Reporting on FIA's Forest-Land Indicators for the Northeastern US

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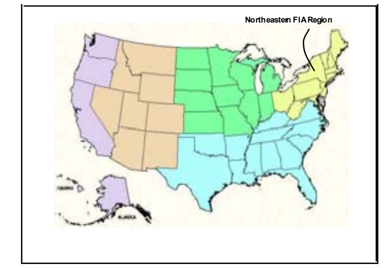
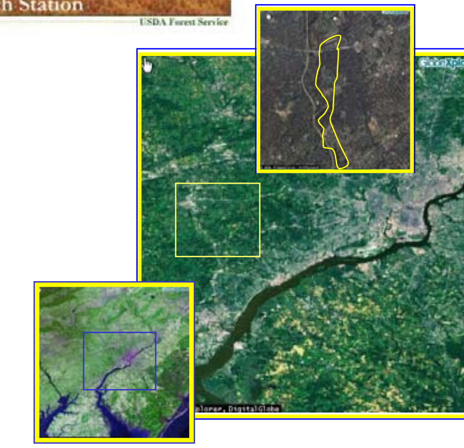
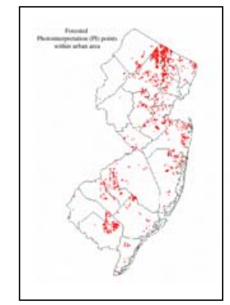
Abstract: The USDA Forest Service's Forest Inventory and Analysis (FIA) project contributes to state, regional, national, and international assessments of forest health by providing indicators from the four-phase measurement system employed across the Northeastern US. Forested ecosystems of the Northeast are strongly influenced by social forces--their extent, composition, structure, function, and vitality are the result of human impacts. As such, the forces of urbanization, parcelization, and fragmentation are valuable descriptors of the effects of human populations and associated patterns on the landscape. Trees growing on land technically not classified as forest add important benefits to society. The traditional suite of FIA reports and other products provide valuable insight into resource issues, for example, the status of balsam fir in Maine following severe spruce budworm outbreaks and salvage harvesting. Some issues, such as the status of oak, transcend FIA regional boundaries and require larger-scale analysis. New annual inventory reporting protocols include reporting for years prior to full completion of each State's inventory and publishing comprehensive analytical reports every five years. The incorporation of forest health monitoring indicators has widened the array of ecological indicators that can be examined. Integrating intensive site monitoring (ISM) data with FIA samples offers promise in addressing "scaling up" issues. For example, collecting information on carbon associated with forest litter at ISM sites provides the opportunity to develop a model for predicting this component across the northeast. Adjunct studies and other value-added research fill gaps between standard reporting products and special issues. The purpose of this poster is to present forest-land indicators being developed and reported for the Northeastern United States. Examples of other indicators include estimates of carbon budgets, regeneration adequacy, timber products output, and net primary productivity. Most of the indicators discussed fall under Criteria of the Montreal Process.

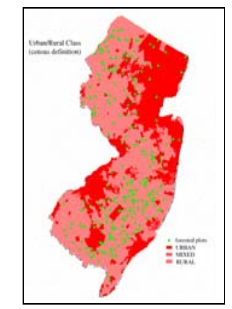


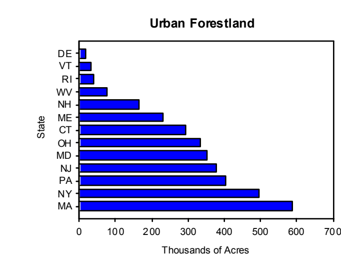


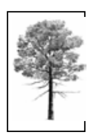
Urbanization: extent and abundance of people in the context of forest location and function is key to understanding how "urban" forest is defined. Forests that meet standard FIA definitions must be at least an acre in size (or 120 feet wide) and have an understory that provides the opportunity for renewal (regeneration). By relating population statistics developed by the U.S. Bureau of Census to FIA locations that meet these requirements, estimates of forestland for different population levels reveals interesting information on "forests in an urban setting." This supplements more intensive inventories conducted within urban areas for street trees, clumps of trees, and other arboreal assemblages (see Trees on Non-Forest Land below).

Estimation Procedures: There are many options for estimating "urban forestland." In the past FIA has used estimates based on land-use conditions surrounding FIA sample plots. The traditional estimate includes the area represented by all forested sample plots that are completely surrounded by urban development based on evaluation by FIA field crews. This can be a difficult variable to classify in the field, so alternative methods have been explored with the intent of developing a method that is objective, repeatable, and available for use across the northeastern US. A study in NJ used the 1990 Bureau of Census population density and urban/rural/mixed classes to classify FIA's Phase 1 and 2 samples. Four approaches were evaluated:
1) classify and sum FIA P1 plots with population density > 1000 per square mile,
2) classify and sum FIA P1 plots classified as "census urban (see first map at right),"
3) classify and sum FIA P2 plots with population density > 1000 per square mile,
4) classify and sum FIA P2 plots classified as "census urban" (see second map at right).
The study concluded that classifying FIA P2 plots using either the 1000 per square mile threshold or the census urban definition produced meaningful estimates of urban forestland and that the use of Block Group level data are recommended. The use of the population threshold may be preferred because it avoids the issue of the "mixed" designation. The chart to the right displays the results for northeastern states. Future work will address what type of forest was captured or missed in each category and how the resulting definition fits with contemporary use and understanding of the term "urban forest."









Parcelization: an increasingly common trend in our Nation's forests is the subdivision of larger tracts owned by a single ownership into multiple smaller tracts owned by many or at least more ownerships. These subdivisions can be invisible on the landscape, but can also be the precursor of significant changes. If the forest structure remains intact, the ecological processes will continue, but access to the resource and management goals can change significantly when parcelization results in land-use changes, such as clearing land for a home site, ecological processes will be altered, and fragmentation can ensue.

Estimation Procedures: Information on parcelization comes from the National Woodland Owner Study (NWOS). The NWOS provides timely information on the number of owners and area owned for private woodland owners across the country. The NWOS samples private forestland owners. Questions relating to parcel size are used to quantify the results by state and inventory region. Information on trends in parcelization come from successive owner surveys.

Example: Parcelization data for Pennsylvania are shown in the table at the right. Comparing regions and survey dates reveals some interesting trends. For example, comparing the percentage of private acres in the largest parcels (1000+ acres) indicates that the industrial forests of the Allegheny Region had 22 percent of private forest in large parcels, compared to only 5 percent in the urbanized Southeastern Region. However, the Allegheny Region is experiencing parcelization, as the area in large parcels decreased by more than one half.

Forest Parcelization in Pennsylvania

Estimated number of private ownerships and private acres of forest-land by size class and region, 1993, 1978, and difference

1993

Parcel Size	Western Owners	Western Acres	Allegheny Owners	Allegheny Acres	North Central Owners	North Central Acres	Southwestern Owners	Southwestern Acres	Northeastern Owners	Northeastern Acres	Pocono Owners	Pocono Acres	Southeastern Owners	Southeastern Acres	South Central Owners	South Central Acres	State Owners	State Acres
1-99	130,500	1,688,900	43,700	719,600	33,400	678,100	34,000	538,200	50,700	718,600	51,100	549,800	81,600	706,700	67,200	719,200	492,200	6,319,100
100-199	2,800	348,700	2,100	311,800	1,900	242,200	2,100	279,900	2,200	287,400	1,100	139,900	600	79,400	1,400	179,800	14,200	1,869,100
200-499	700	174,300	900	275,800	1,500	411,700	700	236,800	600	164,200	600	169,900	300	79,400	600	171,200	5,900	1,683,300
500-999	100	65,400	200	132,700	300	181,600	100	96,900	100	30,800	200	110,000	W	23,800	100	42,800	1,100	684,000
1000+	100	195,300	100	403,000	200	470,700	100	208,300	W	88,600	100	391,400	W	47,600	100	134,500	700	1,939,400
	134,200	2,472,600	47,000	1,842,900	37,300	1,984,300	37,000	1,360,100	53,600	1,289,600	53,100	1,361,000	82,500	936,900	69,400	1,247,500	514,100	12,494,900

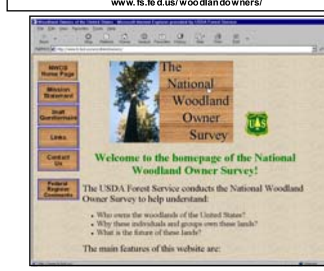
1978

Parcel Size	Western Owners	Western Acres	Allegheny Owners	Allegheny Acres	North Central Owners	North Central Acres	Southwestern Owners	Southwestern Acres	Northeastern Owners	Northeastern Acres	Pocono Owners	Pocono Acres	Southeastern Owners	Southeastern Acres	South Central Owners	South Central Acres	State Owners	State Acres
1-99	118,000	1,649,100	32,700	580,400	50,800	789,500	47,100	580,200	48,700	600,200	35,400	531,600	79,800	697,700	55,600	621,200	468,100	6,049,900
100-199	3,400	399,500	1,300	175,400	2,500	323,500	2,200	294,900	2,200	263,800	1,700	228,200	500	72,700	1,600	210,100	15,400	1,968,100
200-499	700	178,900	900	215,000	900	274,600	700	190,600	600	200,800	600	187,400	100	16,500	700	184,800	5,200	1,448,600
500-999	100	51,800	100	87,700	200	119,200	100	57,100	100	55,100	200	124,900	W	2,000	W	31,500	800	529,300
1000+	W	146,200	100	859,600	200	581,100	100	206,500	W	118,100	100	325,500	W	70,300	100	149,600	600	2,456,900
	122,200	2,425,500	35,100	1,918,100	54,600	2,087,900	50,200	1,329,300	51,600	1,238,000	38,000	1,397,600	80,400	859,200	58,000	1,197,200	490,100	12,452,800

Difference

Parcel Size	Western Owners	Western Acres	Allegheny Owners	Allegheny Acres	North Central Owners	North Central Acres	Southwestern Owners	Southwestern Acres	Northeastern Owners	Northeastern Acres	Pocono Owners	Pocono Acres	Southeastern Owners	Southeastern Acres	South Central Owners	South Central Acres	State Owners	State Acres
1-99	12,500	39,800	11,000	139,200	-17,400	-111,400	-13,100	-42,000	2,000	118,400	15,700	18,200	1,800	9,000	11,600	98,000	24,100	269,200
100-199	-600	-50,800	800	136,400	-600	-81,300	-100	-15,000	0	23,600	-600	-88,300	100	6,700	-200	-30,300	-1,200	-99,000
200-499	0	-4,600	0	60,800	600	137,100	0	46,200	0	-36,600	0	-17,500	200	62,900	-100	-13,600	700	234,700
500-999	0	13,600	100	45,000	100	62,400	0	39,800	0	-24,300	0	-14,900	NA	21,800	NA	11,300	300	154,700
1000+	NA	49,100	0	-456,600	0	-110,400	0	1,800	NA	-29,500	0	65,900	NA	-22,700	0	-15,100	100	-517,500
	12,000	47,100	11,900	-75,200	-17,300	-103,600	-13,200	30,800	2,000	51,600	15,100	-36,600	2,100	77,700	11,400	50,300	24,000	42,100

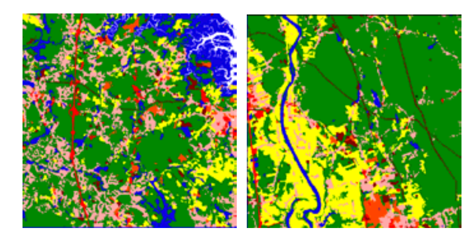
For more information, please consult the NWOS web page:
www.fs.fed.us/woodlandowners/



Fragmentation: once blocks of forestland are cleared for land uses other than forestry, the process of forest fragmentation begins. Fragmentation creates a mosaic of forest patches of varying size and is perhaps the most direct visual image we have of forest loss. Forest patches vary in quality with respect to watershed protection, carbon sequestration, wildlife habitat, species diversity, timber production, aesthetic values, recreation opportunities and other amenities. The context of this loss, its size, and resulting ecological impacts are significant, but little understood. Statistical techniques for assessing fragmentation are evolving. One glaring need is for adequate measures of change in fragmentation over time.

Estimation Procedures: There are various useful data sources for quantifying forest fragmentation, ranging from aerial photos for finer scale studies, to classified satellite imagery for regional assessments. Satellite data can be obtained in a more cost effective manner than can aerial photos, but a great deal of spatial and informational resolution is lost when using classified pixels. NE-FIA plans to use a combination of both data sources in order to meet its research and analysis objectives.

Example: Fragmentation statistics provide valuable data to supplement FIA's traditional estimates of land area by land use. To illustrate the need for fragmentation information, the two adjacent maps illustrate how two areas with nearly identical amounts of forest can have very different spatial characteristics. The example on the far right is a prototype of a statistical summary of various fragmentation statistics calculated for Worcester County in Massachusetts. Note the combination of tabular, graphical, and map display of fragmentation information. The intent to make the information accessible and appealing to NE-FIA's diverse clientele.



These two scenes show areas of roughly equal percent forest (61 and 62%), but different spatial distributions of forest, and different surrounding land uses (agriculture vs. residential). We can summarize the length of boundary between forest and other land uses, average patch size, average core area size, and various other fragmentation information to obtain a more clear understanding of the forests in these two areas.

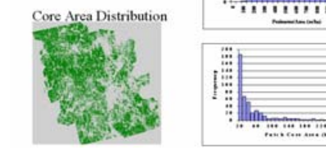
Worcester County

	Forest	Residential	Agriculture	Urban Open	Transitional	Water
Landuse adjacent to forest (%)	*	25.8	32.9	14.2	3.0	24.1
Landuse composition (%)	70.7	8.2	8.1	5.2	0.9	6.9

Forest Patch Statistics

Avg Core Patch Size (ha)	22.6
Shape Index (m)	30
Aggregation Index	0.919

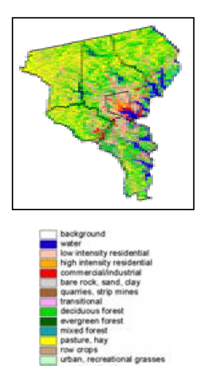
Core Area Distribution

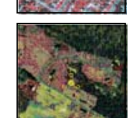


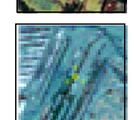
Trees on Non-Forest Land: FIA's definition of forestland encompasses tracts at least 1-acre in size (or at least 120 feet wide) that have functioning understories (functional in the context of ubiquitous conditions). Land with trees that do not meet this definition—there is a wide range of conditions that could occur, from a wooded picnic ground to a city street with landscaped trees-- require monitoring for several reasons, including to estimate contributions to carbon budgets, characterize floral composition and structure, estimate the contribution to air and water pollution amelioration, evaluate worth to human residents, provide baseline statistics on overall forest health in the larger forested landscape. Often, invasive plants and other unique pest occur at this important urban-forest interface.

Study Region: A six-county region surrounding Baltimore, MD was chosen to study the character of tree cover on non-forestland (see map). The Baltimore study region provides an excellent forest-to-urban continuum for studying a variety of non-forestland conditions. The diversity of non-forestland conditions is shown in the three aerial photo's to the right.

Methods: A grid of 1/10th-acre plots coincident with the FIA grid was laid across the region. At each plot, a selected set of P2 and P3 tree- and condition-level variables were collected. Data were summarized to fill in gaps in our knowledge of the contribution and character of trees on non-forestland.

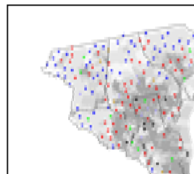




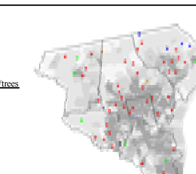


Results: The results provide interesting new information and comparative statistics for use in evaluating the underlying differences between trees on forestland and trees on non-forestland. The forested plots tended to have many more trees and higher basal areas per acre than non-forestland plots. Trees on non-forested plots were fewer in number, but larger in size. The two types of plots had many tree species in common, but the non-forestland plots added 16 species to the mix for the study region. Sixty-three percent of the trees on non-forestland were exotic, compared to 21 percent for forested plots. Information on land use indicates that while most of the non-forestland plots occurred on agricultural land, most of the trees occurred in residential areas (see box below) The data also provided an opportunity to add missing information to the region's carbon budget and allows a more complete estimate of Net Primary Productivity (see box at right).

Land Use


all NF plots

	%NF	%NF w/trees
Residential	41	72
comm/indus	6	2
urban open	8	12
Transport	6	2
crops/pasture	36	7
Open	3	5


NF w/trees

Effect on Regional Calculations of Carbon and NPP:

Tree biomass stocks for nonforest land were, per unit area, roughly 25% of the biomass computed for forest land.

Wood production (WNPP) for nonforest land was approximately 22% of that for forest land.

Calculating this for the entire northeast using known %'s of F and NF area → NF land adds 13% to the total biomass and 24% to the total WNPP. (assuming ratios of NF:F biomass and NPP are the same…) -- source: Jenkins

FIA Factoid? Where does the word "survey" in the old FIA moniker ("Forest Survey") originate from?

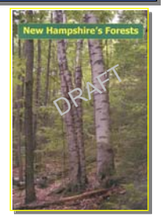
Answer: The term "survey" is of French origin, with the common prefix "sur" indicating "above," and the suffix "vey" meaning "to see," that is, **"to see as if from above."**

Presented at the Forest Health Monitoring Workshop, New Orleans, LA, February 4-7 2001

Focusing on Reporting

Closing-Out Periodic States

NE-FIA is in the process of working with state partners to produce issue-oriented resource reports, such as the brochure and color booklet to the right. Other outlets include web pages, fact sheets, conferences, and workshops. The remaining states with periodic inventories yet to be closed out include Vermont, New Hampshire, Connecticut, Massachusetts, Rhode Island, New Jersey, Delaware, Maryland, and West Virginia. The intention is to complete the analysis of these states in a timely fashion and eliminate the backlog that has developed for completing state-level analyses.

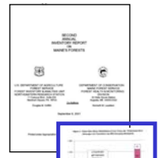


Annual Reporting is Underway in Maine and Pennsylvania

Ramping-Up in the Early Years

Visit our web site: www.state.me.us/doc/mfs/mfshome.htm

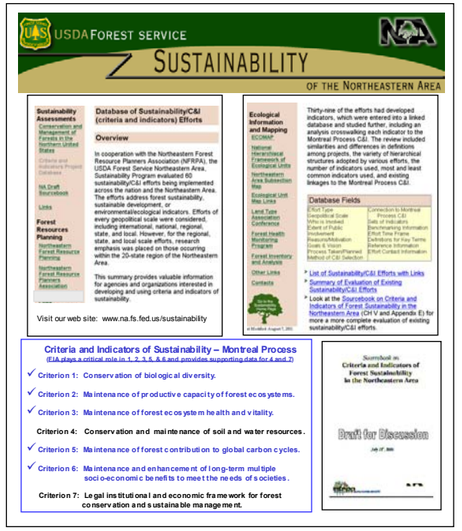
Under the auspices of the national FIA program and the supervision by state partners, NE-FIA is forging ahead with reporting for each state following each year's inventory for the first five or seven years until the first set of inventory panels are complete. The detail of reporting varies depending on the number of sample plots measured, variability of forested landscapes and associated disturbances, and interest from state partners. At the right, the first annual report in the northeastern region is shown. Pennsylvania has gained some insights from a set of tables produced in year one and is anxiously awaiting the extra level of detail that the second year's measurements will add.



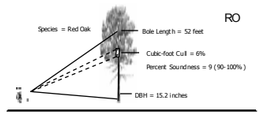
The Comprehensive Analysis

The national Analysis Band is designing a template for analyzing forested ecosystems across the US. A set of tables, charts, maps, and other products are being designing for regional implementation in the 5-year comprehensive analytical reports required under the annual inventory system.

Visit the AB web site: socrates.lv-hrc.nevada.edu/fia/ab



Examples of Issue-Based Analyses



Traditional Forestland Indicators from Phase 2

NE-FIA has been reporting on standard forestland indicators since the 1950's. These indicators provide valuable trend information on extent, character, composition, structure, sustainability, and health of northeastern forests. Although most of the past information has focused on "timberland" and "growing-stock tree," newer reports cover all forestland and trees. The information has traditionally been reported in statistical reports, analytical reports, and other outlets. The basic set of indicators offers an general picture of forestland conditions that can be elaborated on as specific forest issues arise. A list of some of the more commonly used indicators follows:

Area*

Land-use
Ownership class
Forest-type group
Stand-size class
Stocking class
Volume class
Disturbance Class

Numbers of Trees*

Species
Diameter class
Tree class

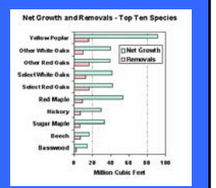
Biomass/Volume*

Forest-type group
Stand-size class
Species
Diameter class
Tree class
Tree grade

Growth, Removals, and Mortality*

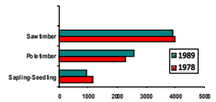
Species
Change component
Land-use

? Sustainability ?



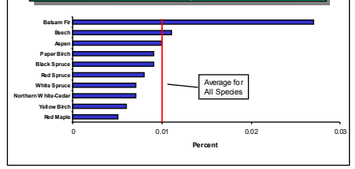
How are Composition and Structure Changing?

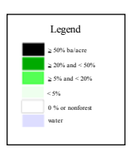
The mixed-oak forests of Pennsylvania have been maturing in recent decades and inventory results indicate that the area of young stands of oak are decreasing. This is indicative of a large-scale phenomena that is occurring throughout much Of the eastern US.



What is the Status of Tree Mortality?

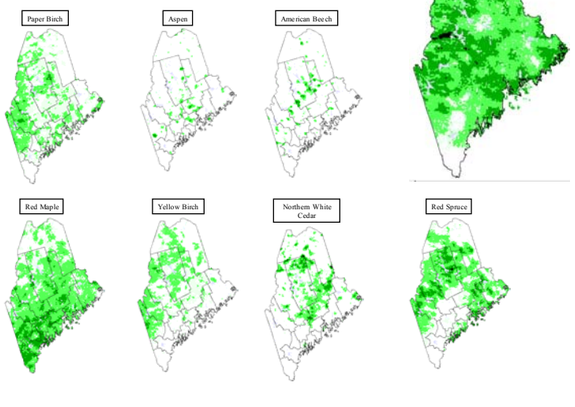
During the 1980's, severe spruce budworm outbreaks ravaged the spruce-fir forests of Maine. Subsequent mortality was heavy, especially for balsam fir—a favorite host for the budworm. The chart below shows an index of mortality for the top ten species in Maine over the period from 1982 to 1994. The heavy mortality of balsam fir bears closer monitoring.

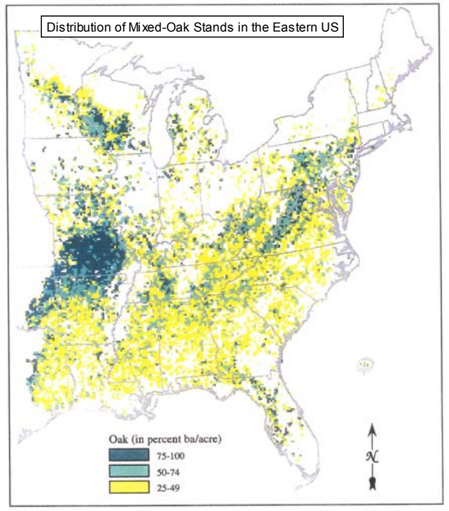


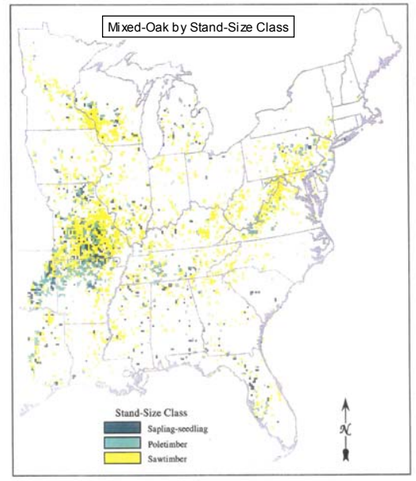


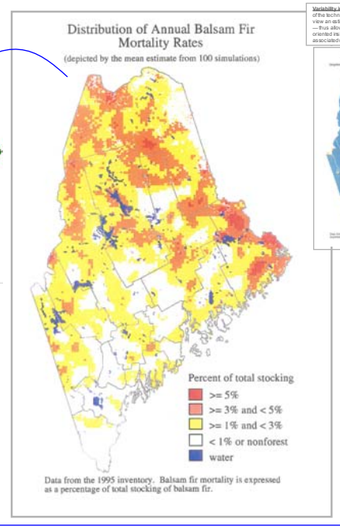
To further examine the issue, a kriged map of oak species occurrence was developed. The first map to the right shows the distribution of timberland with at least 25 percent basal area in oak species. The occurrence of oak in forest stands throughout the eastern US is readily apparent. The largest block of high density oak is located in the Ozark Plateau of Missouri and northern Arkansas. Other areas with high oak density are the Central lowlands of Minnesota and Wisconsin, the Appalachian Mountains from central Pennsylvania to northern Alabama, the Nashville Basin of Tennessee, and the Western Florida Peninsula. Of course, our maps should be considered spatial bar charts that reflect major patterns across the forested landscape--ie, species that occur sparsely, such as oak in Vermont, are better addressed by studies such as Little's (1975) and others'. To examine the occurrence of oak-dominated stands, a map was developed showing the distribution of stand sizes for stands where oak comprised at least 50 percent of the total basal area per acre. It is immediately apparent that young successional stands are rare and that sawtimber-size stands predominate across most of oak's native range in the East.

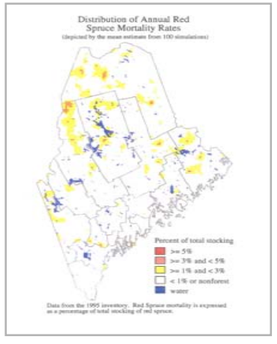
The issue of heavy mortality has major ramifications for the health and sustainability of spruce-fir forests in Maine. Species distribution maps provide context and perspective for the extent and impact of spruce budworm impacts. The maps below show the distributions for the eight of the species shown in the chart. Relatively rare species, such as White Spruce are too difficult to map in this manner. To further examine the magnitude of mortality on Balsam Fir, a map showing the mortality was developed. Because mortality is highly variable, a map showing the associated variability of the estimate is included.

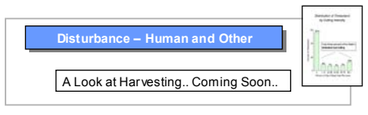










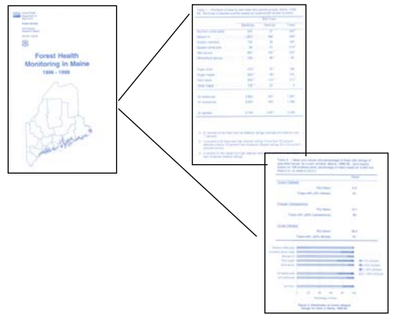


Forest Health Reports

Brochures summarizing FHM plot conditions for each of 12 northeastern states are currently being printed.

Each brochure summarizes the conditions on the plots based on the most recent visit from 1996 through 1999. In addition to plot-level characteristics, crown conditions for major species groups are summarized and discussed.

Similar brochures will be developed for the FHM and Phase 3 data collected in the 2000 and 2001 field seasons.



Coming Soon..

In 2002, Northeastern Area State and Private Forestry will publish a report summarizing forest health conditions throughout the 20 state region.

The report will summarize forest health conditions from 1996 through 2000. It will include information from state surveys, aerial surveys, and the FHM plot network.

Look for similar reports to be produced for the foreseeable future.

Annual Reporting Update

The national FIA Program is in the fourth year of activities to design, develop, and implement the annual inventory system. The activities center around "bands" representing the major issues facing FIA during the implementation years. The Analysis and the Indicator Bands are currently working on reporting templates for annual reporting and the five-year comprehensive reports. The Indicator Advisors are providing templates for core presentation of their respective data to round out the suite of indicators reported for by FIA. Tree damage is a key element of vitality assessments. The tabular information shown below is a prospective core table that will provide consistent tree-damage information across the US.

Table #. Volume of trees by damage agent.

Species Causal Agent →. . .00 01 02 03 04 05 11 12 13 20 21 22 23 24 25 31 Total

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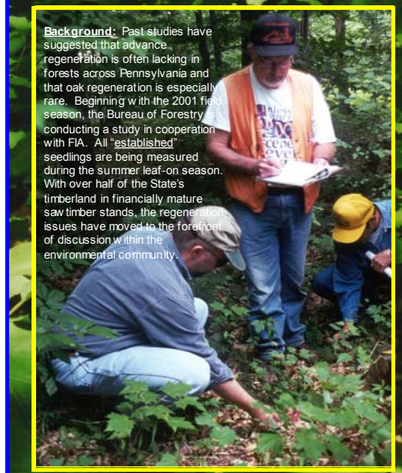
Causal Agent Codes:

00	Healthy
01	Canker, gall
02	Conks, fruiting bodies, and signs of advanced decay
03	Open wounds
04	Resinosis or gummosis
05	Cracks and seams
11	Broken bole or roots (< 3-feet from bole)
12	Brooms on roots or bole
13	Broken or dead roots (> 3-feet from bole)
20	Vines in crown
21	Loss of apical dominance, dead terminal
22	Broken or dead branches
23	Excessive branching or brooms
24	Damaged foliage, buds, or shoots
25	Discoloration of foliage
31	Other

Example of an Adjunct Inventory

Pennsylvania Regeneration Study

Background: Past studies have suggested that advance regeneration is often lacking in forests across Pennsylvania and that oak regeneration is especially rare. Beginning with the 2001 field season, the Bureau of Forestry is conducting a study in cooperation with FIA. All "established" seedlings are being measured during the summer leaf-on season. With over half of the State's timberland in financially mature saw timber stands, the regeneration issues have moved to the forefront of discussion within the environmental community.



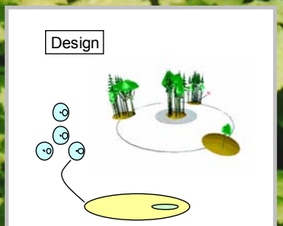
Study Objectives:

Specific research questions to be answered are:

1. What are the abundance, composition, and quality of advance regeneration?
2. What are the abundance, composition, and quality of regeneration following disturbance?
3. What are the extent and composition of other understory vegetation?
4. What is the status of regeneration of oak and other key species?

Once the first five-year cycle of inventory plots is completed, the regeneration data study data will begin to address these questions with statistical confidence and provide longer-term monitoring of regeneration.

Design

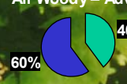


Methods: An interpenetrating sub-panel of each year's annual measurement panel in the State will be measured during the leaf-on summer window from June through August. Each FIA sample location is comprised of four 24-foot-radius subplots. Each subplot includes a 6.8-foot radius microplot. At each microplot, all established seedlings at least 2-inches in height are tallied by seedling source and height class. To be considered "established," seedlings must pass the "tug test" or in the case of oak and some other species, root collar diameter (RCD) in excess of 0.20 inches in diameter determines if the seedling is established. A code for "competitive" oak seedlings (RCD >= 0.75 inches) was also used. Competing vegetation is tallied on the larger subplot by life form and cover percent.

DCNR The Pennsylvania Department of Conservation and Natural Resources Forestry

Previous Results

All Woody – Advance



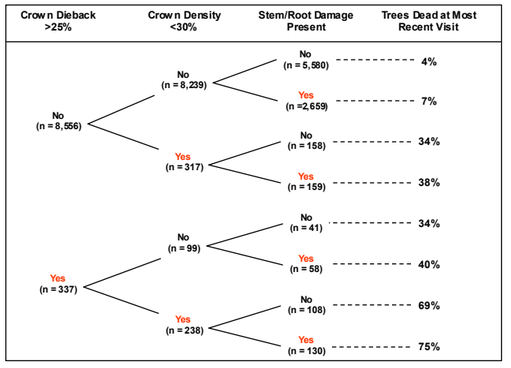
Mixed Oak – Post - Disturbance

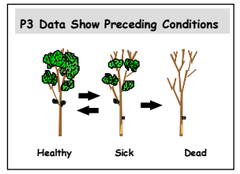
For periodic updates on the progress of the study, visit our web site, as well as those of cooperators at the USFS Silviculture Labs in Warren, PA and Morgantown, WV: (www.fs.fed.us/ne/).

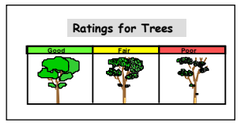
Tree Vitality

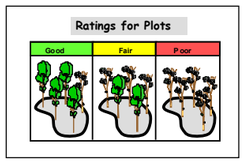
This analysis summarizes data collected in the northeastern and mid-Atlantic states between 1991 and 1999. Based on work done by Steinman, it compares the condition of trees at the most recent visit with their condition at the most recent previous visit. The time between visits ranged between 1 and 4 years with an average of about 2 years between measurements.

In general, trees with crown dieback of more than 25%, crown density of less than 30%, and any stem or root damage had higher rates of mortality than trees with other combinations of conditions. The basic concept of rating trees and plots is illustrated at the right.

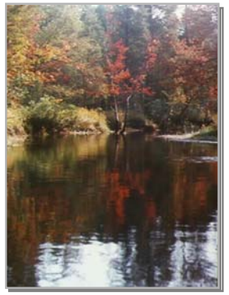








Integrating Intensive Site Monitoring and FIA Samples

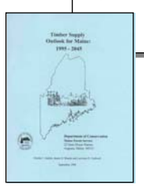


Other Adjunct Studies

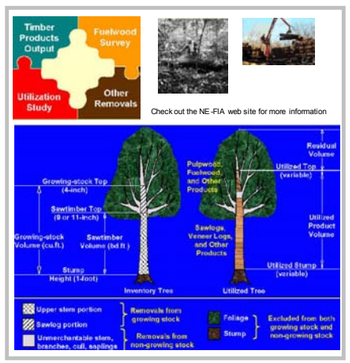
Futuring Wood Supply and Ecological Indicators

Visit our web site: www.nefa.conknet.com

- Cooperative Study: USDA NRS, NEFA States, NCASI, and Academia
- Two-year study funded by State & Private Forestry.
- Provided:
  - Timberland area projections by habitat type,
  - Wood-supply projections (inventory, growth, & removals),
  - Quantified and projected new set of ecological indicators.
- Being used by States for planning, policy development, and other needs.

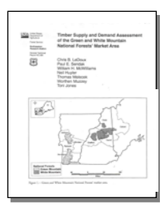


NWOS



National Forest System Assessment

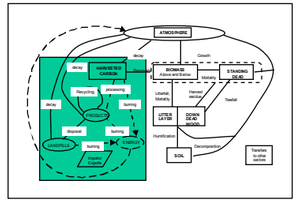
- Cooperative Study: USDA NRS - Green & White NF's.
- Assessed demand for timber by primary wood processors.
- Compared demand to available timber supply (quality, operability, and cost).
- Evaluated three treatments: regeneration cut, partial cut, and diameter-limit cut.
- Estimated available timber supply for the NF Market Area.
- Results are being used in the NF plan revision process.



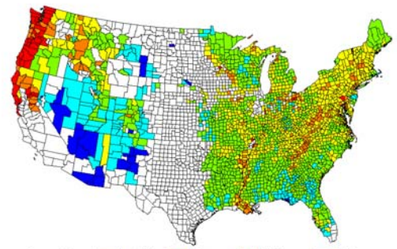
A Few Examples of Value-Added Indicators

Accounting for Carbon in the US

Carbon Estimation: Interest in strategies to ameliorate the effects of increased carbon dioxide in the atmosphere has provided yet another extension for FIA data. Studies of carbon storage and accumulation in terrestrial ecosystems have drawn heavily on FIA data to quantify the contribution of forest vegetation. Estimation procedures have yielded information the distribution of stored carbon and flux in the United States (See figure and map). A forest carbon budget model (FORCARB) has estimated prospective trends in carbon dynamics. Experience with modeling carbon has inferred additional information needs for broad-scale inventories. Inventory designs have been enhanced by P3 measures vital for understanding deeper ecological relationships between plants, soils, and the environment.

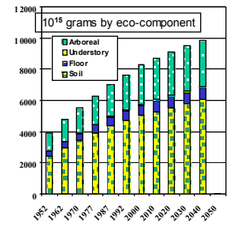


Tree Carbon Per Hectare by U.S. County



Managed forest lands, US, 2008-2012
Avg. annual C stock change (Tg/yr)

C taken up by trees in managed forests	381.9
C released by harvesting trees	-276.0
Net C taken up in Soil	32.4
Net C taken up in Floor	12.8
Net C taken up in Understory	0.7
Net C accrued in live biomass & soil	**171.8**
C increase in logging residue	**26.1**
C in products in use	39.1
C in products in landfills	51.3
C stored in products & landfills	**90.4**
Net C removals related to managed forests	**288 +/- 15% Tg/yr**

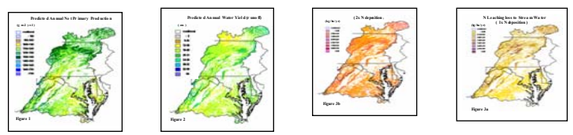


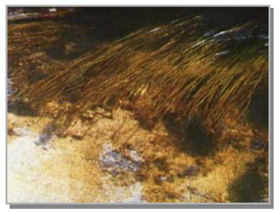
Predicting Forest Production, Water Yield, and N Leaching in the Chesapeake Basin

The Chesapeake Bay is the largest estuary in the United States. Forest ecosystems in the Bay Basin are very sensitive and vulnerable to changes in environment because they have already suffered a long history of human disturbances from development, population, pollution, and land-use changes. With concern of global change effects at regional level, there are questions about how the changes (such as increase in N deposition) will affect forest productivity, health and water quality in the Bay Basin. An explicit way to answer these questions is crucial to policy decisions managing ecosystems in the Basin. Process-based ecosystem models are indispensable tools for addressing these questions because they are able to study spatial pattern of ecological processes and environmental factors that influence them.

The PnET model

The PnET-II model is a simple, lumped parameter, monthly-time-step model of carbon, nitrogen and water balances of forest. It can be used to estimate carbon storage, net primary production (NPP), wood production, and water yield, as well as rates of N mineralization, nitrification, N leaching losses and maximum N cycling in forest ecosystems. The model has been applied to study forest ecosystems for contemporary climates and GCM projected climate scenarios at both stand and regional levels. The model was well validated for predictions of NPP, water yield and N losses in steams at numbers of location within the northeastern U.S. For regional studies of PnET, constant foliage Ns are usually assigned to forest types. In this study, we applied foliage N equations in PnET. The equations are functions relating foliage N with climatic variables across gradients. The figures below display the results for





To be continued …