establish a by-pass for fish around the Howland dam. Based on the apparent success of those efforts, the US Fish and Wildlife Service and the Atlantic Salmon Federation have approached the Maine Forest and Logging Museum and have secured much of the funding needed for the design and construction of a fishway around and aesthetically complementary to the historic Leonard's Mills dam in Bradley. They hope to complete construction by the fall of 2009. Protecting the shorelines, the water quality, the wetlands, and the associated viewsheds of Blackman Stream and Chemo Pond all need to be considered when planning management and research activities within the PEF.

3.7 Special Management Zones and Conservation Areas

State Shoreland Zoning (SLZ) regulations govern management on a sizable portion of the PEF. Additional special habitat areas occur on the forest and receive specific protections. More details about these the regulations governing these areas can be found in section 4.5 on laws and regulations. Additional information about areas of special concern can be found in section 7.2. SLZ specifies buffer distances of 75ft and 250ft around water-bodies, riparian corridors, and significant wetlands depending on the size and character of the feature. Roughly 100ac of 75ft buffer and about 125ac of 250ft buffer occur in compartments A, B, and C (Table 3.4). Maps B2A, B2B, and B2C show the extent of the SLZ buffers in each compartment.

Table 3.4 Area in SLZ buffer

	SLZ 75ft Buffer Ac	SLZ 250ft Buffer Ac
Comp A	27	25
Comp B	4	0
Comp C	67	104
Total	98	129

An eagle nest on the south side of Chemo Pond receives special protection at the State and Federal level. Management of the forest around the nest will be carried out under guidelines from the Maine IF&W. A core area within 330ft of the nest will be off limits to harvest. This buffer overlaps with that of the shoreland zoning buffers as well. In July of 2009 Maine LD 66 removed the Bald Eagle from the State of Maine endangered species listing. Maine IF&W will continue to monitor active nest sites but will reduce the intensity of nest searching. The result is that Maine IF&W GIS data layers may not include all the nest occurrences on a particular ownership. Therefore Forest staff must take extra care to identify nest sites, independently of IF&W mapping, to ensure that management activities avoid causing any negative impacts to eagle nest sites.

Compartment D was designated a reserve area at the time of the 1999 management plan update. The compartment is approximately 629ac in size. Much of the area borders Blackman Stream to the north and includes a significant percentage of wetland both forested and non-forested along the riparian zone. In addition to compartment D there are other designated reserve areas associated with the AFERP research program. Officially designated as controls, the two research areas total around 50ac and include primarily well drained uplands. A small portion of compartment C has been set aside as reserve because of its unique location and characteristics. Stand 252a is 6ac of mature oak and pine on a peninsula jutting out into Chemo Pond. This area will be protected from harvest because of its unique ecological attributes, in relation to the rest of the ownership, as well as its aesthetic value. In all, the area of upland forest designated as reserve totals 258ac or 20% of the total area under management (**Error! Reference source not found.**). This figure does not include the SLZ 75ft buffers, described above, though they will become *defacto* reserve areas, representing a mixture of wetland and upland forest types. While not officially designated as reserve areas two black spruce stands on organic soils in Compartment C (C108 & C114) should be given special consideration and likely excluded from harvest operations. These stands are unique on the ownership and represent important habitat for a variety of plant and animal species. Map B5 shows areas designated as reserves.

Table 3.5 Designated reserve acres in wetland and upland areas by compartment.

	Comp Acres	Wetlands	Non-Wetland Reserves
Comp A	434	70	0
Comp B	515	0	0
Comp C	716	109	55
Comp D	629	424	203
Total	2294	645	258

3.8 Exotic/Invasive Species

Invasive plant species do not appear to be abundant within the managed areas of the PEF. Research by Ecology and Environmental Sciences M.S. student Elizabeth Bryce in the summers of 2006 and 2007 found four species of invasive plants in the compartment study areas of the USFS leased portion of the forest. Where encountered, invasive plants were usually isolated small seedlings (< 0.5 m tall), though a large Japanese barberry (*Berberis thunbergii*) shrub (2 m tall) was seen in one clearcut replicate. Large populations of invasive plants were found in two unmanaged areas of the PEF: at the Leonard's Mills logging museum site and in an old field at the entrance to the PEF from Route 178.

Experience with invasive vegetation in other regions indicates that following disturbance such species are capable of rapid range expansion in short time periods. Furthermore, invasive plants often aggressively colonize disturbed areas such as foot trails,

Table 3.6 Maine Audubon invasive species table

Most Problematic Invasive Plants in Maine

Most Problematic Terrestrial Invasive Plant in Maine		
Common Name	**Scientific Name**	**Habitat**
Barberry, Japanese	*Berberis thunbergii*	Forest understory
Buckthorn, common	*Rhamnus cathartica*	Forest understory
Buckthorn, glossy	*Frangulus alnus*	Forest understory
Honeysuckle, bush	*Lonicera morrowii*	Forest understory
Honeysuckle, Japanese	*Lonicera japonica*	Forest understory
Honeysuckle, Tatarian	*Lonicera tatarica*	Forest understory
Japanese knotweed	*Fallopia japonica*	Edges
Bittersweet, Asiatic	*Celastris orbiculata*	Edges, forest canopy vine
Loosestrife, purple	*Lythrum salicaria*	Wetlands
Rose, multiflora	*Rosa multifloa*	Old field, edges
Source: Maine Natural Areas Program 2006		

***This table was created by Maine Audubon and is reproduced here with permission. For more information about Maine Audubon's forestry program, please go to: http://www.maineaudubon.org/conserve/forest/index.shtml

skid trails, roadsides, ditches and log landings. The proximity of the managed forest to large populations of invasive plant species (Table 3.6), outside the property boundaries, increases the importance of active monitoring for such vegetation. Monitoring protocols and rapid control measures of invasive vegetation should be developed in the near future; once an infestation is underway the opportunity for effective control is severely reduced.

3.9 Recreation

There is a long-standing tradition of public access and recreational use of the PEF. The PEF, the Bangor City Forest, and the Dwight B. Demeritt Forest, are the three sizable public forests located in the lower Penobscot valley. All three forests are experiencing increasing recreational use by a growing population of ever more diverse recreational users.

Visitors use the PEF for a host of recreational activities including walking, bicycling, driving, bird watching, hunting, fishing, paddling, ATV riding, snowshoeing, and snowmobiling.

Vehicular access to the PEF is controlled by a system of gates. The gates on Government Road at Chemo Pond Road are closed to cars and trucks but both gates are set up to allow bicycle, ATV, and snowmobile passage. The gate on Government Road just east of Leonard's Mills is open for cars and trucks from the end of mud season in April until the end of the muzzleloader season for deer in December. This gate also is set up to allow bicycle, ATV, and snowmobile passage. All of the gates on side roads and loop roads are kept closed to protect those roads and the research sites arrayed along them.

Since 2007 limited ATV use has been allowed only for members of the two local ATV clubs over 18 years of age who are operating properly registered ATV's and display an annual UMaine ATV sticker. ATV operation is only allowed on weekends or on weekdays if before 7 am or after 5 pm and only on the Government Road and one designated connector trail. The ATV club members are critically aware that more and more landowners are posting their land against ATV use. The local game wardens of Maine's IF&W work closely with the University Forests Operations Manager to minimize conflicts so that ATV access can continue.

The Government Road is a key part of the groomed snowmobile trail network on the east side of the Penobscot River and serves as a key connector trail providing local access to the ITS system. The University Forests Operations Manager works closely with the local snowmobile clubs to coordinate trail routes, PEF harvest operations, snow plowing, and road closures in order to minimize conflicts and insure everyone's safety.

There are two primitive carry-in boat launch sites on the PEF that are regularly used by anglers and paddlers. One provides access to Blackman Stream via USFS Unit 3 near the old roll dam, the other provides 4WD access to the west end of Chemo Pond near the outlet, Blackman Stream.

Hunting is a long-standing public use of the PEF. Of the three sizable public forests located in the lower Penobscot valley, the PEF is the only one open to hunting. As a working forest, the PEF affords hunters with a diverse array of forest types, age classes, and conditions and is accessed by a well-maintained gravel road network. Hunting is excellent for both large and small game. The USFS and University post safety zone and harvest area signs to alert hunters to ongoing research and harvesting sites. Special use permits, available from the University Forests Operations Manager, are required for hunters placing bear baits or tree stands on the PEF.

To date, there have been surprisingly few conflicts among recreational users of the PEF or between users, forest workers, and researchers. The one exception is an ongoing and serious problem with unauthorized ATV use. The first problem is ATV's on the Government Road during the work day. This has serious and obvious safety concerns for everyone. The second problem is the continued use of ATV's on side roads and unofficial trails with attendant site damage. Signs have had little effect and so far neither have the local ATV clubs. It would be easy to blame these problems on a few, young, unsupervised riders, but adults have been problems, too and set a bad example. Hopefully, the local game wardens can use the power of the law to accomplish what cooperation and polite requests have not.

3.10 Non-Timber Forest Products

Non-timber forest products have to date been of minor consequence at the PEF. We do not allow the public to cut or gather firewood or Christmas trees. Recreational gathering of fruits, berries, mushrooms, etc. has been continual but insignificant. The one non-timber product that has been gathered on occasion is wreath brush and that requires a special use permit from the Operations Manager of the University Forests Office to insure that research sites are strictly avoided.

3.11 Access Considerations

Road access, necessary for timber harvesting activities, is adequate across most of the forest. New truck roads were built in compartment B in 1999 to support planned harvesting; no further road building is planned for the compartment. Compartment C had new roads, totaling 4500ft, built during the same period, allowing access all the way to the eastern end of the compartment. A small area (<10ac) in the southeast corner of compartment C is cut off by wetland. The only potential access to this well stocked stand of white pine is through an abutting property to the east. To date no attempt has been made to gain legal access to this part of the ownership. Access to the southeastern portion of compartment C is through private land via Maine Route 9. No legal ROW exists to this important area which contains AFERP RA's 5 and 6. Access is by a verbal agreement with the landowner, Carol Grover who lives on the property. This lack of a legal ROW is cause for concern since the Grover property represents the only feasible access to this portion of the forest because large wetlands block access from the North. A detailed summary of road maintenance conducted over the period from 1997-2008 is available as a supporting document.

Compartment A remains the last major area in need of some type of road construction to support harvesting actions. Tentative plans exist to install a short section of winter road in the northern portion of compartment A near AFERP RA 9, in one of two places. One option is to enhance an existing trail through USFS Unit 33, currently used to access RA 9, and extend a winter road around the northern portion of the RA. A second option would place a road to the south of USFS Unit 33. A small stream runs through this area and might require a bridge of some type. This decision needs to be made before harvests, scheduled for the 10 year period starting in 2009, can commence. The most important limitation to access in compartment A occurs in the southwest corner of the southern most portion of the compartment. The area, which includes stands A33, A39, A40, and A41, totaling 87ac is cut off from the existing forest road systems to the west by a large wetland complex (B2A). As a result access to this part of the forest must come from the west through abutting properties. An attempt in was made in 2005 gain permanent ROW to this area through abutting private land but private parties backed away from the idea of donating land or a ROW. To date no further actions have been made to gain ROW to this area. These acres have been intentionally left out of the 10 year harvest schedule described in this plan.

Road maintenance is a critical part of ensuring reliable access to the forest. Gates on selected side roads off the Government Road—described in detail in section 3.8—help limit potentially damaging vehicle traffic. The use of erosion control measures in accordance with MFS water quality BMPs further reduce the potential for water damage to roads and other transportation infrastructure. Regular maintenance activities such as road grading, roadside mowing and vegetation control is carried out by University Forest staff. Controlling vegetation on the lightly traveled side and loop roads has required considerable effort in the past. Both mechanical and chemical controls have been used to stifle

Photo 3.1 Box culvert installed in 2006 in compartment C

vegetation encroachment. Control actions should consider ways to limit the introduction of invasive vegetation—see section 6.5.

Persistent flooding problems due to beaver activities have plagued several locations especially the portion of Government Road around the Dismal Swamp stream crossing. Repeated cleanings of the culvert followed by live trapping and relocation of the culprits has improved the situation. However, a more permanent solution is required and may take the form of a "beaver deceiver" as designed by Skip Lisle of Beavers Deceivers Inc. His installations have successfully controlled road flooding due to beavers on nearby Penobscot tribal lands. The University Forest will consider engaging Lisle for a longer term solution.

3.12 Boundary Line Status

Boundary line maintenance is a critical but often overlooked responsibility of forest managers. Failure to adequately maintain the lines may necessitate an expensive retracement survey if line identification by staff becomes impossible. The PEF is a large, long, narrow, irregularly shaped property and so has a lot of property boundary proportional to its size. The boundary is nearly 25mi long. About one fourth of that falls along streams or along the shore of Chemo Pond and does not need regular maintenance. The University Forests Office has worked to maintain the remaining 18.2mi of boundary line since the PEF was deeded to the University of Maine Foundation in 1994. Those portions abutting active timber sales, whether our own operations or on abutting properties, have been given the highest priority. The remaining portions are prioritized based on condition, time since last maintenance, and proximity to work sites. In 2005 a concerted effort was begun to get the remaining lines in shape; as of January 2009 4mi of line still needs to be brushed out and painted and an additional 0.8mi has been brushed but needs painting. In summary to date better than 80% of the dry boundary has been brushed and painted since 2005, leaving 20% to finish in the near future. The lines with recent maintenance have been recorded with GPS, flagged, brushed, and painted. Once this initial pass is complete regularly scheduled maintenance will be required.

Table 3.7 Miles of Boundary Line

	Total Miles	Miles Complete	Miles To Do
Upland	18.2	14.2	4
Shoreline	6.7	NA	NA
Total	**24.9**	**14.2**	**4**

4. Landscape Description

4.1 Climate and Biophysical Regions

The climate conditions of the PEF have been studied and described by the USFS. The following description comes directly from the USFS PEF website:

'The climate is cool and humid. The 30 year (1951-1980) normal (i.e. mean annual) temperature for nearby Bangor, Maine, is 43.9°F (6.6 °C). February, the coldest month, has an average daily temperature of 19.3 °F (7.1 °C) while July, the warmest, averages 68.0 °F (20.0 °C). Normal precipitation is 41.7 inches (1060 mm), with 48 percent falling from May through October. Annual snowfall averages 94 inches (239 cm). Average growing season is 156 days.' [10]

The concept of dividing the State into biophysical regions based on geological and ecological boundaries gained traction in the 1990's. The classification system devised by McMahon 1990[11] has been adopted by the Maine Forest Service.[12] McMahon termed the biophysical region containing the PEF the Central Interior Region. The area is marked by glacial deposition features including extensive glacial marine sediments which dominate the Penobscot River valley. A more detailed description of the key features of this biophysical region is available as a PDF document.

4.2 Natural Disturbance Regime

In recent decades, scientific research[13] has strived to describe and quantify the disturbance regimes affecting the region that includes the PEF. The term disturbance is commonly defined as an event that kills vegetation resulting in the establishment or release of a new cohort or type of vegetation. For the majority of forest types in the region, research indicates that frequent, low intensity events are the dominant pattern of disturbance. These most common disturbance events typically affect an area ranging from 1/500th of an acre to 1/4 acre in size. The time between disturbances influences the type and structure of forest that develops. A long return interval may allow for complex vertical structure to form. In the region, forest disturbance return intervals vary by agent. While natural systems are inherently dynamic, current research indicates that in general, the region experiences intense large scale disturbances infrequently.

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[10] Italic text copied directly from http://www.fs.fed.us/ne/durham/4155/penobsco.htm#CLI
[11] The biophysical regions of Maine: Patterns in the landscape and vegetation (McMahon 1990)
[12] Italic text copied directly from http://www.maine.gov/doc/mfs/biophysi.htm
[13] Seymour, R.S., A.S. White and P.G. deMaynadier. 2002. Natural disturbance regimes in northeastern North America – Evaluating silvicultural systems using natural scales and frequencies. Forest Ecology and Management 155:357-367.

Several studies on the historic disturbance regimes of the region have reached the same conclusion, that on average the annual percent area disturbed is about 1%. If a manager wished to apply this 1% rule to an ownership 100ac in size with harvesting every year, it would require that 1ac of forest land would be regenerated each year for 100yrs until all 100ac had been harvested, at which time the harvest pattern would repeat. Importantly, in natural systems disturbances often repeat on the same acre more frequently and miss other acres all together. This results in a forest with a complex age structure, with some stands reaching very old ages and others repeatedly “reset” to early successional stages. As noted disturbances do not impact all areas uniformly; some natural topographic or soil characteristics may predispose a site to a specific disturbance agent, excessively well drained eskers and fire for example. Thus, management seeking to incorporate natural disturbance principles should use all of the factors that influence disturbance events when determining stand prescriptions. While management in the real world can seldom achieve complete congruence with that described in textbooks, rules like those relating to natural disturbance regimes can form the basis for sound management decisions which attempt to integrate new scientific knowledge about natural ecosystem dynamics.

4.3 Historical Land Use

The PEF, like much of the surrounding land, has seen waves of human activities and alterations. While the USFS research area may have escaped agricultural activities in the last century, other portions of the PEF show clear evidence of past farming and grazing. Remnant fence lines in compartments A and C mark old boundary lines and agricultural areas. Most if not all of the forest area was harvested for timber at least once in the last 150 years. A “roll dam” on Blackman Stream at the Maine Forest and Logging Museum (Leonard’s Mills) indicates that log drives occurred on Blackman Stream and almost certainly included wood harvested from the surrounding watershed. Historic saw log harvests likely high graded out the best pine and spruce logs at the beginning of the 20th century. A booming tan bark industry in downeast Maine, in the early 1900s, led to large scale hemlock harvests in the region. In addition, the orientation of farm fields along routes 178 and 9, east and south of the PEF, indicate that historic farm parcels likely extended into nearly all the portions of the forest. This further supports the likelihood that both agricultural clearing and/or harvest for timber or fuel wood occurred since European settlement began.

Knowledge of these historical human activities may be critical to understanding the origins of current forest conditions on the PEF.

4.4 Condition of Lands Beyond Ownership Boundaries

The PEF stands out in the surrounding landscape because of the mature forest condition present on much of the acreage. 2007 aerial photographs reveal recent harvest activity on virtually all sides of the PEF boundaries. Most of this activity appears to be on the heavy side of the harvest spectrum. In many cases the PEF property boundary is clearly visible as a type change between heavily harvested private lands and lightly or un-harvested forest within the PEF. Significant amounts of the land to the north of Blackman Stream and Chemo Pond was industrial paper company land until the late 1990s. Much of this land received heavy harvests before and after land transfers that occurred when these companies sold off their land holdings. There are also significant water bodies and wetland complexes spread across the landscape. As noted in earlier sections on soils and geology, the forest sits in the Penobscot River valley, much of which is underlain by glacial marine sediments. This impervious substrate results a preponderance of wet sites dominated by organic soils. The condition of the forest within the PEF should be considered in relation to that of the surrounding forest.

4.5 Legal and Regulatory Considerations

The principle legal and regulatory concerns on the Forest involve primarily water quality and wildlife habitat. The State of Maine mandated shoreland zoning regulations (SLZ) govern a significant portion of the Forest especially in compartments C and D. Importantly, the enforcement of SLZ regulations is the duty of individual towns, although towns will soon have the option of relinquishing enforcement of timber harvesting codes to the Maine Forest Service. SLZ dictates timber harvesting procedures and levels around significant water bodies termed “Great Ponds” and related riparian areas, as well as smaller water courses and those non-forested wetlands at least 10 acres in size. The legislation has been interpreted and in some circumstances enforced by the Maine Forest Service[14] to prohibit harvesting within 75ft of the great ponds and related riparian areas and non-forest

[14] Timber Harvesting in Shoreland Zones. 2003. Maine Forest Service publication. http://www.maine.gov/doc/mfs/pubs/pdf/fpminfo/5_shoreland_zoning.pdf

wetlands larger than 10 acres. An area termed the "250ft buffer" governs the 150ft beyond the 75ft buffer; where harvesting is limited to removing no more than 40% of the basal area in a 10 year period in openings not to exceed 10,000ft^2. Maps B2A, B2B, and B2C depict these buffered areas and are included in appendix B. A stand map, created in 2008 to facilitate growth and yield modeling, incorporates these buffered areas in order to more accurately predict timber yields from the buffer zones.

Certain wildlife habitat areas also receive state or Federal protection. An active eagle nest, documented by the Maine IF&W department as essential habitat occurs on the shore of Chemo Pond in compartment C. Two buffered areas surround the nest. The immediate 330ft is off limits to all harvesting and equipment activities. A second buffer extending 990 ft beyond the edge of the inner buffer, prohibits harvesting during the nesting season and imposes harvest restrictions similar to the 250ft zone of the SLZ. The nest buffers are incorporated in stand maps for planning purposes. Deer wintering areas are of special concern in Maine and are designated as significant wildlife habitat. MIF&W maintains GIS maps of known areas; currently no such areas are mapped within the PEF boundaries.

The Maine Forest Practices Act (FPA) is another State regulation that governs the size of clear cut harvests. Harvest areas exceeding 5ac but less than 21ac in size with less than 30ft^2 of basal area that do not have acceptable stocking levels, post harvest, are considered a category one clear-cut. A category two clear cut harvest is one that retains less than 30ft^2 of basal area and exceeds 20ac but less than 76ac; requires a harvest plan. To date most harvests in the PEF have not been subject to FPA regulation. Forest management staff are knowledgeable about the FPA regulations and planning and operations are conducted accordingly.

5. Interaction with Nearby Properties

5.1 Current Land Uses and Conditions

As described in section 3.4 much of the forestland surrounding the PEF has seen recent heavy harvests. During the same period, title to a portion of this land has been recently transferred from vertically integrated forest products companies to investor groups such as TIMOs. Encroachment by development is occurring primarily along the Route 178 corridor to the west of compartment A. An aerial photo view (B11A) shows the development footprint in this area. While new housing units do not by any means dominate the landscape, the potential for their numbers to increase is high especially in light of the USFS report described in section 4.3. Pressure for camp lot development is strong in the State and a significant portion of the Chemo Pond shoreline abutting the compartment C is already heavily subdivided for this use (B11B).

5.2 Pertinent Ecological and Social Conditions

Of ecological and aesthetic significance is over 6000ft of undeveloped shoreland on Chemo Pond within compartment C. As noted earlier, compartment D is bounded by Blackman stream for over 3.5mi and 4500ft along Chemo Pond. This area has already been designated as a reserve area. In compartment C forest management activities in proximity to the lake will be conducted in accordance with shoreland zoning regulations and will take habitat and aesthetic considerations into account.

The PEF is in the heart of the region known as the lower Penobscot Valley. The large cities of Bangor and Brewer are less then 15 miles from the forest and represent one of the largest and fastest growing population centers in the State. The towns around this urban center report increased residential home and second home construction. A 2008 report by the USFS entitled Forests on the Edge suggests that this portion of Maine, *"is among the 15 watersheds in the Nation projected to experience the greatest increases in housing density on private forests by 2030."* If expectations about population and home construction prove true, the forestland surrounding the PEF will see substantial development pressure. Consideration of these trends should be made part of the management planning process. Increased growth holds a variety of implications for recreational use, wildlife habitat, invasive species, and the economics of the timber industry in the immediate area and entire region.

5.3 Invasive Species and Abutting Properties

While invasive species are not currently a significant problem on the forest they will almost certainly become one in the future. The forest should adopt protocols to reduce the likelihood of unintentional introductions of invasive vegetation. This must involve working with abutting owners who may already have infestations on their properties that pose a risk for spreading to the PEF ownership. This concern is especially pronounced along Chemo Pond where numerous camp lot abutters could foster introductions, and along major forest roads which are known to be significant vectors for invasives.

6. Silviculture, Harvesting, and Monitoring

The following section deals with the rationale and activities related to several core management elements. These include details of silvicultural systems, harvesting systems, harvest rates, as well as monitoring programs and protocols. The descriptions that follow pertain primarily to the managed portion of the forest in compartments A, B, and C. Based on GIS mapping, the total area of forest under management in 2009 is approximately 1260ac. This value represents the acreage described in section 3.1 (Table 6.1) less the stands that are not currently accessible and the area in Shoreland Zone (SLZ) 75ft buffers, which for management planning purposes is considered off limits to harvesting.[15]

Table 6.1 Acres of forest under management

	No Access	SLZ 75ft Buffer	Forest Land Under Management
Comp A	87	27	244
Comp B	0	4	495
Comp C	0	69	521
Total	35	100	1260

6.1 Silvicultural Prescriptions and Species Selection Rationale

A variety of silvicultural systems are currently or will in the future be used across the forest. At the most coarse level these systems can be broken into two classes, even-age and uneven-age (multi-aged). Even-age silvicultural systems include shelterwood, seed tree, and clear-cutting. Uneven-age systems involve the selection system as single tree or group cuttings. An additional uneven-age system classified as an irregular group shelterwood or by the German name "Femelschlag" is being utilized as part of a research and demonstration project on the PEF. Variations on this system may be implemented outside the research areas in coming years. This approach blends elements of both even and uneven-age systems.

In this early stage of University Forest management of the PEF, determination of where to implement each system will be made based on stand level assessments in coordination with overall management goals for the forest. In an April 2009 ROT meeting, it was suggested that general targets be established defining the percent area managed under three approaches: intensive even-age, uneven-age, and some mix of irregular shelterwood and traditional shelterwood. A split of 25%, 25%, and 75% in each respective category

[15] The forest within the SLZ 75ft buffers can be harvested under certain conditions but for purposes of this management plan and harvest scheduling scenarios, it has been decided that the area within this particular buffer should be considered out of production and therefore will not influence allowable cut determinations and related analysis.

might be the most appropriate. This idea was put forth after the modeling work—described in following sections—was completed. Overall the management directions described in the following sections align well with these targets although the area under intensive even-age management is below the 25% level.

In the run up to the 2009 management plan revision, specific stands were selected for uneven-age management. In all, 16 stands totaling 198ac were identified in this process. An additional 25 stands totaling 111ac fall in the 250ft SLZ buffer area and have been added to the uneven-age category. The percent area classified as under uneven-age management is 25%, out of a total of 1260ac currently under management (Table 6.2). Stand prescriptions for non-SLZ areas will generally be stand specific. SFR faculty member Robert Seymour has suggested broader application of the irregular group shelterwood system. Variations of the selection system will be applied as well, likely to include a single tree approach in one of the few northern hardwood stands on the forest, stand B63 (B2B).

The prescriptions for the SLZ 250 stands must be based on the pertinent SLZ regulations. As described in section 3.5 of this plan, harvests in the SLZ 250 are limited to removing no more than 40% of the basal area in a 10 year period in openings not to exceed 10,000ft^2. There are a number of ways to layout a harvest in accordance with this rule. A 2008 variation on the strip selection system[16] in stand C172_250 created a series of 50ft wide strip-cuts running perpendicular to the wetland edge separated by 100ft. All trees except specified leave/legacy trees were removed from the strips. If successfully regenerated, these strips and subsequent harvests of the residual areas will result in an area controlled uneven-age stand. Another system under consideration involves more circular openings, appropriately spaced and sized, based on pre-determined GPS points. Leave trees and the gap edge could be marked with the aid of electronic distance measuring tools to ensure accurate area determination.

Table 6.2 Area designated for uneven-age management

Stand Type	Count of Stands	Acres	Acres Treated Pre08	% Total Area Under Mgt
Non-SLZ	16	198	42	16%
SLZ 250	25	111	na	9%
Total	41	309	42	25%

The area slated for even-age management includes the managed forest area (Table 6.1) less the area designated for uneven-age management.

[16] Smith, David M, B.C. Larson, M.J. Kelty, and P.M.S. Ashton. 1997. ***The Practice of Silviculture: Applied Forest Ecology (Edition 9).*** Wiley and Sons, New York. P371.

The total acres in the even-age category are 951ac, or about 75% of the managed forest area. Even-age prescriptions will generally take the form of 1 or 2 stage shelterwood systems with provisions for permanent retention of a percentage of the overstory. These even-age treatments will represent a departure from traditional even-age systems in that variable amounts of retention trees will remain post harvest. This will create stand structures that are more complex then those of a true even-age approach. The result will be two storied, multi structured stands, representing a type of hybrid between traditional even and uneven-age systems. Clear-cuts with retention will be used selectively, initially only for the regeneration of specific wildlife patch-cuts that were installed in compartment C during the 1970's as part of a Dept of Wildlife Ecology research project.[17] These wildlife cuts total 28ac. Clear-cuts will also be implemented as part of specific research projects such as the Chestnut Foundation's blight resistant chestnut plantations.

Pre-commercial stand tending treatments are an important yet costly investment. The University Forests has a labor force of student workers who can be trained to complete PCT with a brushsaw. In 2009 there are few if any stands in the PEF that are ready for PCT. However even-age regeneration treatments are likely to produce such conditions by the end of this planning period. Therefore managers must reassess the details of implementing PCT as appropriate stand conditions are created. Such treatments will likely target, productive sites, well stocked with desirable species, and retain a mix of species.

Section 3.3 describes the application of scientific knowledge of regional natural disturbance regimes and what is termed the 1% rule to stand and forest level management. The 1% rule has been applied in the AFERP research project. If this rule were to be followed for the whole PEF, with 1260ac of forest currently under management, it would result in 12.6ac regenerated annually assuming a 100yr rotation age. To date, management of the PEF has not employed this concept. Growth models simulating management actions—described in detail in following sections—can aid managers in determining the extent to which proposed management actions resemble these natural forest dynamics.

Silvicultural prescriptions for individual stands are based on a multitude of criteria and stand conditions. The type of soils underlying the stand is of principle importance.

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[17] Bailey, Michael E. 1977. Production and Deer Utilization of Vegetation on Small Clearcuts in Central Maine. MS Thesis, Unpublished Manuscript. Graduate School University of Maine Orono May 1977

Stands on wet soils require different prescriptions from those stands occurring on dry soils. Section 3.2 of this plan describes the soil types present on the forest in detail. This information combined with GIS and field assessments will inform prescription development and execution. All systems will consider the retention, conservation, and recruitment of coarse woody material (CWM) like large downed logs and standing snags. A set of guidelines to aid in implementing this concept are included in the Maine Audubon harvest retention guidelines and will be considered as part of harvest planning on University Forests holdings.

The rationale for species selection for harvest and retention is based on multiple factors. As described in plan sections about biodiversity, achieving a diversity of vegetation types and structures is an important objective of management on the PEF. In accordance with this, managers wish to avoid mistakes of forestry's past when tree species—like yellow birch—considered to be "junk", were systematically eliminated from the forest only to become economically and ecologically significant in following decades. To this end species selection must be based as much on form class and quality as on species type. Species adaptation to site characteristics is also a critical consideration.

White pine is a dominant species on the forest and possesses desirable qualities such as rapid growth, longevity, and strong financial value in the marketplace. Special attention will be paid to perpetuating white pine on appropriate sites. To this end the shelterwood method will be an important tool. In addition, white pine can be regenerated using the femelschlag approach in the right circumstances. Eastern hemlock is a common species on the forest and in the eastern Maine region. It grows well on many sites across the forest and while not as economically desirable as white pine it is long lived and provides important habitat values as well as income opportunities.

6.2 Description and Justification of Harvesting Techniques and Equipment

A variety of harvesting equipment systems have been used on the PEF in the last decade. They range from one and two person cable skidder crews to whole tree harvesting with feller bunchers, grapple skidders, and stroke delimbers. Cut to length equipment has also been used. The USFS has preferred to use cable skidders on most of their research areas, though in winter 2009 they are experimenting with using a cut-to-length system to harvest a selection unit. The University Forest staff operates a cable skidder on the Demeritt Forest and occasionally will conduct harvests in the PEF with their equipment.

Future harvest operations are likely to involve a mix of cable skidders and cut-to-length systems. Under these two systems, careful operators can keep trails narrow and minimize residual stand damage. Softwood and mixed-wood stands lend themselves to harvest by either of these systems. The area in trails should generally be minimized to the greatest extent possible, targeting 15% or less. Soil and seasonal conditions are important considerations for the selection of harvest systems. Several hardwood dominated stands in compartment B are known to remain unfrozen during normal winters and have caused difficult operating conditions for cable skidders in the past. Cut-to-length equipment can operate on delimbed brush and thus has the potential to limiting soil compaction, rutting, and erosion, which are critical operational concerns for all stands in the forest. Equipment selected should be based on silvicultural and operation goals and constraints, avoiding a *one size fits all* approach.

6.3 Growth and Yield Simulation

Modern forest management must involve an assessment and projection of forest growth and yield as a means of insuring both sustainable harvest levels and maintenance of ecosystem integrity. With assistance from SFR faculty Wilson and Seymour, the University Forest has employed Forest Vegetation Simulator (FVS) based modeling software called Landscape Management System 2.1 (LMS)[18]. LMS is a powerful landscape management tool with a user friendly interface. The software allows for projection and treatment simulation of individual stands while also enabling projection of multiple stands—comprising a whole forest—with relative ease. Treatments are created and executed within LMS while growth projections are based on running individual stand tree lists through the FVS Northeast (NE) variant. Integration of spatial information, in the form of GIS stand maps, permits a spatially explicit analysis far superior to a process that ignores details about the arrangement of forest resources. Lastly, LMS enables the user to create realistic forest visualizations at the stand and landscape level, adding a whole new dimension to the communication of forest management activities.

[18] Two versions of LMS exist. Version 2.1 was used for the analysis described here, however 3.1 promises to be much faster with stand projections and will be used in future simulations of the PEF.

Spatial Inputs

Assembling the required LMS inputs began with updating multiple MapInfo GIS layers to ensure accurate depictions of a variety of spatial attributes across the PEF. This work started with updating the property boundary layer for the entire PEF ownership. The USFS Management Unit layer was also revised, ensuring accurate delineation of internal property lines. Among the most important of these GIS layers was the forest stand map of compartments A, B, and C (B2A, B2B, and B2C). Existing GIS stand delineations, originally derived from stereo photography, were updated where necessary, using 1 meter resolution 2007 NAIP ortho-photography.

National Wetland Inventory (NWI) GIS data was used in concert with ortho-photography to identify isolated non-forested wetland polygons ≥ 10ac and those polygons < 10ac but part of a larger wetland complex. These wetland polygons were used to create layers representing 75ft and 250ft SLZ buffers. All non-forested wetland polygons were assigned 75ft buffers; those polygons or complexes ≥10ac were assigned 75ft and 250ft buffers. The newly create stand polygons were then split along these buffer layers in order to create new stand polygons that accurately reflect the areas requiring special management protocol. Each stand was given a unique ID value to enable spatial integration with LMS.

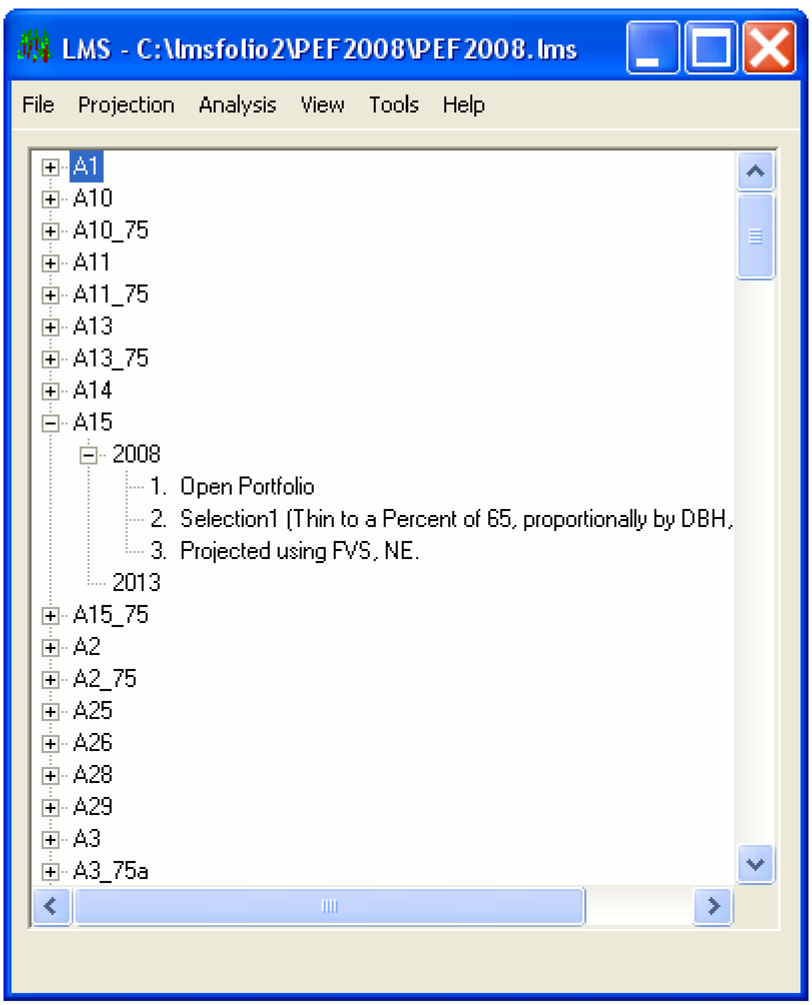

Figure 6.1 View of the LMS program running the PEF portfolio

Inventory Inputs

The next step required that each stand polygon be populated with inventory data termed a "tree list". A 2006 planning inventory gathered data on most of the stands that had not previously been harvested, in accordance with the 1999 PEF management plan. However, this inventory project missed a few stands, predominantly those not on the list for upcoming harvest. The project also did not assess the condition of recently harvested stands. University Forest staff in conjunction with SFR faculty members determined that an inventory of these remaining stands, especially those with regeneration present following harvesting, was needed before the planned LMS modeling could be initiated.

An inventory of these stands was conducted in the fall of 2008 utilizing variable radius overstory samples with nested fixed radius understory plots. Data from these two temporary inventories were imported into the new University Forest inventory database. Overstory and understory data from selected CFI plots were also used to bolster stand inventories that lacked an acceptable number of samples. Combining these two types of data eliminated the potential of generating meaningful statistical confidence values for the inventories associated with each stand. This was deemed a necessary evil to insure a more robust tree list for each stand. A few stands, mostly those of small size in isolated or very poorly drained sites still lacked inventory data. In these unique cases inventory from similar stands was used as a surrogate. NRCS soil polygons, with drainage attributes, enabled an average balsam fir site index value, based on slightly modified Briggs site classes[19], to be assigned to each stand polygon.[20] The modification to the Briggs classification involved lumping poorly and very poorly drained classes together.

Regeneration Inputs

Since FVS does not have a default way of generating regeneration, a specific regeneration tree list was created based on the sapling level data from the 2008 inventory and CFI data. A matrix of 9 unique regeneration tree lists, based on the intersection of 3 basal area values and 3 site index values, was created in Access. LMS can be set to automatically "plant" the appropriate tree list in a stand at the start of a projection period. Out of this process emerged an "LMS portfolio" for the PEF, ready for projection in 5yr periods and manipulation by simulated treatments.

[19] Briggs, R. 1994. Site Classification Field Guide. CFRU: TN6 MAFES: 724

[20] This Balsam fir SI value was converted to a Sugar maple SI value using a formula listed in FVS manuals SM_SI_value=(-1.404 + 1.104 * BF_SI_value)

Scenario Development

Based on recommendations from SFR faculty member Jeremy Wilson—an expert in landscape growth models and a member of the LMS software development team—2 management scenarios were created. Scenario 1 (Scn1) projects all stands 50 years into the future with no harvest actions simulated. This scenario serves as a bench mark against which other scenarios can be compared. The growth projections from this no harvest scenario indicate a calculated growth rate of approximately 1/3 of a cord per acre per year.

A second scenario (Scn2) was created to simulate one possible management scheme for the next 50 years. Harvests for Scn2, in the first 2 periods 2008-2018 (5yr periods), were based on an existing harvest schedule that had been worked out in 2007 using the 2006 inventory. This schedule targeted the most high risk stands, those with over mature canopies of intolerant hardwood, and attempted to keep the area harvested in a single year to approximately 35ac. This schedule also incorporated the timing of harvest of research areas for the first 20yrs.

Treatments were created in LMS to mimic those described in section 5.1 of this plan. These included intermediate treatments like thinnings, wildlife patch cuts, 2 stage

Table 6.3 Simulated treatments used in LMS Scn2

	Scn2 TreatCode	Treatment Name	Treatment Description	Silvi System	Uneven-age	Regenerated
1	SWEST	Shelterwood Establishment; Retain BA 60	Harvest is proportional through diameters targeting dbh 6-60 for merch reasons; 10% removal across all DBHs for trails	SW	FALSE	FALSE
2	SWOSR	Shelterwood OSR; Retain BA 15	Harvest targets dbh 6-60 for merch reasons; 10% removal across all DBHs for trails; 20% removal DBH 1-4 simulate rgn damage	SW	FALSE	TRUE
3	OSR	OSR not preceded by a SWEST; Retain BA 15	Harvest targets dbh 6-60 for merch reasons; 10% removal across all DBHs for trails; 20% removal DBH 1-4 simulate rgn damage	OSRw/R	FALSE	TRUE
4	SEL	Single Tree Selection; Retain 65% of BA	Harvest is proportional through diameters targeting dbh 6-60 for merch reasons; 10% removal across all DBHs for trails	SEL	TRUE	FALSE
5	THIN	Thin stand; Retain 65% of BA	Harvest is proportional through diameters targeting dbh 6-60 for merch reasons; 10% removal across all DBHs for trails	Tending	FALSE	FALSE
6	SLZ	Single Tree Selection; Retain 70% of BA	Harvest is proportional through diameters targeting dbh 6-60 for merch reasons; 10% removal across all DBHs for trails	SEL	TRUE	FALSE
7	WILD	Wildlife patch cut OSR; Retain BA 15	Harvest targets dbh 6-60 for merch reasons; 10% removal across all DBHs for trails; 20% removal DBH 1-4 simulate rgn damage	OSRw/R	FALSE	FALSE
8	SF_SWEST	Sp-fir Shelterwood Establishment; Retain BA 95	Harvest is proportional through diameters targeting dbh 6-60 for merch reasons; 10% removal across all DBHs for trails	SW	FALSE	FALSE

sherlterwood systems, and a selection system (Table 6.3). Since LMS and the FVS do not simulate the spatial arrangement of residual and harvested trees, spatially complex systems like a group selection cannot be modeled easily. Through using a GIS, the spatial context of a harvest can be incorporated into the model, but that type of complex and extremely time consuming work was not possible given time constraints on the modeling process for this planning process. The selection harvest that was modeled in LMS most closely resembles a single tree system rather than a group selection. However, in application it is assumed by the planners that most selection treatments will be conducted as some variation of group or expanding gap harvests. Additional treatments were created to simulate the establishment of trails and harvest related damage to regeneration during OSRs.[21] The order in which treatments are implemented in the model is important; trails were removed before the desired harvest was implemented to ensure that residual basal area targets were met. Trail area estimates of 10% were used, but 15% may be more accurate. While not spatially perfect, these extra treatments help to make simulations more representative of operation realities.

The outputs from these two scenarios were organized, summarized, and analyzed using Microsoft Access database software; appropriate results were imported to MapInfo and ArcGIS enabling a spatial analysis. An existing database, created by Professor Jeremy Wilson specifically for use with LMS outputs, was used for the final analysis of both Scn1 and Scn2 simulations. This database uses a basic inventory output file from LMS and through a series of queries, summarizes the data as it relates to volume, structure, habitat, and protection classifications. This easy to use database tool enabled staff to consider implications the two scenarios might have on a variety of forest conditions. It also allowed for comparison between the two management scenarios. A discussion of the results of these two scenarios is included in the following five sections, 6.3a through 6.3d.

6.3a Annual Harvest Rate, Area Regulation, and Standing Volumes

The management simulations created for the PEF help answer questions about sustained yield of timber volume. As noted in previous sections of this plan, the forest is currently dominated by intermediate and mature stand types. This condition is the result of little or no management activity on the non-USFS portion of the forest in much of the last century. University Forest staff and the ROT have determined that an area regulation approach is an appropriate starting point for a planning process aimed at better regulating the age structures and

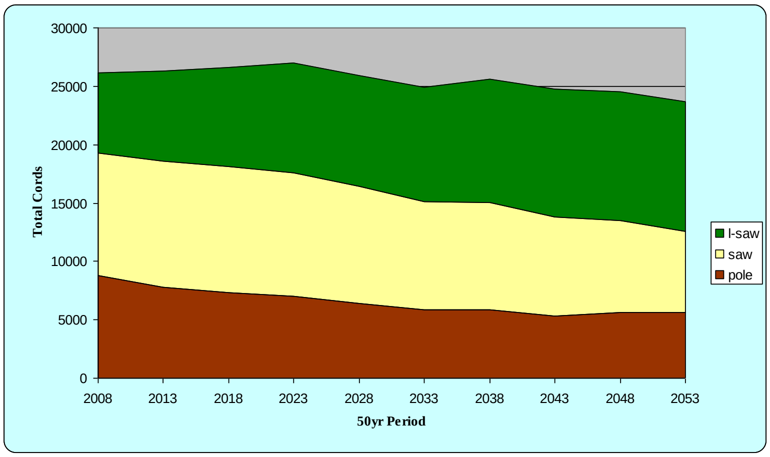

Figure 6.2 Scn2 Total cords of standing volume in managed forest area 1260ac

[21] Ray, David; Saunders, Mike; Seymour, Robert. 2009. Recent Changes to the Northeast Variant of the Forest Vegetation Simulator and Some Basic Strategies for Improving Model Outputs. Northern Journal of Applied Forestry. Vol. 26, No. 1, pp 31-44.

harvest volumes on the forest. Scn2 simulates a 50yr projection of management that calls for harvesting 35ac per year or 175ac per 5yr period.[22]

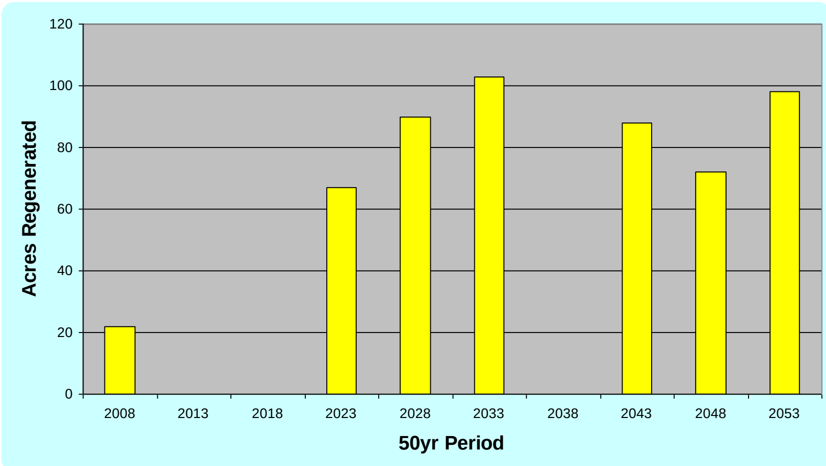

Figure 6.3 Scn2 Total acres regenerated

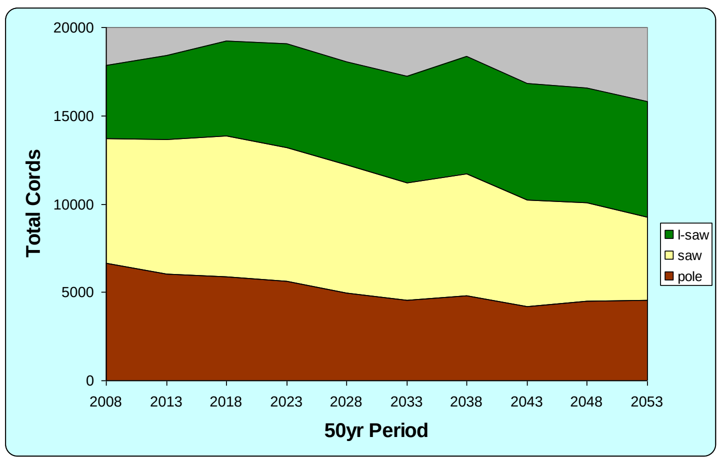

Figure 6.4 Scn2 Total cords standing volume in even-aged area

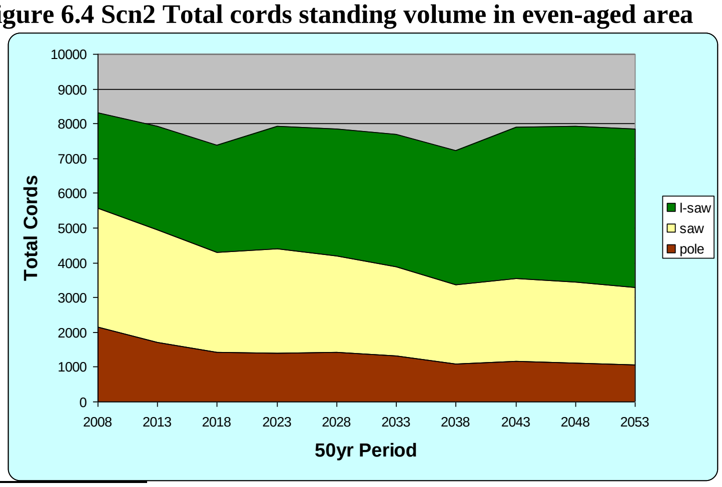

Figure 6.5 Scn2 Total cords standing volume uneven-age area 309ac

[22] Note that this 35ac per year is not a specific area control figure, but rather an estimation of what was operational feasible. However it also seems to fit well with silvicultural goals of regulation.

Results from this simulation show several important outcomes over the 50yr projection period. The first is a gradual decline in standing volume from the start of the period to the end (Figure 6.2). This is a logical consequence of moving towards an area regulated structure across the managed portion of the forest. Importantly, the area regulation concept only applies to the even-age portion of the forest as those stands under an uneven-age system should individually achieve a within stand regulation. However, many of the uneven-age stands also must undergo a volume reduction to achieve within stand regulation (Figure 6.5).

Even-age harvests simulated in Scn2 regenerated on average 10.8ac/yr. If a 90yr rotation is assumed on the 951ac area, true area regulation would require that 10.6ac be regenerated each year (951ac/90yr =10.6ac/yr). On average the harvests simulated in the model are nearly identical to this calculated goal of area to regenerate. However, these results are reported as averages and a look at the area regenerated per period in the simulation shows that the actually areas per period fluctuate from 0ac to about 100ac (Figure 6.3).

The second part of the regulation calculation involves estimating growth. Simulation outputs indicate the average gross cord per acre per year growth, for the even-age stands over the 50yr timeline in Scn2, equals 0.43cd/ac/yr. If this growth rate were applied in a simple area regulation calculation to a forest equal in size to the 951ac even-age area, growing uniformly at the 0.43cd/ac/yr rate, and managed on a 90yr rotation an estimate of the desired standing volume of a fully regulated forest can be reached. In this case such a

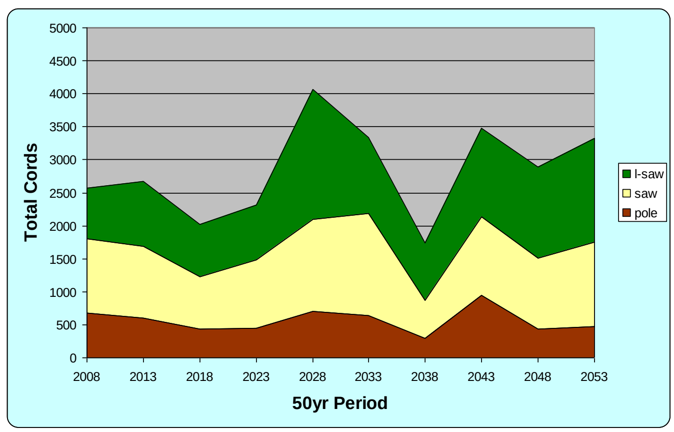

Figure 6.6 Scn2 Total cords harvest volume over 50 years

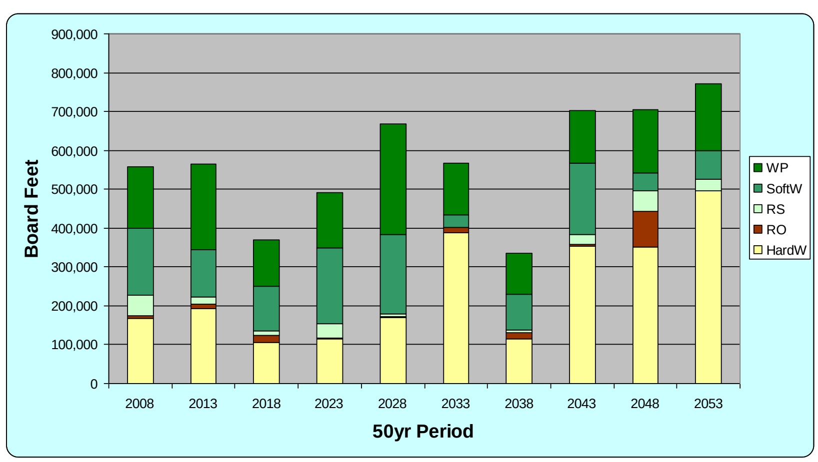

Figure 6.7 Scn2 Board foot harvest volumes of sawlogs

calculation gives 18,401cd.[23] Comparison of this value to that of the standing volume of even-age stands in period 2053 of Scn2 shows that volumes are reduced by just over 2000cd over the 50yr period from 17,800cd to 15,801cd (Figure 6.4). The fact that the simulated standing volume is less than the theoretical maximum, under complete regulation, at both the start and end of the simulation is not surprising. The theoretical value assumes maximum stocking and a constant growth rate, and constitutes a significant simplification of the forest. The fact that the standing volume at the end of the projection is within a few thousand cords of the theoretical goal of a regulated forest seems to indication a reasonably successful application of an intentional volume reduction to achieve long term sustainable harvest levels.

Year	HardW	RO	RS	SoftW	WP	TOTAL	Yearly Avg/Period	
2008	$ 22,347.07	$ 1,848.85	$ 7,800.29	$ 14,664.66	$ 23,254.84	$ 69,915.70	$ 13,983.14	
2013	$ 26,803.61	$ 3,372.27	$ 2,915.09	$ 11,700.94	$ 31,664.48	$ 76,456.39	$ 15,291.28	
2018	$ 14,694.66	$ 5,566.82	$ 1,907.59	$ 10,983.02	$ 17,260.75	$ 50,412.84	$ 10,082.57	
2023	$ 15,636.78	$ 372.56	$ 5,443.26	$ 17,864.83	$ 20,677.91	$ 59,995.34	$ 11,999.07	
2028	$ 23,820.43	$ 574.95	$ 1,634.12	$ 18,996.12	$ 41,691.25	$ 86,716.88	$ 17,343.38	
2033	$ 45,588.77	$ 4,023.18	$ 206.11	$ 5,556.11	$ 19,069.86	$ 74,444.03	$ 14,888.81	
2038	$ 15,623.15	$ 4,404.88	$ 1,109.32	$ 8,930.98	$ 15,017.78	$ 45,086.10	$ 9,017.22	
2043	$ 38,048.24	$ 1,408.78	$ 4,126.75	$ 19,202.19	$ 19,669.21	$ 82,455.17	$ 16,491.03	**Avg Per Period**
2048	$ 37,947.31	$ 26,191.19	$ 7,236.25	$ 6,157.09	$ 23,411.79	$ 100,943.63	$ 20,188.73	**$ 74,184.47**
2053	$ 57,479.22	$ -	$ 4,444.53	$ 8,825.38	$ 24,669.47	$ 95,418.61	$ 19,083.72	**Avg Per Year**
TOTAL	**$ 297,989.23**	**$ 47,763.49**	**$ 36,823.32**	**$ 122,881.31**	**$ 236,387.33**	**$ 741,844.68**		**$ 14,836.89**

Table 6.4 Scn2 revenue projections

An examination of the standing volumes in the uneven-age stands shows that a volume reduction of almost 475cd takes place during the period (Figure 6.5), about ¼ of the reduction simulated in even-age stands (Figure 6.5). This is likely due to the fact that all the uneven-age stands see one or two harvests during the projection period, while not all of the even-age stands are harvested due to merchantability and scheduling constraints.

6.3b Harvest Volumes and Revenue

Since certain financial obligations must be met annually a basic analysis of projected volume flows and revenues from Scn2 is necessary. Projected harvest volumes fluctuate per 5yr period ranging from approximately 2,000cd to 4,000cd (Figure 6.6). The 1260ac managed forest area is not large enough to truly regulate volume flows and thus some fluctuation must be expected. The area regulation approach, explained in the preceding section, should help smooth these flows in the long run, but cannot hope to completely overcome fluctuations. The sawlog volumes harvested in the simulation are dominated by white pine, other softwoods, and hardwoods, in respective order of significance (Figure 6.7). The annual

[23] An excel spreadsheet showing these calculation can be viewed through this link.

harvest of sawlogs for all species is projected to be around 100,000bf. The harvest of non-sawlog (pulp, firewood, biomass) volume is dominated by hardwood species with softwoods making up just over 30% of the total harvest over the 50yr scenario.

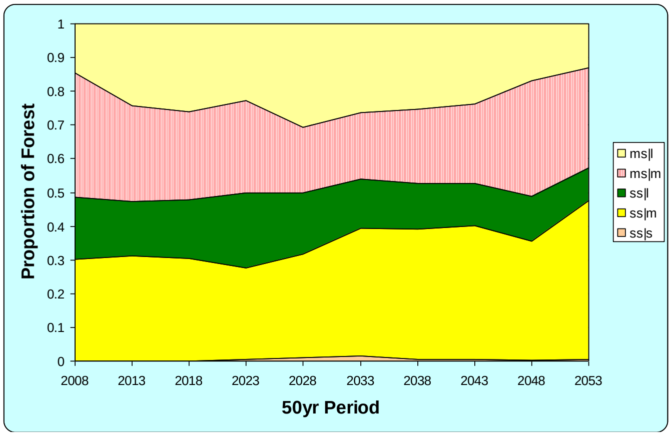

Figure 6.8 Scn2 Proportion of forest in 5 structural stages

A simplistic estimation of harvest revenues was developed based on LMS projected volumes and product value estimations from staff with 25 years of experience buying and selling logs, pulp, and stumpage for both. No attempt was made to adjust for inflation or product value increases, rather it is assumed that values will keep pace with inflation, but will not increase at a faster rate. Revenue estimates are conservative and reflect current wood prices which are on the low end of the price spectrum. These estimates are based on species specific prices for the two product types described above. White pine together with non-red oak hardwood sawlogs, provide over 70% of the total value of sawlogs over the projection period; (Table 6.4 Scn2 revenue projections). The average revenue per period from both sawlogs and other products is approximately $75,000. Together both product classes, break down to an annual average revenue figure of just under $15,000. The 5yr period starting in 2038 has the lowest projected revenue, where the average annual revenue dips to just under $10,000. The periods following 2038 see some of the highest revenue produced. Future management planning should work to smooth this fluctuation in revenue.

The annual cost of providing one full year scholarship to the University of Maine is currently about $6,500. A flexible portion of the remaining revenue will go towards the PEF research account. The estimates of annual revenue provide a comfortable margin with which to meet the financial obligations of the ownership. A discussion of finances today cannot be complete without some mention of the current global recession that has brought both world stock markets and local wood markets to historic lows. A portion of the PEF operating budget has in the past come from endowment dollars, which have suffered in the recent downturn. With the resumption of harvesting on the PEF in coming years stumpage dollars, despite expected poor markets, will hopefully help buffer the temporary loss of endowment income.

6.3c Structure/Development Stages

A variety of vertical stand structures are projected to persist on the forest throughout the 50yr period under either Scn1 or Scn2 across portions of compartments A, B, and C. In both scenarios proportional area is split fairly evenly between single-strata and multi-strata stand types. Under Scn2 the area in multi-strata stands of medium sized trees increase in area as do single-strata medium stands (Figure 6.8). A principle difference between Scn1 and Scn2 is the appearance of single-strata small stands as a result of regeneration scale harvesting activity. From a diversity stand point the general lack of this early successional structure is a noted deficiency. The PEF management objectives for biodiversity call for a diversity of structures to occur across the forest. These objectives are met under Scn2, with a few noted exceptions.

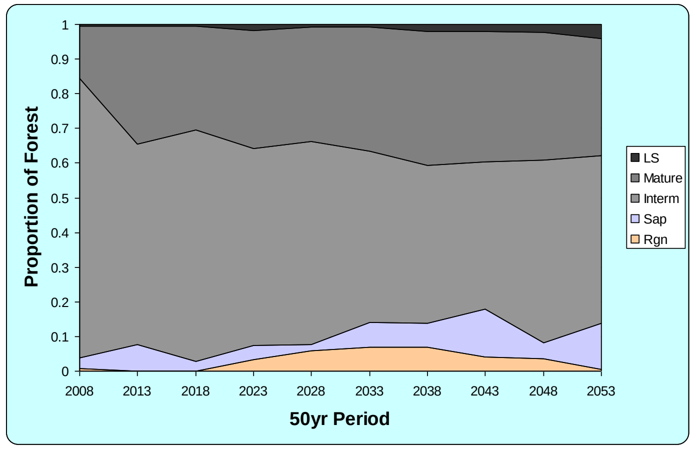

Figure 6.9 Scn2 Proportion of forest in FSF development stages

Using the Focus Species Forestry (FSF) classifications, described in earlier sections, related trends are observed. Scn1 shows an elimination of regeneration or sapling development classes and a gradual increase in mature and limited late successional classes. Under Scn2 the late successional (LS) class increases at a slightly faster rate than under the no harvest scenario. A pulse of regeneration or sapling development classes appear after 2018 when OSR harvests release regeneration established under shelterwood conditions in the first three periods (Figure 6.9). The forest remains dominated by the intermediate size class. While harvesting activity reduces this dominance slightly over that in Scn1, the lack of balance with respect to this class is something that should, at the very least, be considered during future management planning. The specific percentage goals, described in the the objectives section of this plan, with respect to this FSF classiscation are achieved under Scn2 with the exception of $\geq$ 10% of the area in LS conditions. It is important to note that this goal is difficult to reach because it requires an abundance of trees with large diameters, something that doesn't happen over night. The amount of forest that qualifies as LS does increase steadily over the 50yr projection, a trend that should continue in to the future.

6.3d Habitat

Simulation projections for both scenarios indicate that the percentage of forest classified as softwood will increase. In the case of Scn2 the softwood type will cover almost 40% of the forest over the 50yr period. This will come at the expense of primarily the area in mixed-wood type and to a lesser extent area in hardwood forest. The FSF habitat types are evenly distributed in proportional to one another in compartments A, B, and C at the start of the simulation period. This condition remains relatively unchanged under both scenarios with proportions remaining slightly better distributed under Scn2 (Figure 6.10). The exception to this is the northern white cedar type which gradually declines to almost 0% by the end of the projection. This decline may in part be due to a lack of cedar regeneration being simulated in the model. Analysis of area with the potential to serve as deer wintering habitat reveals that less than 5% of the forest can be classified as such habitat under either scenario over the simulation period. Currently, no portion of the forest is designed as deer wintering area (DWA) by the MIF&W. Managers may want to consider how management actions might create more of this forest condition in the future. The area around dismal swamp may currently serve as wintering habitat for deer in the PEF.

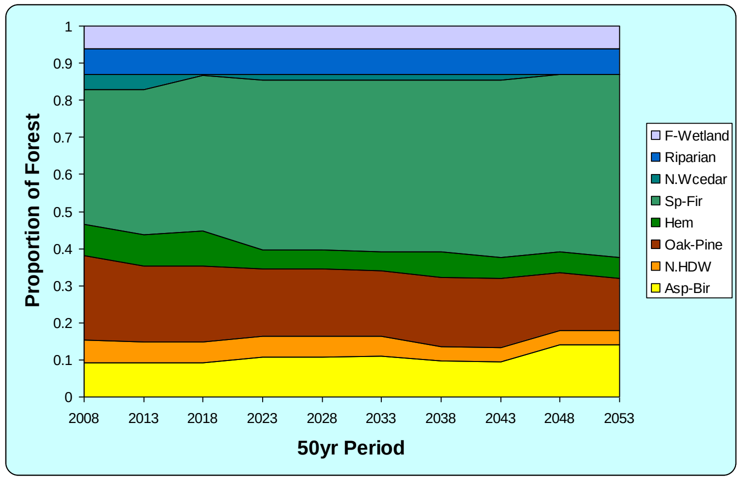

Figure 6.10 Scn2 Proportion of forest in FSF habitat classes

Conversely, more than 80% of the forest has the potential to serve as pine martin habitat under both scenarios. An index for late successional forest, created by Manomet[24] was applied to both scenarios. The Manomet index portrays the forest as being generally evenly distributed across the 9 index classes under both Scn1 and Scn2. However, as noted earlier the area classified under FSF as late successional is still less than the 10% goal across the forest at the end of the either simulation.

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[24] http://www.manomet.org/sites/manomet.org/files/scidocs-pdfs/FMSN2004-3LSIndex.pdf

6.3e Vulnerability

Concerns about vulnerability to a variety of native and exotic pests are critical to any management planning exercise. The PEF scores very well for susceptibility to both spruce budworm and the exotic hemlock wooly adelgid. The spruce budworm index shows a general increase in susceptibility in keeping with expectations as sapling stage balsam fir grows into more mature classes. However, the severe and very severe classes never reach more than 2% of the total forest area over the 50yr projection Scn2 and only rise above 2% at the end of Scn1.

6.3f 2008-2058 Harvest Schedule

Based on the LMS modeling and the results of Scn2 a recommendation for a 50 year harvest schedule has been developed. A PDF document entitled "Harvest Schedule 2008_2058" listing: the target stands, treatments (as simulated in LMS), project harvest volumes, related stand and or harvest attributes, and a detailed description of the treatments as modeled in LMS is include in appendix D of this document. Map B11 shows the spatial arrangement of treatment types during the first 15 years of the model. Based on LMS modeling this schedule satisfies the goals developed in the 2009 planning process. This is intended as a proposed schedule and is certain to be modified in application due to: market, logistical, weather, and other constraints. Market conditions are a critical factor in the operational application of this schedule. Stands can be swapped and substituted between harvest periods to accommodate species specific price conditions, or other operation factors. As described in previous sections, an area control approach was used in the schedule determination and therefore any substitutions between periods should consider the acreages treated. The treatments are described in detail in both sections 5.1 and 6.2. As noted in early sections the selection harvest that was modeled in LMS most closely resembles a single tree system rather than a group selection. However, in application it is assumed by the planners that most selection treatments will be conducted as some variation of group or expanding gap harvests.

6.3g Summary of Model Analysis and Achievement of Objectives

Overall, analysis of the model outputs describe a sustainable harvest schedule that satisfies multiple management objectives including sustainable timber supply, maintenance of a variety of forest conditions available to research and educational activities, and attention to principles of biodiversity. The following 3 sections discuss how well the model results demonstrate achievement of the first 3 management objectives.[25]

Objective 1: Sections 6.3a and 6.3b describe a gradual draw down of standing volume over 50 years in keeping with an intended area regulation approach. The area regulation effort simulated in this planning process appears to have the intended effect of reducing gradually standing volumes, though it would take roughly 100yr to complete the regulating process. The modeling work accompanying this plan ends at 50yr so there is no modeled prediction of how the regulation process concludes. Anecdotally, there appears to be plenty of standing volume and regenerated acres coming online at the end of the 50yr period satisfy the goals of sustainable timber supply. Harvest volumes fluctuate over the projection period, as does the area regenerated. Under ideal conditions these gyrations would be smoothed to provide more regularity to harvesting and income. Many of the most dramatic fluxes come after 20yrs and future managers will hopefully regulate these ups and downs. On average the projected income generated from harvests satisfies the financial objectives for the forest.

Research and Education: Determining achievement of the objective to provide opportunities for research and education through model outputs is not clear cut as the requirements are difficult to quantify given uncertainty about future needs. However, providing a variety of age classes, stand structures and forest types within a managed forest setting does provide some assurance that a diversity of options will be able for either research or education projects.

[25] Management objectives 1.4-1.6 are not discussed here as they are not easily quantified and thus analyzed as part of a modeling process.

Biodiversity/ Habitat/ Areas of Special Concern: As with the previous objective certain elements of biodiversity conservation do not lend themselves to quantitative analysis. Characteristics such as habitat quantity may be measured through mathematical means, but questions of habitat quality are much more elusive. Using the FSF stand classifications described in sections 6.3c and 6.3d some determination of available habitats can be made. Projected development stage distributions point to a diversification of forest conditions that include more young as well as late successional forest. If these distributions are compared to the objectives described in section 1.3, over all management actions successfully achieve targets for 3 out of the 4 classes for the majority of the 50yr period (Table 6.6). The target percentage of LS condition is difficult to achieve as large/old trees do not appear over night. Over the period the percent of LS forest increases but does not reach the goal of 15%. The LS forest condition is discussed in more detail in section 7.1.

Table 6.6 Measure of achievement of target percentages of FSF development stages as modeled in 50yr Scn2.

Development Stages	Target	YES	NO
Late Succesional	***≥ 15%***		
Mature	***≥ 20%***		
Intermediate	***≥ 20%***		
Sapling & Regen	***5-30%***		

The measure of habitat types on the forest based on the FSF classification indicates a constant diversity of types over the projection. The one exception being the northern white cedar type as noted in section 6.3d. Even though the species decline may be an artificial construction of the model it is still advisable for the condition of this forest type to be closely monitored by managers over time. An evaluation of projected conditions against habitat type objectives reveals that 4 out 6 of the criteria are met with the other 2, northern hardwoods and white cedar as candidates for continued attention (Table 6.5).

Table 6.5 Measure of achievement of target percentages of FSF habitat types as modeled in 50yr Scn2.

Habitat Types	Target	YES	NO
Aspen-Birch	*> 5%*		
N. Hardwood	*> 5%*		
Oak-Pine	*> 5%*		
Hemlock	*> 5%*		
Spruce-Fir	*> 5%*		
N. White Cedar	*> 5%*		

6.4 Provisions for Monitoring Forest Growth and Dynamics

The University Forest Office uses both CFI plots and temporary inventory samples on the PEF. The CFI system, described below, is currently re-measured every five years. Temporary inventory samples are taken as required for planning or operational activities. This system is appropriate for the property size and the staff time available to conduct such work.

A network of CFI plots was established on the PEF between 2000 and 2005 based on a protocol that has since been revised (Pre2008; Oct2009). Each year 20 plots were installed for a total of 100 plots on a 5 year measurement interval. Initially, each CFI plot was made up of 3 separate sample plots: a permanently marked 1/10ac circular overstory plot, a non permanent 1/100ac under-story plot, and a permanent 1/100ac coarse woody material (CWM) plot. The CWM plot was dropped after 2005 when the re-measurement process began. In 2008 the under-story plot was increased in size to a 1/50ac circular plot sharing the same plot center as the overstory plot. Measurements in the fall of 2010 will mark the completion of the first complete re-measurement cycle. To date no growth estimates have been worked up using this data set. The next plan update to be completed should utilize this data to calibrate growth and yield projections.

By December 2008 all of the CFI data had been added to the new inventory database. In the future, information from the CFI system will be integral to estimating volume growth, mortality and ingrowth. However, the true utility of this work will likely not be fully realized until after the close of the second re-measurement period. The CFI system for the PEF is up for review in the summer of 2009 to determine its current strengths and weakness. The review will consider how the network can be improved to ensure that significant information is collected in the most expedient fashion possible.

Starting in the summer of 2008 the University Forest Office embarked on an upgrade of its entire information/data management system in part to ensure a robust analysis of growth and yield questions across all its forestland. This upgrade led to the development of a Microsoft Access database, designed to manage both CFI and temporary forms of forest inventory data. This database is used in concert with GIS software to place inventory in its spatial context. The database also promotes the standardization of data collection and formatting, which is especially critical to ensuring the utility of CFI information in the long term.

Temporary inventory types include fixed and variable radius samples, line-transects, and 100% tallies. Collection of this data is organized into individual projects, where each project has a specific inventory goal but may involve a variety of sample types. Temporary inventories are used for both short-term harvest planning and long-term purposes like the preparation of management plans. Both CFI and temporary inventory activities are being updated to collect information important for answering biodiversity questions.

A single database housing all the inventory information enables staff to quickly feed tree lists to any number of inventory or growth and yield software. This capability significantly enhances the utility of field data and is critical to modern management planning. Integration of inventory data with GIS enables spatial analysis of forest attributes such as the distribution of forest/habitat types and merchantable timber volumes by site classes.

Tracking of harvested volumes is accomplished through a variety of methods. In some instances pre-operation cruises tally all marked timber. Cruise estimations of volume can be compared against mill slip tallies to help validate cruising efforts. If a pre-operation cruise is not possible then the mill slips are used to determine harvest removals in terms of volume. Post-operation cruises are also used to determine removals if pre-operation data is available. The University Forest is currently considering how best to track harvest volumes, for all its operations, using database technology.

6.5 Invasive Vegetation Management

Section 3.8 of this plan indicates that presence of invasive vegetation, in managed areas of the PEF, is minimal at the current time; however this is almost certain to change in the future. When evidence of invasive vegetation is discovered the first step must be the development of a control plan. With a plan in place, management may use a variety of control options both mechanical and chemical. A table of control options for relevant species, created by Maine Audubon, lists species specific measures.

In addition, maintenance activities like mowing and re-seeding of roads and landings can result in unintentional introductions. To minimize this potential mowing equipment should be carefully cleaned before it is moved onsite so no unwanted seeds are introduced. Mowing should also start in the center of the forest and work outwards to the edges where invasive vegetation is most likely to occur. This will help reduce the potential for mowing equipment to bring seed into the heart of the forest. Mulch and seed mixes should be selected carefully to minimize the possibility of introducing seed sources.

6.6 Forest Protection

Wildfire is an ever present danger in Maine's forests. Though infrequent when compared to other regions, forest fires in Maine have the potential to severely impact managed forests because very few of our native tree species are adapted to withstand even a modestly severe surface fire. Most forest fires in the northeast are caused by humans, some indirectly by our machines but most are the result of human carelessness. In addition to the students, staff, and researchers working in the PEF, the PEF is used year round by visitors engaged in a diverse array of recreational pursuits. With the exception of the shore of Blackman Stream and Chemo Pond, virtually all of this use is via the extensive gravel road network on the PEF. The roads are thus the key to prevention, education, and suppression.

Prevention:

The PEF system of roads and gates makes it possible to reach almost all of the workers and visitors with only a few informational signs to raise awareness and encourage vigilance. Signs of this type are available from The Maine Forest Service. (See Appendix F)

Education:

Fire prevention and emergency response is part of the training for all of the USFS and University personnel working on the PEF. All the contracted loggers working on the forest are Certified Logging Professionals (CLP) and have received fire prevention training.

Suppression:

Wildfire suppression on the PEF is the direct responsibility of the towns of Bradley and Eddington. A call to 991 will dispatch the appropriate town's fire department. It is thus vital for forest workers and visitors to know where the town lines cross the PEF. Currently these lines are not well marked. One action item resulting from this plan will be the clear demarcation of the town lines along with appropriate signage so that calls to 911 can reach the right first responders.

Preparation:

Roads: Ensure all roads are adequately brushed out and well maintained to permit fire equipment access.

Water Access Points: Identify and maintain appropriate tanker turnarounds and general access to designated water access points. (B9)

Bridges: Maintain bridge structures capacity to carry the 1000 to 1200 gallon tankers that will be respond to fire events.

7. Environmental Safeguards

7.1 Biodiversity Monitoring and Assessments

The University Forest Office is committed to protecting those plants, animals, and natural communities that are unique and potentially imperiled. Additionally, the Office is committed to managing for a diversity of ecosystem types and conditions, while satisfying other management objectives. Multiple approaches are employed to ensure the protection and conservation of these resources. Primary among these is the use of GIS to map the locations of important species and habitats. Locations of important species are obtained from State agencies like MIF&W and MNAP, University researchers working in the PEF, and the field observations of staff during routine forest inventory activities. Advances in GPS technology greatly improve the spatial resolution of this type of information. The University Forest Office has access to forest industry standard GPS units as well as high end units capable of sub-meter accuracy. It must be noted however, that despite multiple sources of information and sophisticated technology the property size prohibits an exhaustive survey for all species and or habitat occurrences. In the absence of perfection, the PEF relies on the best efforts of staff to ensure compliance with legal and ethical responsibilities.

Table 7.1 Stands classified as LS using FSF criteria

Period	Count	Projection Year	Stand	FSF DEV
1	1	2008	A29	LS
2	1	2013	A29	LS
4	1	2023	B205	LS
5	1	2028	B205	LS
6	1	2033	B205	LS
7	1	2038	A26	LS
	2	2038	B205	LS
8	1	2043	C106c	LS
	2	2043	A26	LS
	3	2043	B205	LS
	4	2043	C106a	LS
	5	2043	C106b	LS
9	1	2048	B205	LS
	2	2048	C106a	LS
	3	2048	C106b	LS
	4	2048	C106c	LS
	5	2048	A26	LS
10	1	2053	B205	LS
	2	2053	C106a	LS
	3	2053	C106b	LS
	4	2053	C106c	LS

Section 3.4 of this plan describes the current forest conditions with respect to biodiversity and unique communities and species. Section 4.4 notes that the mature character of the forest within the PEF stands in contrast to much of the surrounding privately owned forest. The forest also occurs on the edge of a growing urban area to the south and west. These two factors should play an important part in management decision making. If the PEF occupies a unique place in the surrounding landscape then management should carefully consider actions that might dramatically alter this condition. Importantly, the potential role the PEF might play in serving as a bastion of mature forest must be considered carefully in the context of other management objectives such as the silvicultural and habitat goals of creating a more balanced age structure across the ownership.

Section 6.3 explains in detail the forest simulation work completed for this plan to answer both silvicultural and biodiversity questions about the future forest. Projections of forest conditions enable analysis of the implications management actions may have on the objectives of maintaining and enhancing conservation attributes across the managed forest. Lack of late successional (LS) forest is an often cited deficiency of working forests in the region. Based on FSF classifications, simulation projections indicate that the presence of LS forest will increase over time. This is attributed largely due to the lack of harvesting in the SLZ 75ft zones and to a lesser extent the SLZ 250ft areas. There are some non SLZ stands that meet the LS requirements and these should be considered for special management options (Table 7.1). Jeremy Leicy '09 completed his FTY 477 capstone class project using the LMS portfolio of the PEF. One of the goals he tried to reach in simulating management was to increase the amount of LS forest condition. He identified several stands that are classed as LS early in the simulation and if left untreated in the short term serve to increase the percentage of LS forest, thereby bringing the forest closer to the 10% goal.

7.2 Protection of Rare, Threatened, and Endangered Species

Locations of nest sites or other habitat areas are mapped using a combination of staff knowledge and reconnaissance and State wildlife agency data. Once these resources are mapped the necessary restrictions on management operations can be integrated into the planning process. For example, the known location of a bald eagle nest on the south side of Chemo Pond enabled the creation of appropriate buffers in GIS, which then informed the development of stand maps. These maps are utilized in the LMS model where simulated harvests are tailored to meet harvest guidelines defined for the nest buffers.

As of the writing of this plan no endangered species are known to occur within the PEF. It is possible that the Bald Eagle, already federally de-listed, may also be removed from the list of threatened species in Maine in 2009. As noted above, an active eagle nest, documented by the Maine IF&W as essential habitat exists on the shore of Chemo Pond in compartment C (B10B). Two buffered areas surround the nest. The immediate 330ft is off limits to all harvesting and equipment activities. A second buffer, extending 990 ft beyond the edge of the inner buffer, prohibits harvesting during the nesting season and imposes harvest restrictions similar to the 250ft zone of the SLZ. The nest buffers are incorporated in stand maps for planning purposes. Deer wintering areas are of special concern in Maine and are designated as significant wildlife habitat. MIF&W maintains GIS maps of know areas; currently no such areas are mapped within the PEF boundaries.

Maps from MNAP and MIF&W indicate the presence both rare plants and significant wildlife habitat. The rare plants include, Clematis occidentalis (Purple Clematis) *ranked as an S3* by MNAP, in the USFS portion of the ownership (B10A & B10B). The S3 plant Carex oronensis (Orono Sedge) has been identified on the Maine Forest and Logging Museum (Leonard's Mills) land (B10A). Portions of the Chemo Pond shoreline in compartments D and C are home to two S3 aquatic plants (Potamogeton pulcher and Pipewort - water lobelia) (B10A & B10B). Large wetlands and parts of the Chemo Pond shoreline are known nesting habitat for shorebirds and have been identified as significant wildlife habitat and ranked by MIF&W (B10A & B10B). The shoreline areas are protected under the SLZ guidelines and so no other special management considerations are planned for that habitat. Vernal pools are known to exist on the property but no comprehensive survey information about these habitats is currently available. While vernal pools are classified as significant wildlife habitat by the State, forestry activities are exempted from regulation. A manual developed by Calhoun and deMaynadier in 2006 titled Vernal Pool Habitat Management Guidelines will be used to inform management planning and harvest operations around these sensitive areas. To facilitate identification and mapping of habitat and unique features, the University Forest Office plans to create a simple survey form to be carried by all cruising teams during inventory projects. When a unique feature or habitat, like a vernal pool, is found the crew will complete the form and GPS the location to update GIS layers.

8. Maps

Maps are referenced throughout this document. Mapping is a basic but essential part of any level of forest management. Today geographic information systems (GIS) are the standard for cartographic projects but also greatly expand the potential spatial analysis of forest resources. GIS mapping of the PEF has formed the foundation of virtually every part of this management planning process including: inventory design, stand delineation, wetland delineation, riparian and wetland buffering, LMS stand inputs, LMS output analysis, and habitat and biodiversity analysis. The data layers that form the basis of the maps which accompany this plan were generated using MapInfo software. The actual maps were created in Adobe Illustrator using base maps created in MapInfo and ArcGIS. The following list of features and attributes are depicted on maps in appendix 2. Each item on the list below also serves a clickable link to a PDF of the map itself.

1. B1 property boundaries; compartments; roads; research areas;
2. B2A Comp A: stand boundaries; SLZ / riparian zones; wetlands; streams;
3. B2B Comp B: stand boundaries; SLZ / riparian zones; wetlands; streams;
4. B2C Comp C: stand boundaries; SLZ / riparian zones; wetlands; streams;
5. B3 forest types;
6. B4 soil drainage classes;
7. B5 ecological reserve areas;
8. B6 2008 FSF development classes;
9. B7 2008 FSF habitats classes;
10. B8 topography;
11. B9 life flight landing zone and fire fighting water access locations;
12. B10A (PEF east) locations and habitats for sensitive, rare, threatened, and endangered species;
13. B10B (PEF west) locations and habitats for sensitive, rare, threatened, and endangered species;
14. B11 15 Year harvest schedule 2008-2023;

9. Adaptive Management

9.1 Critical Management Directions and Considerations

There are numerous important considerations that need to be revisited and monitored over the life of this management plan. The following is a brief summary of some of the most important of these topics.

Harvest Schedule: Implementation of the harvest schedule in a timely fashion is necessary to stay within the modeled growth and yield projections. This will be challenging to be sure, but should receive significant attention.

Regeneration Assessments: Monitoring the success or failure of regeneration treatments is essential. If regeneration failures occur or species composition varies significantly from expectations then managers must consider the implications of such events on future available volumes as well as the stand types/conditions evaluated during the 2009 planning process.

Northern White Cedar: Along these lines the model predictions of a decline in white cedar should be given significant attention as part of a monitoring and adaptive management approach. When harvests as planned for areas with significant amounts of NWC special attention should be given to promoting the species and then monitoring harvest results.

9.2 Future Plan Updates

This management plan is based upon the best available information and technology as well as staff time. If one thing is certain in the planning process, it is that staff, procedures, and software will change in the future. This reality necessitates that this planning document be able to evolve with new realities. The website like format of this document will hopefully help in reaching this goal. The standardization of data collection, processing, and storage is proving very beneficial for the University Forest, but the greatest benefits will likely be realized when future planning updates are undertaken. Well structured data and clear planning objectives will allow current and future staff to meet the goals of adaptive management. Orderly GIS data will enable future retrospective analyses to consider the spatial context of management actions and consequences. The MOU currently requires 10yr plan updates making the next update due in 2019. (See section 11. for additional future consideration for management planning on the forest.

9.3 Response to Climate Change

Recently, both public awareness of, and scientific knowledge about, climate change has surged to the forefront across the globe. Climate change presents a new challenge to the foresters tasked with managing forest resources for multiple objectives. To date, management planning has involved predictions of future stand structure, composition, and economic value, but going forward these elements must be considered in light of the potential for significant changes to climate during the span of a single rotation. This potential flux adds another critical factor for managers to consider when planning for the future. A 2009 report by the University of Maine Climate Change Institute outlines the likely climate impacts for the State of Maine.[26] The report indicates the region containing the PEF will likely see temperature changes averaging about 6°F for all seasons, as well as increased precipitation. Succinct descriptions of the potential impacts on forests and the implications for forest management provide useful background on this topic. Maine Audubon has also

[26] Jacobson, G.L., I.J. Fernandez, P.A. Mayewski, and C.V. Schmitt (editors). 2009. Maine's Climate Future: An Initial Assessment. Orono, ME: University of Maine.

published a one page document outlining basic principles relating to forestry and climate change.

In a 2007 paper, published in the journal Ecological Applications, Constance Millar and colleagues[27] propose that forest managers consider three options when confronting climate change in the management of forest resources. The options include managing for ecosystem **resistance**, **resilience**, and/ or the capacity for ecosystems to **respond** positively to a changing climate by adapting to a new set of circumstances. Millar proposes that foresters consider trying to increase stand and or forest **resistance** only in cases of high economic or ecological value. Maintaining such a stand would come at the expense of considerable effort and energy. The authors recommend that forests which have a strong likelihood of returning to normal condition after a disturbance and that can accommodate changes in climate should be managed with the concept of **resilience** in mind. Similar to the idea of resistance, resilience may only be feasible in the short term. Both of these approaches can be though of as mitigation strategies, meant to forestall what maybe inevitable changes; the purpose being to reduce the negative impact to ecosystems and human society brought on by such changes. The third concept requires managers to find ways to assist forested ecosystems to **respond** and **adapt** to climate changes and thereby promote long-term ecosystem integrity. Inherent in all three concepts, especially the third, is the idea of spreading risk rather than concentrating it (Millar et al. 2007)

This idea of reducing the potential for catastrophic loss by using a diversity of management approaches is akin to the precautionary principle, which states that when the future is uncertain actions should err on the side of caution, thus reducing the likelihood that unanticipated outcomes will trigger disruptions. Mention of the precautionary principle is limited in forestry literature; however, fisheries management literature contains many references to the concept. A 2007 paper by Gerrodette et al.[28] discusses the importance of the principle in relation to the stability of marine resources, and describes a useful concept termed "precautionary buffers." At the most basic level the idea requires that prudent management of resources, where uncertainty about sustainable harvest levels exists—due to

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[27] Millar, Constance I. Stephenson, Nathan L. Stephens, Scott L. 2007. Climate Change and Forests of the Future: Managing in the Face of Uncertainty. Ecological Applications, Volume 17, Number 8, pp. 2145-2151.
[28] Gerrodette T, Dayton PK, Macinko S, Fogarty MJ. 2002. Precautionary management of marine fisheries: moving beyond burden of proof. Bulletin of Marine Science: Vol. 70, No. 2 pp. 657–668

ecological variables like climate—requires that management consider "buffering" (reducing) harvest levels relative to the level of uncertainty. Applying this concept to forestry might involve a reduction of annual allowable cut to a specific level below the annual volume growth, thus providing a cushion incase of unforeseen ecosystem alterations due to climate change.

10. Forest Workers

10.1 Staff and Contractor Training

The University Forests employs three regular staff members as well as graduate and undergraduate interns to manage the 13,000+ acres of University Forests. About half of this land base is owned by the University and half, including the PEF, is owned by the University of Maine Foundation. The PEF represents about 1/3 of the acreage responsibilities of the University Forests.

The Forest Manager (3/4 time position) is responsible for administration and overall management of the land including mapping, inventory, and records. The Forest Manager is a faculty member with the School of Forest Resources (1/4 time) and for the past 4 years has been able to engage graduate students in the Master of Forestry Program (M.F.) in the forest management process. This plan is in many ways a direct result of the Houston Graduate Fellowship program which has supported Richard Morrill (M.F. expected May 2009) as he worked closely with the regular staff, the ROT, and the faculty to complete it.

The full time Operations Manager oversees day-to-day operations including harvest contracts and records, forest products marketing, road maintenance, and is the safety officer for the Forests. The full time Forest Technician's time is focused on the PEF and the Demeritt Forests. The Forest Technician supervises the 6-10 undergraduate student workers, oversees the annual CFI work, and is responsible for vehicle, facility, and property maintenance including boundary lines, mowing, and early stand tending treatments. The Operations Manager and the Forest Technician are both Certified Logging Professionals (CLP) and are instructors for CLP workshops. They attend and or deliver several training sessions each year to remain current. In addition, they both belong to the Master Logger Certification Program that has additional standards and inspections for training, procedures, and harvest sustainability. The Forest Manager is a Licensed Professional Forester in Maine which requires continuing education through workshops and professional meetings to remain current.

In addition to the professional certification and training requirements outlined above, all University Forest employees, both regular and student employees, must be current with First Aid, CPR, University annual safety training, work site specific training, and task specific training. The Operations Manager maintains a listing for every employee to be sure that these requirements are met.

The contractors who do the harvesting on the PEF are required to have current CLP training and credentials. For the past 4 years, all three contractors working at the PEF have belonged to the Master Logger Certification Program.

11. Future Planning Goals and Needs

11.1 Forest Inventory

The current planning process is comprehensive but with some noted areas for potential improvements. A principle improvement for future management planning on the forest must be the inventory of Compartment D the reserve area. The 2009 plan does not have any information about the forest conditions in this compartment and as a result the landscape level approach is missing a critical element. Temporary inventory projects as part of future planning must be designed to include this portion of the forest. It might be possible to conduct such an inventory on a forest type basis rather than an individual stand approach. In addition to including compartment D forest inventories should also be designed to measure forest attributes related to biodiversity issues not just timber. This would mean an inventory looking at stand and downed dead wood in the forest. Another potentially feature to inventory are vernal pool resources on the forest. Better mapping and monitoring of invasive vegetation should also be incorporated into the inventory process.

11.2 Landscape Level Forest Modeling

The forest modeling completed as part of the 2009 planning process is a good first step. However, future efforts should attempt to include the USFS portion of the forest as well as the AFERP research areas. Bringing these parts of the forest into the analysis for current and future forest conditions will provide a much more robust landscape level analysis. It may also be possible to consider the forest conditions within the immediate parts of the forest boundary. An inventory any area outside the forest would necessarily have to be done at a very coarse scale but would none the less be a valuable consideration if management is to be conducted based on landscape level considerations.

Appendix A. Research Summaries

A.1 AFERP

A Brief History of AFERP:
Acadian Forest Ecosystem Research Program

www.forest.umaine.edu/facstaff/facstaff_pages/wagner/FERP/default.html

Figure 11.1

During the early 1990s, there was a broad movement in forestry to adopt silvicultural regimes that were based on the disturbance ecology of a given region. This movement precipitated a new paradigm, called "New Forestry," that initially swept through the Pacific Northwest and other western states. In the Northeast, Seymour and Hunter (1992) published the "Triad" concept of forest land allocation; this was an attempt to address many of the biodiversity concerns with traditional forestry systems that were being applied in the region. Under the Triad, the forested landbase was allocated into three major uses: 1) 10-20% reserves, 2) 10-20% production silviculture, and 3) the remaining 60-80 % is treated according to principles of ecologically-based forestry.

The Triad, had one glaring weakness—there were few or no examples of disturbance-based silvicultural systems being studied around the country, including the Acadian Forest Region. Traditional silviculture methods, like those found in the long-term silviculture experiment at the Penobscot Experiment Forest (PEF) (Sendak et al. 2003), had weaknesses that might make them unfeasible for broader management at the landscape scale under an ecological forestry paradigm. Research with hybrid silvicultural systems, hybrids of both even-aged and uneven-aged systems, was needed.

To fill this research niche, the Acadian Forest Ecosystem Research Program (AFERP) was established in 1994. AFERP was designed as an interdisciplinary, long-term research effort that would complement the USDA Forest Service's experiment at the PEF near Bradley, Maine. AFERP's mission is to: 1) Enhance understanding about the forest ecology of the Acadian Forest Region; 2) Evaluate ecosystem-scale effects of forest practices; and 3) Explore the potential for developing alternative silvicultural techniques and systems based on regional disturbance ecology. An overarching objective for AFERP is to provide the science that helps landowners develop hybrid systems that combine the economic advantages of even-aged methods with the flexibility to provide many of the structural features found in uneven-aged stands.

Although AFERP is only a teenager, it is currently one of the countries oldest running experiments on the effects of disturbance-based silviculture. Our first sample inventories were taken from 1995-1997 the season before initial harvest treatments were installed. Since then, AFERP has contributed in many ways to UMaine's overall research infrastructure. For example, AFERP has provided a platform for: 7 graduate research projects, 3 undergraduate capstone projects, and numerous groups on field tours of the experiment. The 3 years form 2005-2007 were milestone years for AFERP during which the first round of gap expansions were installed (2^{nd} entry). These successes would not have been possible without support from many sources including the University Forests Office. With our next measurement cycle rapidly approaching (2010-2012), we look forward to the next 15 years; a period that includes: 3 inventories, harvest entry 3, and the first round of expansions on our small gap treatment.

A.2 Maine LEAP

The **Land-use Effects on Amphibian Populations** study, or LEAP, is a multi-region, collaborative project involving researchers at several universities. The LEAP study is funded by the National Science Foundation (NSF) and is being conducted at study sites in Maine, Missouri, and South Carolina. This website is dedicated to the portion of the study being conducted in Maine by researchers from The University Department of Wildlife Ecology at the University of Maine.

Global declines in many amphibian species are of great concern to conservationists and while many factors are implicated in these losses (e.g., global climate change, ultraviolet radiation, disease) habitat loss and degradation are two of the most important issues. In the context of forest management the most likely effects are linked to changes in the cool, moist microclimates that many amphibian species prefer. More specifically, the size of canopy openings and the fate of coarse woody debris (CWD) associated with forest logging are likely to be key factors influencing amphibian habitat.

We are studying these issues in a five-year project funded by the National Science Foundation using four replicated experimental arrays. Each array is oriented around an amphibian breeding pool with four delineated terrestrial quadrants (~2.5 hectares each; 164 m X 250 m) surrounding it (Fig. 1). Two are in the Penobscot Experimental Forest and two in the University's Demeritt Forest; analogous sets of arrays have been established at the Savannah River Site in South Carolina by the University of Georgia and at the Daniel Boone Forest in Missouri by the University of Missouri. The size of the quadrants is based on biological criteria for terrestrial habitat needs of salamander populations (i.e., 164 m for retention of 95% of the population dispersing from a breeding pool; Semlitsch 1998). At the scale of amphibian habitat use each array can be considered to represent a heterogeneous landscape. Each quadrant has been randomly assigned a different forest management treatment: 1) complete clearing with coarse woody debris (CWD) removed, 2) clearing with coarse woody debris retained, 3) partial cutting (about 50% of canopy retained), and 4) uncut forest control (Fig. 1). Within each array amphibians are surveyed using drift fences constructed of 1 m tall silt fencing and pitfall traps at 5-m intervals on both the inside and outside of each fence. A fence with pitfalls complete encircles each pool approximately 1 m from the water's edge (Fig. 2). In each treatment, there are also 3 10-m fences at 50 m, 6 at 100 m, and 9 at 150 m, with a total of 72 traps per treatment, and 288 per site. This arrangement allows the same proportion (38%) of the arc at each distance to be sampled.

Pitfall traps are checked approximately every other day from late June through early October, the period when juvenile amphibians are dispersing away from breeding sites. Captured individuals are identified, aged, sexed for adults, measured (snout-vent length) and marked using visible implant elastomers (VIE) sometimes individually, sometimes by date and/or location. Captures and recaptures of marked animals allow us to assess habitat selection choices made by different groups (species, age class, size class, and sex). The consequences of these choices in terms of survival, growth, and reproduction are assessed by keeping select species (wood frog *Rana sylvatica*, northern leopard frog *Rana pipiens*, and spotted salamander *Ambystoma maculatum*) in pens located in each treatment where they can be periodically surveyed for growth and mortality. Further insight into habitat selection is being obtained by following the movements of individuals using radiotelemetry and fluorescent powder trailing.

To date we have published two papers from our work, three more are in manuscript stage, two Phd students will complete their dissertations in 2007 and 2008, a third is being recruited currently, and a continuing proposal will be submitted to NSF in 2007.

Management of LEAP sites on Penobscot Experimental Forest

Viorel Popescu (PhD student) and Malcolm Hunter (PI)
**Submitted to the University Forests on October 6, 2009*

The two LEAP sites on the PEF (South Chemo and North Chemo) will no longer be monitored for amphibian species. We are currently in the process of removing the drift fences and other structures built in the past 6 years from the two sites, as well as the pond liner placed in the South Chemo central pool.

Further management at these sites should be based solely on the University of Maine Forest Office silvicultural and/or scientific requirements.

A.3 Four-Toed Salamander M.S. Research

Research by a MS student, Rebecca Chalmers '04, in Wildlife Ecology located and map Four-Toed Salamander nest sites on the PEF[29]. Spatial data from the research project shows the location of actual nest sites most of which fall within the USFS research area. The only site on the University Forest managed area is along the eastern edge of a large wetland in compartment C (B10B). The nests sites are mostly within an inoperable non-forested wetland and the portion that is on forested ground falls in a 75ft SLZ buffer. Harvesting activities in this area should be conducted in concert with the Vernal Pool Habitat Management Guidelines developed by Calhoun and deMaynadier 2006.

[29] Chalmers, Rebecca. 2004. Wetland and Nest Scale Habitat Use by the Four-Toed Salamander in Maine. MS Thesis, Unpublished Manuscript. Graduate School University of Maine Orono December 2004

A.4 USFS Research

Penobscot Experimental Forest

John C. Brissette, Thomas A. Skratt, and Laura S. Kenefic [30]

Introduction

In the mid-1940s, nine pulp and paper and land holding companies discussed establishing a long-term research area for the spruce fir (*Picea-Abies*) forest type so important to Maine. In 1950 these companies pooled resources and purchased land in east central Maine, about 16 km (10 miles) north of the city of Bangor. Approximately 10 km (6 miles) long and 1.6 km (1 mile) wide, the 1,540 ha (3,800 acres) were leased to the U.S. Forest Service's Northern Research Station for 99 years to provide a location for long-term forest management research in a mixed northern conifer forest.

The property was named the Penobscot Experimental Forest (PEF). Its history before 1950 is not well documented. Only a small portion was cleared for agriculture or grazing, but much of the area was cut lightly in the recent past (perhaps 20 to 40 years before 1950) for pine, hemlock and spruce sawlogs. Earlier cutting may have been heavier; charcoal and old burned stumps in some areas indicate fires following cutting of pine. In 1950, the PEF had an irregular age structure, with some trees more than 200 years old.

In 1994, the industrial owners donated the PEF to the University of Maine Foundation. With the donation, the owners stipulated that the mission of the Forest is "to afford a setting for long-term research conducted cooperatively among U.S. Forest Service scientists, University researchers and professional forest managers in Maine; to enhance forestry education of students and the public; and to demonstrate how the timber needs of society are met from a working forest." Under a formal agreement between the University of Maine Foundation and the Northern Research Station, the Forest Service maintains control of its long-term research and any new research is subject to approval by a committee of University and Forest Service scientists.

Climate

The climate is cool and humid. The 30 year (1951-1980) normal (i.e., mean annual) temperature for nearby Bangor, Maine is 6.6 ^{o}C (43.9^{o}F). February, the coldest month, has an average daily temperature of 7.1 ^{o}C (19.3 ^{o}F) while July, the warmest, averages 20.0 ^{o}C (68.0 ^{o}F). Normal precipitation is 1060 mm (41.7 inches), with 48

[30] Project Leader, Forestry Technician (retired), and Research Forester, U.S. Forest Service, Northern Research Station

percent falling from May through October. Annual snowfall averages 239 cm (94 inches). Average growing season is 156 days.

Soils

Soil attributes of the PEF are primarily the result of glacial influences; consequently the soils are highly complex and variable. Wisconsin glacial till derived from fine grained, dark colored sedimentary rock forms the principal parent material. Major soil types occurring on the glacial till ridges are well-drained Plaisted loams and stony loams, and moderately well-drained Howland loams and sandy loams. Flat till areas between the ridges are occupied by poorly and very poorly drained Monarda and Burnham loams and silt loams. Outcroppings of vertically bedded shale covered by a thin mantle of till represent the Thorndike stony and very stony loams.

Some of the lowest areas along the present water courses and in depressions are occupied by deposits of lake and marine fine sediments. Common soil types of these parent materials include moderately well-drained Buxton silt loam, poorly drained Scantic silt loam, and very poorly drained Biddeford silt loam and silty clay loams.

A treeless flood plain occurs along Blackman Stream, the major water course in the PEF. Soil types here are very poorly drained Saco silt loams and fine sandy loams. Glacio fluvial sands and gravels are limited to a small esker system along Blackman Stream at the northeastern edge of the PEF. Soils on these materials are excessively drained Stetson gravelly sandy loam, well-drained Stetson fine sandy loam, and well-drained Machias fine sandy loam.

A few organic deposits of muck and peat occur. In general, such soils do not support forest stands, but those on the experimental forest do.

Major Plant Communities

Under a recent ecological land classification, the location of the PEF is within the Central Maine Coastal and Interior Section of the Laurentian Mixed Forest Province. It is dominated by mixed northern conifers, including eastern hemlock (*Tsuga canadensis*); spruce, mostly red (*Picea rubens*) with some white (*P. glauca*); balsam fir (*Abies balsamea*); northern white-cedar (*Thuja occidentalis*); eastern white pine (*Pinus strobus*); and, infrequently, tamarack (*Larix laricina*) or red pine (*P. resinosa*). The most common hardwoods are red maple (*Acer rubrum*); paper birch (*Betula papyrifera*); gray birch (*B. populifolia*) and aspen, both quaking (*Populus tremuloides*) and bigtooth (*P. grandidentata*). Sugar maple (*A. saccharum*), yellow birch (*B. alleghaniensis*), American beech (*Fagus grandifolia*), white ash (*Fraxinus americana*), black cherry (*Prunus serotina*), northern red oak (*Quercus rubra*), and American basswood (*Tilia americana*) are scattered throughout the Forest. Canadian literature refers to this forest type as Acadian.

Data Bases

Road and topographic maps are in digital format. A soils survey in the 1960s resulted in a map that was recently digitized. In 1988, forest stands in those areas not in long-term research were typed and mapped from aerial photography and that map has also been digitized. The 1988 data were updated with field sampling in 1996. A depth to water table map has been created for the forest, and GPS data have been collected for compartment boundaries, roads, and some sample plots.

Forest Service researchers measure growth, yield, stand structure and species composition in a number of treated and control areas, called compartments, covering almost 30 percent of the total PEF area. About one half of these compartments date from the 1950s, the rest have been established at various times since then. Periodic inventories are taken on a network of approximately 580 permanent plots. These plots consist of three concentric circles, the whole plot 0.08 ha (0.2 acre) in size, the inner plots 0.02 ha (0.05 acre) and 0.008 ha (0.02 acre). Tree species and quality information are recorded and diameter breast height (DBH) at 1.37 m (4.5 ft) measured on living trees. Condition of dead trees, or snags, is also recorded. All trees and snags larger than 11.4 cm (4.5 in) DBH are measured on the whole plots. Living trees with DBH between 1.27 cm (0.5 in) and 6.4 cm (2.5 in) DBH, and between 6.4 cm and 11.4 cm DBH, are measured on the 0.02- and 0.008-ha plots, respectively. Regeneration (living trees taller than 15 cm (6 in) but with DBH less than 1.27 cm) is measured for several height classes and ground cover is recorded on three 4.05-m^2 (0.001-acre) plots located on the circumference of the 0.02-ha plot. On a subset of 0.08-ha plots, height, crown length, crown width and spatial location are recorded for trees larger than 11.4 cm DBH. Inventories are taken every 10 years and before and after each stand entry. Volumetric data are calculated from a local volume table. All inventory data from this long-term research are stored in electronic format.

Examples of Research

There are presently close to 50 individual Forest Service research areas comprising about 445 ha (1,100 acres) on the PEF. The largest study, a replicated experiment comparing a number of silvicultural treatments, was established between 1952 and 1957 on about 162 ha (400 acres) (see the study plan "Silvicultural Effects on Composition, Structure and Growth of Northern Conifers in the Acadian Forest Region: Revision of the Compartment Management Study on the Penobscot Experimental Forest"). The experimental design is completely random; each of nine treatments is replicated twice for a total of 18 stands, called compartments. Treatments include three intensities of the selection system (5-, 10- and 20-year cutting cycles), two uniform shelterwood strategies (two- and three-stage overstory removals), two diameter-limit cutting methods (fixed and modified diameter limits), and a commercial clearcut. In addition, two compartments were established in a "natural" area to serve as an experimental control. Although there was no evidence of recent harvesting when the controls were selected, cutting likely occurred in the past.

Over the years, additional experiments have been overlaid on the silviculture study. For example, studies of soils, leaf area, wildlife, understory vegetation, and entomology have been completed or are ongoing. These experiments tested or are testing hypotheses about responses to silvicultural treatment.

A number of additional stands, called units, are managed predominately under the selection system with a 15-year cutting cycle. The units are less intensively studied that the compartments and fewer data are collected; only trees over 11.4 cm DBH are measured.

Within a year of the PEF being leased to the Forest Service, an unreplicated demonstration was installed and has been maintained since. Called the Management Intensity Demonstration, this 16-ha (40-acre) area was divided into four blocks. Four treatments are demonstrated: commercial clearcut with and without precommercial thinning, diameter-limit cutting, and selection cutting on 5- and 15-year cycles. These stands are inventoried every 5 years with all trees over 11.4 cm DBH measured and saplings and seedlings sampled.

There are a small number of genetic test plantings on the PEF. In the 1960s, provenance tests of both eastern white pine and white spruce were planted. A half sib progeny test of white spruce was planted in 1974-75. Additional studies of shelterwood cutting, retention, strip cutting, and burning has been initiated over the years; a complete list of Forest Service experimental areas is attached.

Faculty and students at the University of Maine account for an increasing number of areas on the PEF used for research, currently totaling about 120 ha (300 acres). The University's major effort on the PEF is the long-term Acadian Forest Ecosystem Research Program (AFERP). AFERP is investigating effects of innovative silvicultural prescriptions on ecosystem structure and function; response of trees, other flora, fauna and soil processes are being evaluated.

Facilities and Administration

The Penobscot Experimental Forest is one of 14 experimental forests assigned to the Northern Research Station's Research Work Unit NRS-07, "Center for Research on Ecosystem Change," (CREC) which has staff in Maine, New Hampshire, Vermont, Massachusetts, and Minnesota. Research on the PEF and other experimental forests operated by CREC is part of an integrated research program (see the Center's Research Work Unit Description).

Currently all the permanent structures on the PEF are Forest Service buildings. Near the center of the Forest is a two-story building constructed in the 1950s that was once used as a field office and quarters but has been replaced with a newer facility closer to the entrance to the PEF.

The current Forest Service facility is a 208-m^2 (2240-ft^2) building completed in 1997. It has offices, a library/conference room, workspace, bedrooms, bathrooms and a basement with workshop and storage areas. It is fully accessible to individuals with physical disabilities. It also houses the administrative offices of the Maine Forest and Logging Museum, which is located adjacent to the PEF and shares the entrance road.

The Forest has 6 miles of good quality gravel road traversing it. There are also over 4 miles of additional gravel loop roads providing access to most of the research areas.

Location

The PEF is located in the towns of Bradley and Eddington, Maine, across the Penobscot River from Orono and the University of Maine. State Highway 178 parallels the eastern bank of the river and provides access to the Forest. The Forest Service administration building is on the access road about 0.4 km (0.25 mile) from Highway 178. It is located at approximately 44 degrees 52.7 minutes North and 68 degrees 39.2 minutes west. Winter access beyond the Forest Service office may be limited to skis or snow machines.

Suggested Reading

Brissette, J.C. 1996. Effects of intensity and frequency of harvesting on abundance, stocking and composition of natural regeneration in the Acadian Forest of eastern North America. Silva Fennica 30(2): 301-314.

Garber, S.M., J.P. Brown, D.S. Wilson, D.A. Maguire, and L.S. Heath. 2005. Snag longevity under alternative silvicultural regimes in mixed-species forest of central Maine. Canadian Journal of Forest Research 35: 787-796.

Kenefic, L.S., P.E. Sendak, and J.C. Brissette. 2005. Fixed diameter-limit and selection cutting in northern conifers. Northern Journal of Applied Forestry 23: 77-84.

Safford, L.O., R.M. Frank, and E.L. Little, Jr. 1969. Trees and shrubs of the Penobscot Experimental Forest, Penobscot County, Maine. Research Paper NE-128. U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station, Upper Darby, PA. 27 p.

Sendak, P.E., J.C. Brissette, and R.M. Frank. 2003. Silviculture affects composition, growth, and yield in mixed northern conifers: 40-year results from the Penobscot Experimental Forest. Canadian Journal of Forest Research 33: 2116-2128.

Seymour, R.S. 1995. The northeastern region. In: Barrett, J.W. (ed.). Regional silviculture of the United States, third edition. John Wiley & Sons, New York: 31-79.

Weaver, J.K., L.S. Kenefic, R.S. Seymour, and J.C. Brissette. In press. Decaying wood and tree regeneration in the Acadian Forest of Maine, USA. Forest Ecology and Management.

Contacts

For general information about the Forest, or to schedule a tour, contact:

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U.S. Forest Service, Northern Research Station
686 Government Road
Bradley, ME 04411
Tel: (207) 866-7255

For specific information about research, or if interested in conducting cooperative research, contact:

Project Leader, Center for Research on Ecosystem Change
U.S. Forest Service, Northern Research Station
Louis C. Wyman Forest Sciences Laboratory
271 Mast Road
Durham, NH 03824-0640
Tel: (603) 868-7632

or

University Forests Office
University of Maine, School of Forest Resources
5755 Nutting Hall
Orono, ME 04469-5755
Tel: (207) 581-2887

List of U.S. Forest Service, NRS-07 Experimental Areas on the PEF (as of February 2009)

Compartment Study

Compartment	Treatment
4	Fixed diameter-limit cutting
8 †	Commercial clearcutting
9	Selection cutting (5-year)
12	Selection cutting (10-year)
15	Fixed diameter-limit cutting
16	Selection cutting (5-year)
17	Selection cutting (20-year)
20	Selection cutting (10-year)
21 ††	Shelterwood (2-stage overstory removal)
22 †	Commercial clearcutting
23A †††	Shelterwood (3-stage overstory removal) with precommercial thinning
23B	Shelterwood (3-stage overstory removal)
24	Modified diameter-limit cutting
27	Selection cutting (20-year)
28	Modified diameter-limit cutting
29A	Shelterwood (3-stage overstory removal) with precommercial thinning
29B	Shelterwood (3-stage overstory removal)
30	Shelterwood (2-stage overstory removal)
32A	no harvest
32B	no harvest

† location of rehabilitation study
†† location of precommercial thinning and fertilization study (Study 58)
††† location of Cooperative Forestry Research Unit commercial thinning study

Management Intensity Demonstration

Compartment	Treatment
90	Selection cutting (5-year)
91	Selection cutting (15-year)
92	Fixed diameter-limit cutting
93A	Commercial clearcutting
93B	Commercial clearcutting
93C	Commercial clearcutting with precommercial thinning

Additional Compartments

Compartment	Treatment
2A ‡	Shelterwood with retention
2B ‡	Shelterwood with retention
6	Shelterwood with retention
7A	Shelterwood (2-stage overstory removal)
7B	Shelterwood (2-stage overstory removal)
10	Shelterwood with retention
13	Diameter-limit cutting with crop tree retention
25	Diameter-limit cutting with crop tree retention
33§	Strip cutting

‡ location of logging methods study
§ inactive study

Units

Unit	Treatment
3	Selection cutting (15-year)
11	Selection cutting (15-year)
14	Selection cutting (15-year)
18	Selection cutting (15-year)
19	Selection cutting (15-year)
26	Selection cutting (15-year)
31	Selection cutting (15-year)
50	Selection cutting (15-year)
51	Selection cutting (15-year)
52	Selection cutting (15-year)
53	Shelterwood
54	Selection cutting (15-year)

Plantations

	Treatment

Appendix B. Forest Resource Maps

1. **B1 property boundaries; compartments; roads; research areas;**
2. **B2A Comp A: stand boundaries; SLZ / riparian zones; wetlands; streams;**
3. **B2B Comp B: stand boundaries; SLZ / riparian zones; wetlands; streams;**
4. **B2C Comp C: stand boundaries; SLZ / riparian zones; wetlands; streams;**
5. **B3 forest types;**
6. **B4 soil drainage classes;**
7. **B5 ecological reserve areas;**
8. **B6 2008 FSF development classes;**
9. **B7 2008 FSF habitats classes;**
10. **B8 topography;**
11. **B9 life flight landing zone locations;**
12. **B10A (PEF east) locations and habitats for sensitive, rare, threatened, and endangered species;**
13. **B10B (PEF west) locations and habitats for sensitive, rare, threatened, and endangered species;**
14. **B11 15 Year harvest schedule;**

Appendix C. 2008 Forest Stand Conditions

C.1 2008 Stand Conditions

Appendix D. Harvest Schedule 2008-2058

D.1 PEF 50 Year Harvest Schedule 2008-2058

D.2 Map B11 15 Year harvest schedule 2008-2018

Appendix E. Commonly Used Abbreviations in the Text

Abrev	Full Term
Ac	Acre(s)
AFERP	Acadian Forest Ecosystem Research Project
BF	Board Feet
Cd	Cord(s)
CFI	Continuos Forest Inventory
Comp	Compartment
FPA	Forest Practices Act
FSF	Focus Species Forestry manual by Maine Audubon
FVS	Forest Vegetation System
GIS	Geographic Information System
GPS	Global Positioning System
In	inche(s)
LEAP	Land-use Effects on Amphibian Populations
LMS	Landscape Management System
LS	Late Successional
MFS	Maine Forest Service
Mi	mile(s)
MIF&W	Maine Inland Fishers and Wildlife
MNAP	Maine Natural Areas Program
NRCS	Natural Resources Conservation Service
OSR	Overstory Removal
PEF	Penobscot Experimental Forest
ROT	Research Operation Team
Scn1	LMS model Scenario 1
Scn2	LMS model Scenario 2
SFR	School of Forest Resources
SLZ	Shoreland Zoning
SVS	Stand Visualization System
USFS	United State Forest Service
Yr	Year(s)
DWA	Deer Wintering Area
CLP	Certified Logging Professionals

Appendix F. Forest Protection Additional Resources

Maine Forest Service – Forest Protection Division

Wildfire Control, Natural Resource Law Enforcement, Incident Management and Disaster Response

Mission Statement

The mission of the Division of Forest Protection is to protect homes and Maine's forest resources from wildfire, respond to disasters and emergencies and to enhance the safe, sound, and responsible management of the forest for this and future generations.

Maine's Forest Protection Division is a member of the Northeastern Forest Fire Protection Commission or "Compact" which was formed shortly after the devastating forest fires of 1947. Members include all the New England States, New York, the Provinces of New Brunswick, Quebec and Nova Scotia, plus the New England Forest which includes the White, Green and Finger Lakes Forests. This Compact was assembled to bolster fire suppression capabilities, as well as meeting training needs. Equipment and manpower are often called upon during the forest fire season, greatly increasing each member's fire fighting arsenal. The full membership meets each year during a week long winter training/meeting session. Former State of Maine-Forest Commissioner Austin H. Wilkins was instrumental in forming the Compact, fifty years ago.

For more information you may e-mail the Executive Director-Thomas Parent at necompact@pivot.net

The Northeastern Forest Fire Compact Web site is located at: http://www.nffpc.org/

Central Region Headquarters -

Old Town: (207) 827-1800

Local Fire Departments Contact Information

Eddington Fire Dept

906 Main Road Eddington, ME 04428
(O)207-843-5251
(H)207-843-0628
(FAX)207-843-5275
Contact Person: Gene D. Kelso

Bradley Fire Dept

Phone 207-827-9273

Forest Use Application Form:

For research, education, and demonstration activities/uses or other developments on the properties managed by the University Forests, University of Maine

Any planned or proposed activity; the Woodlands Manager must approve use or development on the University Forests in advance. Any proposed activity must be summarized in an application, which must include the following information:

1. Description of the proposed activity/use,
2. Objectives of the activity/use,
3. Nature of the activity: Educational, Demonstrative, Research, Recreational, other, (explain),
4. Amount of land involved,
5. Location of proposed activity, a scaled map showing compartment block,
6. Who will benefit from the activity/use, Dept., College?
7. What is the amount and source of funding for the activity/use,
8. What time frame is associated with this activity/use,
9. Will this activity/use make long term or permanent changes on the site or affect its availability for other uses or activities?
10. Who will be responsible for developing and coordinating the proposed activity/use?
11. Will any follow-up or long-term work be required for the activity/use? If so, who will be responsible for such work?

Please submit this information and maps to Alan Kimball, Woodlands Manager.

Alan Kimball, M.S., LPF
Forest Manager & Assoc. Prof. of Forest Resources
250 Nutting Hall
University of Maine
Orono, ME 04469
581-2849 (office)
356-0622 (cell)