

United States
Department of
Agriculture

Forest Service



**Southern
Research Station**

General Technical
Report SRS-61

Fresh Ideas, Perspectives, and Protocols Associated with Forest Inventory and Analysis Surveys: Graduate Reports, 1974 to July 2001

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February 2003

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Abstract

Graduate M.S. theses and Ph.D. dissertations were searched to provide a body of information associated with the U.S. Department of Agriculture, Forest Service, Forest Inventory and Analysis (FIA) database. Authors' abstracts were included if available in electronic form and published since 1974. Novel technical and nontraditional FIA data uses, as well as the geographic region of the reported studies, were highlighted in keywords and annotations. The search yielded the 103 citations included in this report. Dominating efforts were in economics, Geographic Information Systems, timber production, and selected States, with a broadening array of subjects in more recent years. Research institutions in States with regional FIA survey unit offices granted one-third of the graduate degrees. Providing an overview of the uses of FIA data in student research, the results show that a body of knowledge based on the data is evolving, whereas the distribution of subjects and study regions has been somewhat limited.

Keywords: Bibliography, dissertation, historical synthesis, interdisciplinary, MRI (multipurpose resource inventory), thesis.

Introduction

The multifaceted role of forests and expanding public involvement in forestry has led to differing concerns, measurement priorities, and sometimes opposing opinions about land use and forest resources. Large landholding commercial firms and Federal, State, and local public agencies conduct inventories and monitor changes to obtain information and make decisions about the resources in their care. In today's society, these activities must also satisfy the integrated information needs of a more involved public. Forests are not just groups of trees but represent a subtle balance of esthetics, economics, wildlife, and processes in which prevailing attitudes determine the context for—and ultimately the value of—forest resources. Methods to analyze, inventory, and model forest resources require a variety of disciplinary perspectives to account for the complexity of associated issues.

In mature organizations, patterns of work activity tend to follow a common tradition in terms of how problems are conceptualized and solved. Cost relative to benefit is of major concern, particularly among individuals with established careers. Graduate studies offer opportunities to pilot test techniques or investigate alternative solutions at

relatively low cost. With the help of university mentors, graduate students incorporate fresh ideas, new perspectives, and novel protocols to test important hypotheses or solve previously intractable problems. Graduate student approaches to analysis often differ from those of veteran analysts and offer perspectives outside the conventional thinking of established organizations.

Solving today's conflicts concerning land use and forest resource allocation requires assessments that use a broader base of information from a range of disciplines and natural resource perspectives. Abstracts of graduate student reports offer an important slice of this larger, evolving body of information. These reports often synthesize the existing literature, initiate novel approaches, and frequently provide details for subsequent journal articles. Occasionally, graduate work also foreshadows new research thrusts or groundbreaking scientific advances.

Though they publish Masters theses and Ph.D. dissertations, research institutions do not always enter the abstracts into traditional citation databases. Graduate student reports may not always be published outside the institution because the former student has no further interest in disseminating results or continuing the research or because the report documented no significant results. Whereas the findings may remain important to the larger scientific community, there is no common knowledge of their existence.

The graduate student reports assembled and categorized here are those associated with the regional field sample-based forest survey conducted by the U.S. Department of Agriculture, Forest Service, (USDA Forest Service), Forest Inventory and Analysis Research Work Unit (FIA). Since the 1930s, the USDA Forest Service has taken responsibility for assessing the current conditions and trends in both public and private forests through the FIA program. The passage of the Forest and Rangeland Renewable Resources Planning Act (RPA) of 1974 [Public Law 93-378 (88 Stat. 476)] and associated laws in 1978 [Public Law 95-307 (92 Stat. 353)], mandated that the USDA Forest Service shift inventory and monitoring efforts from documenting commodity—largely timber—outputs toward conducting “comprehensive”

assessments that also include water, range, recreation, and wildlife values. The FIA program, while maintaining the traditional data the Agency has collected and updated over the past 50 years, can benefit from the fresh ideas and perspectives of graduate research in efforts to meet society's evolving information needs.

This report includes every graduate thesis and dissertation found by the author and includes the abstracts of graduate student research associated with the use of FIA data conducted between 1974, when the RPA was passed, and July 2001. This compilation is intended for use by beginning graduate students, new and veteran FIA stakeholders, university professors, and others interested in forest inventory data, methods, and analysis. To help readers determine the usefulness of each report, annotations reference novel FIA data uses, particularly those associated with nontraditional subjects such as human influences, range, recreation, wildlife habitat, and water. I also provided annotations for studies for which no abstract was available or for which the use of FIA data was not apparent. I further assigned keywords to each abstract that categorized uses relevant to FIA data.

A careful reading of the abstracts and annotations should prove useful to those considering new approaches to the analysis of FIA data, retooling the analyses of FIA data for other issues, establishing new inventory measurements and analytical approaches, and developing new research proposals. Shortcuts are often helpful, however. One section provides the titles of graduate reports sorted by year and referenced by the author's surname and citation number. Titles used reflect the topics selected for graduate study and the issues, techniques, and terms prevalent at the time of their completion. To provide another way to look at patterns of research, I selected keywords for each report based on a reading of available materials. Another section lists each entry in the keyword list, followed by reference to the pertinent abstracts and the two-letter alphabetic State or survey unit code associated with the source of the FIA survey data.

Methods

I used UMI Dissertation Services, currently the largest database of dissertations, as the chief method to locate abstracts. Other sources included libraries of graduate forestry schools with on-line access and the Web search engines AltaVista, Google, and Netscape. I located additional theses, listed without abstracts but indexed by subject in the list of forestry theses published by Fox and DeWolfe (1994).

I limited my queries to on-line bibliography databases, university libraries, and lists of thesis citations from 1974 through July 2001 and confined my on-line library catalog searches to universities with graduate forestry programs. To locate reports, I formed queries using the following search terms: forest inventory, multipurpose and surveys, multiresource and survey, regional and forest and surveys, forest and service and surveys, land and resource and surveys, land use, FIA and forest, and forest and inventory.

The following section contains 103 citations listed in alphabetical order by author. I found 70 percent of the abstracts through UMI® Dissertation Services. These are coded with the letters DAI (Dissertation Abstracts International) or MAI (Masters Abstracts International), followed by volume, issue, year, and reference number. These abstracts—copied “as is” from the UMI database—are published both in hard copy and electronically on the USDA Forest Service, Southern Research Station Web site with permission of ProQuest Information and Learning, which prohibits further reproduction without permission. Copies of dissertations may be obtained by addressing requests to UMI® Dissertation Services, 300 North Zeeb Road, Ann Arbor, MI 48106-1346, (734)–761–7400. Additional information is available at the UMI Web site at: <http://www.lib.umi.com/dissertations>.

I have noted in the abstracts when I have used sources other than UMI for information about graduate reports. Possible other sources included the text of the full report, paper copy of the abstract, a subsequent serial publication, or a keyword index from another source. I annotated information (noted in brackets) from available information if no electronic abstract was obtainable or if FIA data uses were not apparent. When known, I also annotated (in brackets) novel and nontraditional FIA data uses if this information was not provided in the abstract.

Citation and Abstract or Annotation

1. Abt, Robert Carroll. 1984. **Regional production, structure, and factor demand in the U.S. lumber industry.** Berkeley, CA: University of California. 106 p. Ph.D. dissertation.

Source: DAI 46, no. 04B (1984): 1012. The U.S. lumber industry provides an opportunity to analyze the influence of differences in resource characteristics on production relationships. Dominance of regional timber supply and employment issues in forest resource policy provide an incentive to determine the influence of production characteristics on factor demand. Regional production and

price trends are examined and differences in micro and macro production relations are investigated. Aggregate substitution and scale effects are shown to depend on the relationship between a mill's efficiency and its response to output and price changes.

Production characteristics are identified for hardwood, southern softwood, and western softwood regions. Each region consists of three contiguous States. State specific data for 1963-1978 were developed for: (1) output, (2) labor price and cost, (3) sawlog price and cost, and (4) capital stock. Capital stock estimates for each State were derived using a perpetual inventory model, which was consistent with the Bureau of Labor Statistics national capital stock series. Translog restricted cost functions and duality theory were employed to identify regional production characteristics from pooled State data. Sawlogs and labor were considered variable inputs, and capital was considered quasi-fixed.

Results indicated that the underlying production functions in the three regions were significantly different. The fixed-factor proportions hypothesis did not receive support in any region. Constant returns to scale was accepted in the softwood regions, but decreasing returns characterized the hardwood region. Productivity growth was highest in the South, while the marginal product of capital was highest in the West. The effects of production characteristics on factor demand were examined by decomposing factor demand change into: (1) output, (2) own-price, (3) cross-price, (4) capital stock, and (5) time or state of technology components. This indicated that the relative stability in factor use over the sample period was due to offsetting price, substitution and technology effects, rather than fixed production relationships.

Keywords: Economics, timber production modeling, United States.

2. Alig, Ralph J. 1984. **Forest acreage trends in the Southeast: econometric analysis and policy simulations.** Corvallis, OR: Oregon State University. 156 p. Ph.D. dissertation.

Source: DAI 45, no. 09A (1984): 2943. The objective of this study was to develop a system based on economic criteria for projecting changes in land use areas. The total land base was partitioned among three classes of private forest owners and crop, pasture/range, and urban/other uses in the Southeastern United States. The fraction of the land base in an owner/use was hypothesized to be a function of the ratio of the land rent for that owner/use relative to an average rent index for all owners/uses. Systems of econometric equations

for the six owner/use classes were estimated by physiographic region: Coastal Plain, Piedmont, and Mountains. The data comprised a pooled cross-sectional/time series, with observations drawn at four time points from the 21 forest survey units in the Southeast.

Population, personal income, and land commodity incomes were the major significant variables in the land owner/use equations. Changes in population and personal income levels have contributed to a decline in farm forest acreage and a corresponding increase in miscellaneous private forest acreage. Projections of forest acreage trends with the systems of land owner/use equations indicate a continued drop in farm forest acreage. Miscellaneous private forest acreage is projected to continue to increase, in part because of real personal income levels that are forecast to triple by the year 2040.

Projections of acreage changes for the five major forest types by ownership in each physiographic region, using a Markov type model, point to a substantial reduction in natural pine acreage. Transition probabilities among forest types were estimated from forest survey remeasurement data and are conditional with respect to the application of certain management practices.

The importance of exogenous forces (e.g., population) for forest acreage trends suggests the need to improve coordination with land use modeling for other sectors. Also needed are the integration of forest acreage modeling with that for forest type transition, timber inventory projection, and harvest estimation in an interregional framework.

Keywords: Economics, land use, owner, SEFIA.

3. Barlow, Stephen Anthony. 1996. **The influence of urbanization on timber harvest probability in Mississippi and Alabama.** Mississippi State, MS: Mississippi State University. 56 p. M.S. thesis.

Source: MAI 34, no. 06 (1996): 2275. In the Southern United States, increased development in traditionally rural areas is quickly reducing the land base currently used for forest management. This shift from rural to urban uses represents a long term removal of productive forest land.

The impact of urbanization on timber harvest probability in Mississippi and Alabama was investigated in this study. Data from the U.S. Census Bureau were combined with Forest Inventory and Analysis (FIA) data collected by the USDA Forest Service. These data were merged using a Geographic Information System (GIS) to spatially reference the FIA plots to the demographic data.

A binary logit model was estimated to provide a predicted harvest probability for each FIA plot. This study provides a methodology to combine available data sources to assist in the development of a State or regional timber supply model. [Author used proximity to urban populations, U.S. Census tracts, FIA distance from roads and distance from urban or built-up land, and traditional FIA attributes for two FIA surveys of Alabama and Mississippi.]

Keywords: AL, GIS, harvest probability (plot), MS, population density, proximity.

4. Barnes, Robert Brooks. 1975. **A quantitative evaluation of winter deer browse in southern New Hampshire forests.** Durham, NH: University of New Hampshire. 96 p. M.S. thesis.

Source: Paper copy of abstract. [This study evaluated winter deer browse resources for availability and utilization in southern New Hampshire forests from FIA tree and browse production estimates. Browse production was poorly associated with site variables, but was greatest in sapling-seedling stands. Differences by forest type were negligible. Browse utilization was below 10 percent in all but spruce-fir sawtimber stands (20 percent). Mast production was greatest in sawtimber stands, corresponding to the occurrence of mast producing trees.]

Keywords: Browse, mast, NH, wildlife.

5. Bechtold, William A. 1983. **DYNARIP: a technique for regional forest inventory projection.** Durham, NC: Duke University. 58 p. M.S. thesis.

Source: Duke University Library. [This study involved a technique for regional forest inventory projection and policy analysis (Bechtold 1989).]

Keywords: Custom software, SEFIA, timber production modeling.

6. Bell, Kelly, Jr. 1993. **A probabilistic evaluation of the harvesting behavior of private timberland owners in eastern Texas.** College Station, TX: Texas A&M University. 136 p. Ph.D. dissertation.

Source: DAI 54, no. 11B (1993): 5458. This study was conducted to provide a mechanism for improving local timber supply modeling capability by estimating the probabilities of softwood harvest for the two private timberland ownership classes under varying biological

conditions. The FIA data for eastern Texas were examined to determine their viability for use in harvest behavior modeling on small geographic levels and filtering procedures were developed to use the data. Models of softwood harvesting behavior for private timberland owners for two timbershed areas in eastern Texas during the period between 1975 and 1986 were specified and calibrated using the filtered FIA data. The usefulness of logistic regression diagnostic procedures for harvest behavior modeling was examined.

Close examination of the FIA data revealed suspect data values caused by measurement or recording errors, plots with negative periodic gross growth, and other problems that are not usually considered in analyses over small geographic areas using FIA data. Lost plots and substitute points were problematic when estimating the models. After filtering, the probability of harvest for both industrial and nonindustrial owners was found to increase as initial standing volume increased and as periodic growth and periodic mortality decreased. Data from the two timbersheds was pooled, and the dummy variable created to test for differences between the two areas while controlling the stand variables was significant at the $p = 0.10$ level, supporting the notion that differences between the timbersheds could be seen in stand age structure and types of processing facilities.

The diagnostic procedures were useful in identifying influential observations that affected the model fit. The magnitude of the coefficients on the continuous variables in both timbersheds increased after reestimation of the model. Unless there is evidence that measurement or recording errors occurred, however, it is not recommended that such plots be deleted from calibrating the model. The logistic model also offers opportunities to explore other factors affecting timber management behavior that may be useful for forest policy analysis purposes.

Keywords: Harvest probability (plot), owner, TX.

7. Benessalah, Driss. 1985. **Forest area estimation using cluster sampling in single and two phase survey designs.** St. Paul, MN: University of Minnesota. 183 p. Ph.D. dissertation.

Source: DAI 46, no. 10B (1985): 3311. Existing forest surveys utilize large numbers of small to medium scale photo plots with a subsample of ground checks to estimate forest areas. Subsequent breakdowns by cover types are usually based on a much smaller set of carefully measured plots, and consequently, there are large sampling errors associated with cover types on county or smaller area bases.

This is significant in that cover types and stands that comprise them are the actual units on which management is imposed.

The problem addressed in this study concerns the use and cost efficiency of medium scale aerial color photography combined with clusters in single and double phase sampling designs, for forest area determination. Emphasis is also on the usefulness of small format photography systems, and designs to be implemented with minimal technology in developing countries.

The survey covered two study areas, one in Minnesota (USA) and the other in Morocco. On aerial photographs, taken over sample locations, clusters of points were the basis for forest type classification and area proportion estimation. Single and double phase cluster sampling were compared on the basis of feasibility and costs. The analysis involved studying the relationship between intra-cluster correlation and cluster size and distance between cluster elements.

Cluster sampling resulted in a substantial gain over sampling with individual units, and two-phase sampling produced even larger gains. Also, since the variable of interest observed in the cluster is the presence or absence of a given cover type, relatively short distances between cluster elements can be effective, because cover types change so quickly. [Refers to an examination of the FIA sample design. Direct FIA data use is uncertain.]

Keywords: MN, sample design (air photo).

8. Binkley, Clark Shepard. 1979. **Timber supply from private nonindustrial forests: an economic analysis of landowner behavior.** New Haven, CT: Yale University. 127 p. Ph.D. dissertation.

Source: Yale University. [The study involves a micro-economic analysis of landowner behavior. See Binkley (1981) for details.]

Keywords: Owner, timber production modeling.

9. Birdsey, Richard Alan. 1989. **A dynamic matrix model for updating forest resource inventories.** Syracuse, NY: State University of New York, College of Environmental Science and Forestry. 276 p. Ph.D. dissertation.

Source: DAI 50, no. 07B (1989): 2703. The objective of the study was to develop a model to update forest inventory estimates that are outdated. Estimates from past successive forest inventories were used to estimate historical rates of

area change by forest type and disturbance class, and exogenous data were used to adjust rates of change after the most recent inventory. Historical rates of area change by forest type were estimated with Markov transition matrices for major classes of forest disturbance. Principal sources of exogenous data were annual planting records and timber severance tax reports. The model was applied to a large region in southwest Arkansas and validated with a new inventory. The predicted total area of timberland was 1.1 percent different than estimated in the new survey. Predicted softwood volume was also 1.1 percent different than estimated. Predicted hardwood volume was off by 5.8 percent, softwood growth was off by 22.9 percent, hardwood growth was off by 14.2 percent, softwood removals were off by 5.3 percent, and hardwood removals were off by 9.4 percent when compared with the new inventory estimates.

The use of exogenous data to adjust historical rates of change improved the prediction of the area of timberland by forest type, with the exception of upland hardwoods. Additions to timberland from nonforest land uses were predicted accurately, but not landclearing. The total area harvested and its distribution by forest type were predicted accurately in most cases.

The area matrix model is a powerful tool for updating, and could be improved by using more current observations in estimating certain cells of the type transition matrices. An analysis of transition rate stability showed most cell estimates were stable over a 20-year period. The exogenous data was shown to have a close relationship with trends in area harvested and regenerated to pine. It was concluded that estimates of landclearing and other disturbances could be improved with remote sensing for change detection, and that subsampling was needed to improve most estimates of the mean volume, growth, and removals per acre.

Keywords: AR, timber production updating.

10. Bolton, Robert Keith. 1984. **A comparison of diameter growth for selected tree species among physiographic regions of Georgia.** Auburn, AL: Auburn University. 104 p. M.S. thesis.

Source: Auburn University. [Not available. A related publication (Bolton and Meldahl 1989) referred to opportunities and problems with using FIA data. FIA-related measurement issues referenced stand age, stand density, and site class by species.]

Keywords: GA, tree growth modeling.

11. Borges, Jose Guilherme Martins Dias Calvao. 1994. **A modeling approach to spatial constraints in forest management**. St. Paul, MN: University of Minnesota. 128 p. Ph.D. dissertation.

Source: DAI 56, no. 02B (1994): 0587. There is an increasing awareness of the value of forests for wildlife survival, biodiversity protection, recreational uses and aesthetics. The importance of forest uses other than timber production places a new challenge to forest management. The effort to supply wood in order to satisfy an also increasing demand for timber related products may not ignore this challenge, and spatial considerations—how to concentrate or layout harvests in order to account for other demands from the forests—must be given a new prominence when developing forest plans.

In this research project, a heuristic based on dynamic programming was used to develop forest management plans which comply with adjacency constraints. These may encompass both the definition of a maximum clearcut size—ensured by an adequate territorial division of the forest—and a minimum exclusion period—the time that must elapse before two adjacent stands (polygons) are clearcut. The objective of this research project was to assess the potential of this technique to address the large scale attributes of most forest management problems.

After discussing the importance and the potential of operation research techniques to address the complex issues involved in current forest management modeling, a literature review summarizes research efforts that have been developed in order to incorporate spatial factors in forest planning. The heuristic is presented and the model application is described. Data from the Forest Inventory Analysis (FIA) of the US Forest Service and topological information available for the Superior National Forest in Minnesota were used as input to the model. Additional silvicultural and economic data needed was generated using modules from the Decision Support System developed for forest management modeling at the University of Minnesota. Several management scenarios for a hypothetical forest, with an area of 27,221 hectares and comprising 3002 stands were considered to test the heuristic. The results show that this technique can handle effectively the large scale attributes (large areas and extended planning horizons) that characterize most forest management problems. The solutions for the spatially constrained planning problems are presented and perspectives for additional research for the improvement of the heuristic application are summarized.

Keywords: Decision support system, GIS, MN, NFS, planning (spatial constraints), proximity.

12. Brooks, David James. 1984. **Nonindustrial forests, public policy and long-term timber supply in the South**. Corvallis, OR: Oregon State University. 110 p. Ph.D. dissertation.

Source: DAI 44, no. 10B (1984): 2946. Forest Service projections of the long-term supply and demand for forest products indicate that increasing importance will be placed on the supply behavior of nonindustrial private forest owners in the South. The inventory model on which these projections are based may produce biased estimates of southern timber production, however, as a result of the failure to account for changes in management practices and shifts in the distribution of forest area by stand type. In addition, it has not been possible to assess explicitly the influence of government policies on future timber supplies.

The first component of this study is an age-class based inventory projection model that incorporates stand establishment, thinning practices and the successional tendencies of natural regeneration in the South. Model projections of southern softwood inventories differ considerably from previous estimates. Softwood growing stock on nonindustrial private forest land will decline, by the year 2000, by more than 30 percent from the level in 1977 when harvests anticipated by the Forest Service are combined with historical levels of softwood regeneration. Softwood inventories on forest industry lands will increase over the same period due to pine plantation establishment.

The second component is a policy analysis system which is applied to an examination of the long-term impact of reforestation cost-share payments programs. The coefficients of policy-sensitive management equations are estimated from historical data; these equations are linked with the inventory model and a model of timber markets. Projections with these models indicate that when program funding is continued at current levels softwood stumpage and product prices will increase faster than previously expected. Substantial increases in cost-share payments can result in lower prices but have little effect before the year 2010.

Keywords: Reforestation program impacts, SRSFIA, timber production modeling (age class).

13. Brooks, Robert Thomas. 1984. **An analysis of the use of national land use inventories for regional avian habitat assessments**. Syracuse, NY: State University of New York, College of Environmental Science and Forestry. 186 p. Ph.D. dissertation.

Source: DAI 45, no. 12B (1984): 3676. The assessment of wildlife habitat quality is required of both the U.S. Forest Service (USFS) and Soil Conservation Service (SCS) as part of their legally mandated, periodic, national, natural resources surveys. County-level land cover data, from reoccurring national land resource surveys are used to generate regional landscape values for 211 counties in parts of three ecological provinces. Abundance values for 24 bird species are estimated for each of these counties using five-year summaries of applicable Breeding Bird Survey (BBS) route data. The regional landscape values are related to discrete species abundance classes and the resulting discriminant function models are interpreted as descriptive of regional habitat conditions. Of 66 bird province-species combinations, discriminant models correctly predict membership in applicable abundance classes at better than 75 percent. Within species, modeling accuracy levels vary but are consistently better than expected by chance alone. Interpretations of the discriminant landscape models for habitat descriptions are generally comparable to published habitat accounts. Habitat comparisons between species show favorable consistency both within provinces and between provinces.

Keywords: BBS, birds, NEFIA, wildlife.

14. Caprata, Michael W. 1982. **Adaptation of the stand and tree evaluation and modeling systems of the forest resource evaluation program in the Central States.** Carbondale, IL: Southern Illinois University. 43 p. M.S. thesis.

Source: Southern Illinois University. [Objectives of the study included forest growth projections for areas of southern Illinois.]

Keywords: IL, tree growth modeling.

15. Carter, Douglas Ray. 1993. **Empirical evidence on efficiency in forest-related markets.** Athens, GA: University of Georgia. 125 p. Ph.D. dissertation.

Source: DAI 54, no. 06B (1993): 2832. The thesis presents three essays on problems relating to defining and measuring efficiency in two forest-related markets, southern pulpwood harvesting and Federal timber sale programs. At the heart of each essay are the related concepts of efficiency and optimality.

The first essay measures technical efficiency among methods of pulpwood harvesting in the Southern U.S. in 1979 and 1987. An econometric frontier production function

is modeled using analysis-of-covariance methods, which results in consistent estimates of method effects. Employed efficiency measures isolate economies of scale from what can be termed pure technical efficiency. Harvesting methods utilizing either extremely low or high capitalization levels were the most technically efficient. Efficiency measures correlate well with the observed evolution of the industry over the period.

The second essay examines firm specific and average industry technical efficiency for southern pulpwood producers in 1979 and 1987 using an econometric stochastic frontier production function. The stochastic frontier production function is capable of distinguishing deviations from the frontier due to uncontrollable stochastic elements as well as provide a pure measure of technical efficiency. Results indicate that mean industry technical efficiency was nearly constant at 60 percent in both periods while technical change averaged 1.8 percent per year over the period. Production levels, methods of production, and elements of human capital were influential in explaining efficiency differentials among firms.

The final essay develops a model capable of examining the efficiency with which current reservation price setting or appraisal policies under a given auction type maximize Federal timber sale revenues. A simultaneous-equations Tobit model is developed that simulates the impact of increasing reservation price on the market value, given a sold offering, and the probability that an offering will sell. The model is tested on 370 national forest timber sales in North Carolina between 1979 and 1991. Conservative simulations indicate, ex post, that increasing reservation price could increase total revenue by as much as 8 percent in North Carolina. Per unit revenues could increase 21 percent. However, volume might decline by an associated 14 percent since higher reservation prices reduce the volume sold.

Keywords: Economics, NC, NFS, timber production modeling.

16. Catts, Glenn Paul. 1992. **Aerial photographic sampling for statewide resource inventory.** Raleigh, NC: North Carolina State University. 295 p. Ph.D. dissertation.

Source: DAI 53, no. 10B (1992): 5129. The land use and forest resource conditions of the State of North Carolina were photointerpreted from 1:12,000 scale, color infrared aerial photography. Nearly 400 circular plots, of 1000 acres in area, were type mapped by two photointerpreters according to classification definitions adopted from those of the Southeastern Forest Inventory and Analysis (SEFIA) unit of the U.S. Forest Service. Photo plots were arranged in

a statewide systematic layout. Four classification levels were used. The initial 1000 acre plot size was further subdivided into six smaller concentric plot sizes. Acreage photointerpreted was converted into a percentage estimate for each plot by forming a ratio of the number of acres type mapped in the class over the total number of acres in the plot. Regional and statewide percentage estimates for all classes in all classification schemes and for all plot sizes were produced separately. Fieldwork was conducted at nearly 300 locations imaged by the aerial photography.

Results of coincident fieldwork and photointerpretation were cross-tabulated into a series of error matrices used to adjust the initial percentage estimates for classification bias. The precision of the percentage estimates was calculated using a Monte Carlo simulation technique known as bootstrapping. Accuracy of the percentage estimates was assessed by comparison with temporally coincident SEFIA 5th survey results (1982-1984). The influence on precision of the numbers and size of the sample plots photointerpreted, and the number of coincident plots used to build the error matrix was investigated. An optimization model was formulated with the objective of finding a minimum total cost for a multiresource survey design meeting predetermined, class specific precision requirements.

Photointerpretation was found to be accurate and consistent among the most experienced individuals. Adjusted class percentage estimates were closer to SEFIA estimates than were unadjusted for many classes. Bootstrapped confidence intervals contained SEFIA field survey estimates. Solutions to the minimization model indicated that photointerpretation of plots in sizes above 800 acres were most cost effective in an example examined. Optimization modeling could assist resource managers in choosing most efficient multiresource survey designs.

Keywords: NC, remote sensing, sample design (air photo).

17. Cherry, Heidi Ruth. 1998. **Projecting Michigan's aspen timber resource**. East Lansing, MI: Michigan State University. 87 p. M.S. thesis.

Source: MAI 36, no. 06 (1998): 1519. Remeasured plots from 1980 and 1993 Michigan forest inventories were used to develop harvest probability equations based on stand characteristics such as ownership, stocking, and location. Michigan's 1993 inventory plots with aspen were projected thirty years using a modified version of STEMS85 with management based on these equations. Michigan specific diameter growth and mortality correction factors were included. The projected net loss between 1993-2023 in aspen growing stock volume is 60 percent, from 40 million

to 16 million cords. The greatest proportional loss of aspen is projected to occur on private ownerships and in the Upper Peninsula while public lands and the Lower Peninsula increase their proportions. The average annual harvest is projected to increase from a 1983-1993 level of 122 million cubic feet to 128 million cubic feet between 1993-2003. However, projections show a decrease to 97 million cubic feet per year between 2003-2013 and 74 million cubic feet per year from 2013-2023.

Keywords: Harvest probability (plot), MI, timber production modeling.

18. Clements, Stephen E. 1987. **A timber supply analysis for southwest Virginia**. Blacksburg, VA: Virginia Polytechnic Institute and State University. 147 p. Ph.D. dissertation.

Source: DAI 48, no. 05B (1987): 1202. A model was developed to estimate the economic stock supply of primary wood products. Two hardwood products were recognized: logs and bolts. The supply model was used to evaluate the impacts of shifting primary product demands and increasing supply costs on delivered prices and quantities in southwest Virginia.

Homogeneous supply response cells, identified from Forest Service forest survey data, were used to generate log and bolt supplies. Response cells define blocks of forest land with similar biologic, physiographic, and landowner characteristics. Yield equations estimate the volume of logs and bolts available. Harvesting and hauling costs depend on a response cell's physiographic characteristics. Stumpage owners set reservation price as a function of expected stumpage prices, future timber yields, and an alternative rate of return. Recovery cost per cunit in a response cell equals the sum of harvesting and hauling costs and reservation price. The quantities of logs and bolts supplied are determined by comparing harvest revenues to recovery costs. If revenues are greater than or equal to costs in a particular response cell, then timber is harvested.

The demands for logs and bolts are derived from the demand for manufactured products. Log and bolt demand equations in the model were statistically estimated.

For each time period, the model determines the delivered log and bolt prices which equate the quantities of logs and bolts supplied to the quantities demanded. The solution technique is iterative. The quantities demanded and supplied of logs and bolts are determined for the given delivered prices. If quantities supplied do not equal the quantities

demand, then delivered prices are adjusted, and the quantities are recalculated.

Primary product supplies in southwest Virginia are price elastic because of extensive hardwood resources and relatively constant recovery costs. Expansions in primary product demands expected over the next 15 years should have little direct impact on delivered prices. Delivered prices, however, will be sensitive to production costs. These costs will rise if factor input prices, such as fuel prices, wage rates, or machinery costs, increase.

Keywords: Economic haul distance, VA.

19. Cohan, David. 1982. **Forest management and timber industry market equilibrium**. Stanford, CA: Stanford University. 266 p. Ph.D. dissertation.

Source: DAI 43, no. 04A (1982): 1224. Forest management involves a complex system of natural processes and economic interactions. Competing demands for forest products and amenity uses suggest that the tradeoffs involved in forest management will continue to present difficult problems. The purpose of this research is to develop the theory and methodology necessary for modeling the dynamic behavior and market interactions of the timber industry. The result is a flexible capability for developing market equilibrium models that can be used to analyze a wide range of forest management decisions.

The modeling approach is based on four key ideas: the use of generic process models to represent the behavior of economic agents, the use of a network structure to represent the interactions among economic agents, the use of optimal control techniques to develop a detailed theoretical model of forest management and timber supply, and the use of an iterative solution algorithm. Process models are developed to represent private sector timber suppliers, public sector forest management agencies, mills, and forest products demand sectors. The algorithm is used to solve the dynamic models for market equilibrium prices and quantities, timber age-class distributions, and other results that reflect important intertemporal interactions.

The central theoretical result is a set of equations defining the solution to the multidimensional problem of forest management and timber supply. One of the difficult parts of the problem is the optimal choice of timber stands to harvest, given multiple ages, species, sites, and markets for different grades of timber. This research shows that stands should be harvested in order of increasing total marginal cost, where the cost includes both harvest costs and the opportunity cost of the harvested timber. The opportunity

cost, determined as part of the solution, reflects the intertemporal scarcity of standing timber.

A model of the Pacific Northwest softwood timber industry is developed to demonstrate the modeling capability. The use of such a model in analyzing forest policy and management decisions is outlined, and insights from sensitivity analyses are discussed. Results of the model suggest that it may be possible to manage public sector lands more efficiently, providing both increased timber supplies and the expansion of areas reserved for wilderness or other nontimber uses.

Keywords: Economics, PNWFIA, timber production modeling.

20. Compton, Roberta Sue Davidson. 1994. **A tree height model for 34 species of the north central region of the U.S.** St. Paul, MN: University of Minnesota. 59 p. M.S. (Plan B) paper.

Source: Paper copy of report. [This study developed an individual tree height model for merchantable height (4 inch top diameter outside bark) for 34 tree species of the North Central United States. This model was then used to derive merchantable-height prediction equations for trees on Forest Inventory and Analysis (FIA) plots where height was not measured. Such trees included STEMS-predicted (Belcher and others 1982) diameters from growth-simulated past measurements.]

Keywords: NCFIA, tree measurement modeling.

21. Cooke, William Henry, III. 1997. **A remote sensing methodology for testing the applicability and implementation of landscape partitioning systems with Advanced Very High Resolution Radiometer satellite data**. Mississippi State, MS: Mississippi State University. 89 p. Ph.D. dissertation.

Source: DAI 58, no. 07B (1997): 3389. The Southern Research Station, Forest Inventory and Analysis Program (SRSFIA) has the mandate to conduct forest inventories for all Southern States from Virginia to Texas. Except for sparsely forested regions in west Texas and west Oklahoma, forest land in the South has been field inventoried over several cycles in recent history. An assessment of these western woodland resources is needed to meet the SRSFIA's inventory mandate. Advanced Very High Resolution Radiometer (AVHRR) weather satellite data was examined for its usefulness in fulfilling this mandate.

Satellite data analysis for natural resource assessment involves extracting useful information from the data. This study was developed to enhance existing methodologies designed to extract information from AVHRR data. Understanding the landscape processes which dictate plant distributions is essential to this process.

A review of the literature indicated that landscape partitioning systems have been used with AVHRR data in preclassification and postclassification scenarios. Decisions regarding the need for partitioning and the choice of a particular partitioning system have been subjectively made.

This study yielded quantitative evidence that confirms the usefulness of partitioning in general, and the superiority of Bailey's landscape partitioning system for the west Texas and west Oklahoma study area. Statistical tests revealed that variability of Jeffries-Matusita (J-M) distances were within acceptable limits, and that a sample based approach could be used for generating spectral signatures for assessing partitioning effectiveness.

Keywords: OK, satellite remote sensing, TX.

22. DeCoster, James Krause. 1996. **Impacts of tornados and hurricanes on the community structure and dynamics of North and South Carolina forests.** Chapel Hill, NC: University of North Carolina. 361 p. Ph.D. dissertation.

Source: DAI 57, no. 05B (1996): 3000. Severe wind storms, such as tornados and hurricanes, regularly traverse the landscapes of the Carolinas, causing changes in the structure and composition of the forest communities. In order to understand the immediate and possible long-term impacts of these storms, a study was initiated to examine tree damage, mortality, and subsequent regeneration by sprouts and seedlings.

The first part of this study documents the impacts on Piedmont North Carolina forests of a 1988 tornado. Probability of tree damage increased with tree size and varied among species. These factors, and the type of damage sustained, influenced subsequent mortality. Forest recovery proceeded through a combination of seedling regeneration and tree sprouting. Many hardwood trees survived through the prolific generation of sprouts from the damaged stems. Differences in sprouting among trees were attributed to differences in tree size, species and edaphic factors. Seedling regeneration is dominated by species that were of minor subcanopy components in the pre-disturbance forest.

The second part of the study examines the immediate impacts of Hurricane Hugo on the forests of South Carolina.

Tree data from U.S. Forest Service plots across the State were combined with a hurricane model developed by the National Hurricane Center to identify factors that influence tree damage. Tree damage was best modeled as a function of wind speed, tree architecture and site factors. Tree damage was primarily determined by wind speed, while tree height, architecture, and species account for variation in the damage patterns. However, relative susceptibilities of species and tree characteristics were found to vary across gradients of wind speed and damage severity.

In response to wind storms, the differential susceptibilities of species and tree size classes result in immediate changes in the species composition and structure of the forest. Differential mortality and sprouting of the surviving trees, coupled with seedling regeneration, will determine how the forest composition will change over time.

Keywords: NC, SC, tree species susceptibility, weather damage.

23. Dennis, Donald Forrest. 1988. **An economic analysis of harvest behavior: integrating ownership and forest characteristics.** New Haven, CT: Yale University. 152 p. Ph.D. dissertation.

Source: DAI 50, no. 11A (1988): 3682. Ownership surveys reveal that nonindustrial private forest-land owners, who control a majority of the commercial forest land in the United States, hold land primarily for reasons other than timber production. Determining how much timber is available from this sector is difficult because multiple objectives cause these owners to respond to economic forces in a more complex and less predictable way than forest industry.

This study provides insight into the determinants of timber supply from private forests through development of both theoretical and empirical models of harvest behavior. A microeconomic model is presented that encompasses the multiple objective nature of private ownership by examining the harvest decision for landowners who derive utility from forest amenities and income used for the consumption of other goods. Probit analysis estimates the relationship between a dichotomous, yes or no, harvest variable and selected forest, owner, and economic characteristic. Tobit analysis, appropriate for censored samples, estimates the relationship between the quantity of timber harvested and a similar set of explanatory variables. Both analyses are performed on cross-sectional and pooled time-series and cross-sectional data for individual forest plots in New Hampshire. The inclusion of forest, owner, and economic

variables and the in-depth interpretation of the Tobit results distinguish this study from previous work.

The empirical results highlight the influence of forest characteristics and landowner affluence on the harvest decision. High per-acre timber volume and the proportion of commercially valuable species like white pine and red oak were positively correlated with timber harvesting while negative correlations were found for a landowner's exogenous income and years of formal education. Weak correlations, generally not significant at the 10 percent level, were found between financial variables and timber harvesting.

Decomposition of the Tobit coefficients indicates that changes in timber supply are expected to result primarily from changes in the number of acres from which timber is offered for sale and to a much lesser extent from changes in per-acre harvesting intensity. Marginal supply responses vary considerably depending on the values for the other coefficients and variables, underscoring the need to consider the shape of the distribution as well as the mean values for the explanatory variables when projecting harvest behavior.

Keywords: Economics, harvest probability (plot), NH, owner survey.

24. Eckhoff, Janet Dawn. 2000. **Efficacy of forest health monitoring indicators to evince impacts on a chemically manipulated watershed.** Orono, ME: University of Maine. 318 p. Ph.D. dissertation.

Source: DAI 61, no. 05B (2000): 2291. The USDA Forest Service, the US Environmental Protection Agency (EPA), and other agencies jointly developed the Forest Health Monitoring (FHM) program to assess the health of forests in the USA. Among the FHM indicators that have been implemented at sites across the USA are forest mensuration, crown condition, damage & catastrophic mortality, lichen communities, and vegetation structure. The efficacy of these five FHM indicators plus two additional indicators, tree canopy gap fraction and tree seed production, were tested at Bear Brook Watershed in Maine (BBWM) to determine their ability to detect the impacts of enhanced atmospheric deposition on forest vegetation. BBWM is a paired watershed research site, established as part of the EPA's Watershed Manipulation Program. Since 1989, West Bear has been chemically manipulated with bimonthly ammonium sulfate applications.

Results from the FHM damage and catastrophic mortality and crown condition indicators reflected no incidence of foliar damage related to the ammonium sulfate additions at

BBWM. Similarly, the FHM forest mensuration indicator reflected no influence of the ammonium sulfate additions on tree radial growth. There was a significant increase in the number of sugar maple seedlings in the manipulated watershed. Similarly the FHM vegetation structure indicator showed a significant increase in shrub abundance in the manipulated watershed.

The FHM forest mensuration indicator results reflected a slight trend towards decreased diversity in the number of sapling and seedling species present in the manipulated watershed. The FHM lichen communities indicator showed a similar trend of lower species diversity in the manipulated watershed. For lichens, the overall number of species and the average number of species per plot were both slightly lower.

Results from previous studies at BBWM have demonstrated changes in stream chemistry, soil chemistry, and tree and moss foliar chemistries all related to the ammonium sulfate manipulation. However, none of the five FHM indicators, or the two additional indicators, demonstrated decisively that the ammonium sulfate additions were affecting the vegetation at BBWM. A more accurate assessment of the linkage between acidic deposition impacts and forest vegetation is necessary to develop an indicator able to detect chemical perturbations such as acidic deposition.

Keywords: Air pollution, diversity (all vegetative species), FHM, lichens, ME, shrubs, tree crown health.

25. Ediriwickrema, Don Jayantha. 1996. **Modeling and analysis of AVHRR data for biogenic emission inventory system (BEIS).** Raleigh, NC: North Carolina State University. 178 p. Ph.D. dissertation.

Source: DAI 57, no. 03B (1996): 1528. The Biogenic Emission Inventory System (BEIS) is found to be uncertain in the order of a factor of three. The U.S. Environmental Protection Agency operates the BEIS based on three forest classes: oak, coniferous, and other deciduous. The BEIS is used to estimate biogenic volatile organic compound (BVOC) emissions at varying spatial and temporal resolutions. This study proposes a method to estimate the aerial extent of genus-level forest classes from high temporal resolution Advanced Very High Resolution Radiometer (AVHRR) to minimize the uncertainty of the inventory system. The National Oceanic and Atmospheric Administration (NOAA) program acquires AVHRR data twice a day with wide swath coverage (2700 km). The high-temporal NOAA-AVHRR data provide valuable source-data particularly for regional- and global-scale land and environmental studies. However, the potential of the

AVHRR data is limited by one square km coarse spatial resolution. The coarse spatial resolution AVHRR data are mostly found as mixed pixels, and the potential use is limited by the standard classification methods. These mixed pixels must be interpreted by accounting for all mixed classes instead of assigning each pixel into one class. This study proposes a method to estimate the extent of genus level forest classes from the AVHRR and the field data.

The forest areas are estimated from the AVHRR data by the proposed constrained generalized least squares regression (CGLS) method. The method is developed based on linear mixture modeling and the restricted generalized least squares regression analysis. The estimated genus-level forest class fractions are dependent on the fitness of the linear mixture model (LMM), the accuracy of the classified Landsat thematic mapper data used in the calibration of the LMM, the number of classes modeled in the LMM, and the dependency among the classes modeled in the LMM. In addition to the CGLS regression method, this study proposes a hierarchical image classification (HIC) method to produce better classified images than those classified images produced by the maximum likelihood classification with equal prior probabilities. The HIC uses the concept of visualization of pixels in spectral space to delineate the mixed pixels and their components. Improved classified images calibrate LMM reliably. The knowledge of the mixed pixels and their components minimizes the complexities in estimating land use/land cover (LU/LC) class fractions while minimizing the uncertainties in the estimates.

Genus-level forest areas are estimated in a Geographic Information System using the estimated forest class fractions and the Forest Inventory and Analysis (FIA) data. The fractions of the forest classes are estimated from the AVHRR data, and the FIA data are collected in the field by the U.S.D.A. Forest Service. The proposed CGLS regression method along with the proposed HIC method outlines an effective and feasible scenario to estimate the extent of forest classes. The estimated extent of forest classes from the coarse spatial resolution AVHRR data provides a base to derive the extent of genus-level forest classes at a varied level spatial and temporal resolution to minimize the uncertainty of the BEIS.

Keywords: Air pollution, satellite remote sensing.

26. Erkkila, Daniel Lee. 1980. **Forest management opportunities and associated regional impacts for northeastern Minnesota**. St. Paul, MN: University of Minnesota. 52 p. M.S. thesis.

Source: Paper copy of abstract. [This study linked the Forest Resources Economic Plan (FREP) to the Minnesota Regional Economic Impact Forecasting System (MREIFS) for regional analysis (labor, capital, and timber resources) in economic activity of timber-based industries.]

Keywords: Economics, MN, timber production modeling.

27. Erkkila, Daniel Lee. 1991. **Valuation of forest-based nonmarket outputs: a cost-price approach**. St. Paul, MN: University of Minnesota. 176 p. Ph.D. dissertation.

Source: DAI 52, no. 08B (1991): 3972. Nonmarket forest outputs (goods or services not traded in a traditional marketplace) continue to attract increasing attention. Traditional methods of nonmarket valuation, including direct (survey) and indirect approaches, are not widely accepted and often come with high data collection costs. For some situations, like accounting, values based on shadow prices for nonmarket outputs may be adequate.

Analyzing nonmarket outputs produced by timber harvest can be difficult because of the typically large numbers of stands involved in a harvest scheduling problem and temporal aspects of the decision. Models frequently fail from data overload stemming from model size. DUALPLAN, a model overcoming many of these limitations, was used to test a cost-price approach to value grouse recreation-visitor-days (RVDS of consumptive use) and nongame RVDS (nonconsumptive use) while producing timber. Using both simulation and linear programming to report key dual (economic) variables, DUALPLAN identified the marginal costs of producing both timber and the nonmarket outputs from managing a test forest made up of four major cover types (plus added attributes that generated over 4,600 stands).

The DUALPLAN analyses included development of market and nonmarket economic supply tables, even-flows of timber at various price levels (marginal costs), plus reporting other observable timber and nonmarket (price) impacts from varying management cost and stand attribute (production) variables. Timber and nonmarket price sensitivities were observed valuing grouse and nongame outputs at both the RVD and individual animal level and using nonmarket values developed by other methods (i.e., RPA). Harvest scheduling effects were also observed for all analyses, over time. Data limitations primarily involved unavailable data regarding the relationships between nonmarket output production (i.e., wildlife and dispersed recreation) and timber harvest.

DUALPLAN was effective and computationally inexpensive in cost-pricing both market and nonmarket outputs. While data and production function limitations resulted in only two nonmarket outputs tested, broader applications are possible. The DUALPLAN model could analyze significantly more complex forest problems than tested here. This investigation suggests great potential in exploring the nonmarket economic interactions with stand harvest scheduling, when the nonmarket production functions are known.

Keywords: Economics, recreation, timber and recreation modeling.

28. Faulkner, Joanne Lenahan. 1994. **Hardwood timber in Mississippi: recent trends in the resource and its use.** Mississippi State, MS: Mississippi State University. 129 p. M.S. thesis.

Source: MAI 33, no. 01 (1994): 0123. USDA Forest Service Forest Inventory and Analysis [FIA] data from the 1977 and 1987 surveys were used to analyze the status of the hardwood resource in Mississippi. Significant differences between the data were determined for volume, growth, removals, and mortality. Examples illustrating differences between inventory and available volume were provided using operability constraints.

Mississippi severance tax removals were used to determine differences in removals since 1987. Results from the 1994 survey of north Mississippi were analyzed to assess the latest inventory and compare with severance tax removals. The 1977 and 1987 surveys indicated an increasing inventory. Severance tax removals, particularly for pulpwood in northeast Mississippi have increased considerably since 1985. Trends evident in severance tax removals were also evident in the results of the 1994 north Mississippi survey. A shortage of hardwood timber in Mississippi is possible due to the large increases in removals and small increases in hardwood regeneration. [A model to predict removals was developed from average annual removals from severance tax and FIA estimates. The author also used established categories (Bechtold and Sheffield 1991, McWilliams and Rosson 1988, Spencer and others 1986) of volume per acre, average tree diameter, distance from road, slope to describe four operability classes—combinations of road proximity+slope+vol/ac+avg dbh—for the region.]

Keywords: Economics, MS, operability, timber production modeling.

29. Flick, Dennis D. 1984. **Private timber supply projections for western Oregon and Washington: a comparison with 1980 RPA timber supply estimates.** Corvallis, OR: Oregon State University. 88 p. M.S. thesis.

Source: Fox and DeWolfe (1994) #3457. [Mathematical models, timber supply.]

Keywords: OR, timber production modeling, WA.

30. Franco-Lopez, Hector. 1999. **Updating forest monitoring systems estimates.** St. Paul, MN: University of Minnesota. 123 p. Ph.D. dissertation.

Source: DAI 60, no. 08B (1999): 3640. Intensifying public interest in forests and the development of new monitoring technologies have induced major changes in the methods for updating forest monitoring systems. This thesis reviews the available methods for projecting and propagating forest plot and stand information. Since developing a methodology to produce forest maps based in forest inventory data would be very useful for many forest management and planning purposes, emphasis is focused on propagating forest sample information through the landscape for producing locally useful maps of forest variables such as cover type, stand density, and timber volume. Considerable effort in combining forest monitoring systems information, remote sensing, and Geographic Information Systems disciplines has been made in Nordic Countries.

One of the applications developed from this work is the k-nearest neighbors (kNN) method for forest estimation and mapping. In the kNN method, the information contained in field sample units is propagated to the entire population using a similarity function. The result is a form of post-stratification. We examine the use of the kNN method for producing wall-to-wall basal area, volume and cover type maps in the context of the USDA Forest Service's Forest Inventory and Analysis (FIA) monitoring system. Several variations within the kNN method were tested, including: distance metric, weighting function, and number of neighbors. Also, specific procedures to incorporate ancillary information and image enhancement techniques were tested.

The final products from this thesis are basal area, volume and cover type maps based on FIA and other inventory data. Additionally, each of these maps was characterized by estimations of their overall accuracy using cross-validation and other bootstrap based techniques.

Keywords: Geostatistics, GIS, MN, satellite remote sensing and FIA ground measurement, timber production updating.

31. Frazer, Rory Fenton. 1993. **Rural industrial location models for the wood processing industry in Northeastern United States of America.** University Park, PA: Pennsylvania State University. 199 p. Ph.D. dissertation.

Source: Pennsylvania State University. In this study, forest inventory data from the USDA Forest Service was used to construct measures of the stock of forest resources within economic haul distance of rural northeastern communities. The ARC/INFO Geographic Information System was used to convert the forest inventory data for 17 States. These measures along with 26 other community attributes such as agglomeration, inputs, outputs, transportation, demographic, service sector, etc. formed the pool of independent variables which were analyzed by logistic regression procedures. The results were parsimonious industrial location models for the logging, sawmill, and secondary wood processing industries.

Extension of the analysis to include a comparison of all wood processing establishments which started indicated that policy initiatives aimed at recruiting secondary wood processing establishments need to be cognizant of their high attrition rates and propensity for metropolitan locations. Another extension of the analysis indicated that successful establishments chose communities whose characteristics were different from the characteristics of communities chosen by unsuccessful establishments. Given these differences, the industrial location models for successful establishments were chosen as the final models for the three industries.

The final industrial location models for the logging, sawmill and secondary industries comprised nine, six and ten variables, respectively. The forest resources, service sector and agglomeration attributes of the rural communities were important in all models. These industrial location models can be used to target communities for the wood industry as well as assess the potential impact of policy initiatives.

Keywords: Economic haul distance, GIS, location modeling (timber industry), NEFIA.

32. Freimund, Wayne Alan. 1994. **Empirical validation of a forest inventory based aesthetic value model.** Madison, WI: University of Wisconsin. 94 p. Ph.D. dissertation.

Source: DAI 56, no. 03A (1994): 1123. A model is proposed in which perceived forest attractiveness is defined by 14 on-site and contextual dimensions of the landscape. The on-site dimensions include species diversity, presence of old growth and large trees, vegetative distinctiveness, ground plane conditions, negative human scale effects, and spatial

definition and visual penetration. The contextual dimensions include slope steepness, landform enclosure of space, water distinctiveness, absorption capacity, regional slope diversity and regional water diversity, regional vegetative diversity, and regional pattern of open space and forested mass. Each dimension is operationalized within the Forest Inventory and Analysis (FIA) data set and the cumulative value of the dimensions is used to create an index of attractiveness for each FIA plot in Minnesota.

Thirty-five millimeter slides of 100 inventory plots were evaluated by 473 participants representing 18 potentially different perspectives of forest management. The preference ratings of the 18 groups factored into two primary groups. This may have been the result of the order in which they viewed the slides. The attractiveness index explained 19 percent of the variance for one group's preferences and 28 percent of the variance in perceived attractiveness for the other group. A narrative that related the context of the plot was tested on eighteen plots. The narrative had a significant effect on the preference ratings of 44 percent of the plots. The changes in perceived attractiveness resulted in a near complete reordering of the relative preference for the 18 plots.

Keywords: Amenity valuation, GEIS, MN, recreation.

33. Friedman, Steven Kevin. 2001. **Landscape scale forest composition and spatial structure: a comparison of the presettlement General Land Office survey and the 1990 forest inventory in northeastern Minnesota.** St. Paul, MN: University of Minnesota. 159 p. Ph.D. dissertation.

Source: DAI 62, no. 03B (2001): 1157. Initial timber harvesting in Minnesota occurred prior to formal vegetation surveys. Consequently, little is known about species composition patterns, associations with soils, geology, and spatial structural relationships of these forests. Species response patterns to natural disturbance regimes however are well known from this region, they were fire dependent. However, fire suppression policy has been so successful and the introduction of initial harvesting was so complete that resource managers and ecologists are now concerned with the consequence of substituting one disturbance regime for another. This work was conducted at the landscape-scale (3.2 million hectares) to improve our understanding of the relationships of biodiversity and disturbance regimes in a southern boreal forest landscape.

I reconstructed the presettlement forest vegetation in northeastern Minnesota using General Land Office Survey Records (1853 and 1917) from the Arrowhead region of the State. A Geographical Information Systems data base was

established that includes digital maps of the survey records, physiographic zones, geology, and soils. I examined species composition patterns, associations with physical environmental factors, and spatial structural relationships to improve our understanding of the presettlement forest.

Results profile a low diversity forest with complex spatial autocorrelated structure that was influenced by several factors including, fire, geological materials, physiographic zones, soils, and species clustering tendencies and regeneration strategies.

Change in this forest following the introduction of logging and the suppression of fire was assessed using the presettlement records and 1990 East Wide Forest Inventory and Analysis Survey data base. Species composition and proportional basal area was assessed from these records. I conducted this regional change assessment aggregating presettlement and logging-era plot records within 253 10km x 10km cells.

Results show that substantial changes to the relative abundance, proportional basal area and spatial distribution patterns of species across physiographic zones, and soils has occurred. White pine was a dominant or co-dominant species in 45 percent of the presettlement forest. Aspen has become the regional dominant or co-dominant species in 83 percent of the forest. Forest community types with no presettlement-era analog occur in 46 percent of region. Major declines in white pine and larch were noted.

Keywords: GIS, GLO, MN, tree species.

34. Gunter, James Thomas. 1994. **An econometric analysis of softwood stumpage supply response to potential regional environmental changes**. Mississippi State, MS: Mississippi State University. 99 p. M.S. thesis.

Source: MAI 33, no. 05 (1994): 1442. A GCM-generated 2 x CO₂ climatic change scenario for the South was used to project the potential distribution of southern forests. A scenario of the potential effect of a 2 x CO₂ atmosphere on forest yield was also developed. This information was used in an econometric model to determine the potential effects of regional climatic change, an enriched CO₂ atmosphere, and their combined influence on the South's softwood stumpage supply. The factors that would most increase economic impact assessment accuracy were identified and research needs were prioritized. The results indicated that softwood stumpage supply was sensitive to changes in softwood inventory, the area of the South projected to lose forests contained most of the softwood inventory, and the potential yield changes resulting from an enriched CO₂

atmosphere would affect economic impact assessments less than forest migration as migration increases. Refining the estimates of forest distribution would increase economic impact assessment accuracy the most.

Keywords: Climate change (economics), econometrics, SRSFIA, timber production modeling.

35. Hansen, Mark Henry. 1990. **A comprehensive sampling system for forest inventory based on an individual tree growth model**. St. Paul, MN: University of Minnesota. 268 p. Ph.D. dissertation.

Source: DAI 51, no. 12B (1990): 5668. The purpose of this study was to develop an inventory system (sample design and estimators) for 1983 Wisconsin forest inventory. The basic hypothesis of the study was that an individual tree growth model (STEMS) could be used to simulate plot remeasurements. The procedure developed in this study utilizes both remeasurement and new ground plots and incorporates stratification for disturbance as well as the STEMS growth model into the sampling and estimation procedures. Estimates of area, volume, growth, and removals produced by this system were within the accuracy standards set for the inventory. Methods to integrate the new sampling design into the existing NCFIA data base management system and to produce all the information needed by NCFIA were also developed.

The second objective of this study was to modify the basic design developed for the 1983 Wisconsin inventory to find ways that it could be improved and to investigate the importance of various elements of the design. To accomplish this objective a computer spreadsheet model that simulates the sample design was developed. This model can be used as a tool in planning inventories and can also be used to study how changes in inventory design influence the total cost and accuracy of the inventory. Recommendations for further changes to the inventory system are given and areas where additional research may lead to other improvements are suggested.

Keywords: Sample design, tree measurement modeling, WI.

36. Hartsell, Andrew John. 1999. **Financial returns on timberlands in Mississippi from 1977 to 1994**. Mississippi State, MS: Mississippi State University. 85 p. M.S.F. thesis.

Source: MAI 37, no. 05 (1999): 1386. The objective of this study is to compute the real annual rates of return from mature, undisturbed timberlands in Mississippi during a 17-year period (1977-1994). This is performed by using

SRS-FIA timber volume data and TMS data on timber prices. Simple and adjusted financial maturity concepts are used. The study considers the implicit costs of holding timber. Average annual rates of change in value were computed and compared for four forest types across the State. The average annual rate of change in volume was also computed for these stands and compared to the financial rates of return. Three distinct time periods were considered: 1977-1987, 1987-1994, and 1977-1994.

The 1977 to 1987 average annual rate of return of all forest types was 6.82 and 3.50 percent using simple and adjusted financial maturity models, respectively. The 1987 to 1994 average annual rates were calculated to be 18.58 percent for the simple model and 11.32 percent for the adjusted. Average annual rates of return for the entire study period, 1977 to 1994, were 13.82 percent for the simple model, and 8.06 percent for the model using adjusted financial maturity concepts. (Abstract shortened by UMI.)

Keywords: Economics, financial maturity, MS.

37. Heym, Douglas Carey. 1984. **A methodology for comparing published regional field plot data to inventory plot data for natural hardwood stands in the Coastal Plain of South Carolina.** Ann Arbor, MI: University of Michigan. 48 p. M.F. thesis.

Source: University of Michigan, Fox and DeWolfe (1994) #1955. [Forest inventories.]

Keywords: Forest surveys.

38. Husain, Syed Arif. 1997. **Spatial and dynamic analysis of timber and biomass supply in Minnesota.** St. Paul, MN: University of Minnesota, Department of Applied Economics. 184 p. Ph.D. dissertation.

Source: DAI 58, no. 03A (1997): 1009. This research examines the ability of commercial forest lands in Minnesota to meet future timber demand targets and at the same time meet hypothetical future biomass energy requirements. It also assesses the potential for certain agricultural lands to be converted to short rotation poplar production so as to reduce harvest pressure on commercial forests. Timber and biomass prices under several product demands, resource base, and environmental constraints were estimated.

Existing commercial forest production was modeled under environmentally restricted and unrestricted management practices. Agricultural lands were represented by a subset of

lands formerly in the Conservation Reserve Program. Timber product demands at six traditional forest markets and biomass demands at two power plants were considered. Marginal costs of delivered timber and fuelwood products over the planning horizon under different environmentally restricted and unrestricted land base scenarios were estimated using a harvest scheduling model, a transportation model based on the actual road network, and a prescription writer to simulate stand growth after any harvesting activity.

The output from the model is the marginal cost of delivered timber products, location and quantity of forest and agricultural lands harvested, and total costs of meeting the demand target goals in each planning period. The results indicate that industrial demand for all timber products analyzed in this study can be satisfied over the planning horizon, if additional agricultural lands are devoted to poplar production. The addition is made necessary because of aspen, for which existing industrial requirements cannot be sustained over the planning horizon if only existing forest lands are used. The combination of restricted forest and agricultural lands results in higher marginal costs than the combination of unrestricted forest and agricultural lands. The difference in these marginal costs shows the opportunity cost of environmental mitigation. Since it turns out that the power plants modeled in this study would most cost effectively acquire fuelwood from existing forest lands, substantial savings could be achieved if the plants are located in the northern part of the State where major concentrations of the forest lands exist, rather than the currently proposed southwestern locations. [Economic timber resource assessment with a model incorporating tree biomass and the existing road network.]

Keywords: Agricultural land, biomass, economics, location modeling (biomass industry), MN, timber production modeling.

39. Jakes, Pamela J. 1977. **The biological and economic potential of Minnesota's commercial forest land to produce timber.** St. Paul, MN: University of Minnesota. 72 p. M.S. (Plan B) paper.

Source: Paper copy of abstract. [This study determined the potential biological yield and economic maturity potential of Minnesota's commercial forest land.]

Keywords: Economics, MN, timber production modeling.

40. Jorgensen, David O. 1997. **Analysis of wood availability from forest inventory and analysis data using a Geographic Information System.** Syracuse, NY: State

University of New York, College of Environmental Science and Forestry. 106 p. M.S. thesis.

Source: MAI 35, no. 04 (1997): 0972. The U.S. Forest Service (USFS) collects forest inventory data for each State at intervals of 5 to 15 years. This data is used by State forestry agencies to determine the availability of round wood in various aerial parts of their States (woodsheds) in support of economic development. The inventory data is poorly suited to this purpose if analysis of areas other than those provided by the USFS are desired. This project was designed to provide a method of analyzing wood availability for any region of the State (NY is the sample) using the inventory data. A Geographic Information System (GIS, pcARC/INFO) was the platform upon which the analysis application was built. The application has a menu-driven interface which allows the selection of (1) woodshed types (circle, selection of county(s), or user-defined area) and (2) tabular output based on species, minimum diameter (DBH), and several other volume or biomass criteria.

Keywords: Biomass, custom software, GIS, NY, timber supply.

41. Kapple, Douglas Clyde. 1995. **Using forest inventory and analysis data to interpret spatial patterns in a forest management scheduling model.** St. Paul, MN: University of Minnesota. 123 p. Ph.D. dissertation.

Source: DAI 56, no. 05B (1995): 2406. A Generic Environmental Impact Statement (GEIS) on timber harvesting and forest management in Minnesota was conducted in response to concern about the potential impact of proposed increases in industrial wood consumption on Minnesota forest resources. A harvest scheduling model that considered the shipment of multiple timber products from forest stands to multiple market locations synthesized critical information for the GEIS timber supply analysis. Analysis areas in the GEIS model were assumed to be located at Forest Inventory and Analysis (FIA) ground plot locations for the purpose of estimating transportation costs and evaluating wood shipment options. This degree of spatial aggregation raised concerns about whether or not the variation in geographical distribution of forest land was adequately represented and about the effects of locational assumptions on harvest timing decisions for individual stands.

A methodology was developed for utilizing FIA photo plot information to examine the effects of spatial aggregation in the harvest scheduling model. The methodology was refined and applied using data that was synthesized for the GEIS

analyses. Results of this study were compared with the results of the GEIS to identify problems with simplifying assumptions regarding stand location and to evaluate gains from utilizing the photo plot inventory information.

The results of this study indicated that statewide estimates and recommendations from the GEIS model were sound, but that deviations from assumptions about transportation distance could affect the choice of the best management alternative on as much as 16 percent of the timberland. Stands most susceptible to suboptimal management prescriptions are those with the greatest errors in assumed location and those with lower valued products.

Keywords: Air photo, GEIS, GIS, MN, timber production modeling.

42. Knapp, Gunnar Paulsen. 1981. **The supply of timber from nonindustrial private forests.** New Haven, CT: Yale University. 231 p. Ph.D. dissertation.

Source: DAI 42, no. 05A (1981): 2227. Nonindustrial private forests account for 58 percent of U.S. commercial forest area and provide 48 percent of U.S. timber supply. However, the determinants of management practices on and timber supply from these forests are not well understood.

This study develops an economic model of the factors determining private forest management and timber supply, which may be applied to the nonindustrial private forests. Nontimber forest outputs (amenities) are recognized explicitly as factors affecting forestry practices and the value of forest land. A flexible approach is provided by the treatment of nontimber outputs as heterogeneous products, the values of which are determined either directly in amenities markets or indirectly in land markets. Landowners choose those forestry practices which maximize the price of their land, equal to the present discounted value of all future income (including imputed income) from timber and nontimber outputs. Differences in forestry practices between owners and ownership classes result from differences in valuation of timber and nontimber outputs as well as difference in size and quality for producing timber and nontimber outputs of the forest land allocated them by the market.

Equilibrium in the land and timber markets determines land and timber prices and an equilibrium path for forest inventory over time. Harvests take place in response to timber growth and changes in prices, keeping inventory in equilibrium. Prices affect short-run supply primarily through their effects upon removals from timber inventory, and affect long-run supply primarily through their effects upon management intensity and timber growth.

As predicted by the model, estimation results using cross-section time series data for New Hampshire counties indicate that white pine timber supply per acre is an increasing function of timber inventory per acre and the price of timber, and a decreasing function of the price of nontimber outputs as measured by the price of forest land.

Keywords: Amenity valuation, economics, NH, timber production modeling.

43. Kolbe, A. 1998. **A growth model for Wisconsin's and Michigan's northern hardwoods, and management implications.** Madison, WI: University of Wisconsin. 163 p. M.S. thesis.

Source: J. Buongiorno, University of Wisconsin. [The study involved an uneven-aged, multi-species matrix growth model for northern hardwood forests (Kolbe and others 1999).]

Keywords: MI, tree growth modeling, WI.

44. Lee, Karen Jean. 1997. **Hedonic estimation of nonindustrial private forest landowner amenity values.** Raleigh, NC: North Carolina State University. 80 p. Ph.D. dissertation.

Source: DAI 58, no. 06B (1997): 2781. Research into nonindustrial private forest management behavior has often focused on the relationship between harvesting decisions and characteristics of the landowner. In addition to landowner differences, however, private forest management is affected by different levels of amenities present in individual forest stands. This relationship between forest amenity characteristics and private forest harvest and timber supply has not been well established. This paper tests the hypothesis that private forest landowners consider on-site forest characteristics as amenity values in their harvesting decisions. Landowners who value amenities may harvest beyond the optimal financial rotation age, thus incurring opportunity costs. Using a modified hedonic method, a regression of opportunity costs on the forest amenity characteristics provides estimates of the marginal value of these amenities. Because the decision to harvest is influenced by the amenity values present on the site, nonindustrial harvesters are a self-selected sample and econometric techniques were used to minimize bias in the coefficient estimates.

Keywords: Amenity valuation and timber production modeling, economics, NC, opportunity cost.

45. Lin, Ching-Rong. 1995. **Economics and diversity of trees and landscape in northern hardwood forests: implications of deterministic and stochastic models.** Madison, WI: University of Wisconsin. 168 p. Ph.D. dissertation.

Source: DAI 57, no. 02B (1995): 0792. A density-dependent matrix model of stand growth is presented. The model was calibrated with re-measured plots in the northern hardwood forests in Wisconsin. Trees were divided into shade-tolerant, intermediate, and shade-intolerant species in twelve diameter classes. Model predictions were tested against post-sample observations for short-term (15-year) and long-term (steady-state) accuracy.

The growth model (in deterministic form) was first applied to study stand growth dynamics with and without management. Starting with the current average stand state, the predicted stand basal area of an unmanaged stand rose steadily to a maximum, dropped gradually, and finally reached a steady state. The time paths of basal area and tree size diversity were highly and positively correlated. In contrast, tree species diversity decreased when tree size diversity and basal area increased, and vice-versa. When harvesting was introduced, it was found that more intensive harvest increased the diversity of tree species, while decreasing the diversity of tree size. A 20-year cutting cycle could produce higher economic returns than a 10-year cutting cycle, with similar size and species diversity.

In the second part, a Markov decision process (MDP) model was formulated to investigate the economic and ecological consequences of alternative management regimes, under an uncertain environment. Simulation based on the Markovian model showed that old growth stands with the highest tree size diversity would dominate the whole forest after a long time period. Major natural disturbances, as well as management, tended to increase the steady-state landscape diversity of the maple-birch forests in Wisconsin. Compared with the observed current cutting regimes, the economic harvesting policy could produce much more income, while keeping landscape and tree diversity at about the same level. The economic returns decreased as the desired level of tree diversity increased (especially for size diversity). Maximization of tree diversity would have a high opportunity cost compared with economic management alternatives.

The MDP model is attractive for its simplicity in practice. Its drawback is the coarseness of the system state definition. [Data were from 613 FIA plots in maple-birch forest type (Lin and Buongiorno 1998)].

Keywords: Diversity (landscape), diversity (tree species group), economics, tree growth modeling, WI.

46. Liu, Chiun-Ming. 1988. **A decisionmaking framework for assessing atmospheric deposition impacts on regional forest inventory**. Blacksburg, VA: Virginia Polytechnic Institute and State University. 167 p. Ph.D. dissertation.

Source: DAI 49, no. 11B (1988): 4623. A decisionmaking framework was developed to assess atmospheric deposition impacts on regional softwood inventory in Virginia. The Timber Resource Inventory Model (TRIM) was used to project future forest inventory, given initial inventory data, yield information, and harvest request. The timber consumption model was linked with TRIM to simulate the interactions between timber removals and inventory levels.

Algorithm analysis, sensitivity analysis, and an a priori analysis were used to examine the feasibility of TRIM for projecting atmospheric deposition impacts on inventory. Modification of growth and harvest decision variables in TRIM allows this impact estimation.

Schumacher's yield model was modified to develop the timber production function according to goodness-of-fit, minimal collinearity, and biological rationale. Crown length was used as a surrogate of a biological factor to reflect atmospheric deposition impacts on stand growth and yield. The small variance inflation factor allows the crown length elasticity to serve as a measure of the quantitative effects on the yield table. A system of predictor equations was added to the yield equation for simulating stand dynamics.

A consumption function approach was used to develop the timber removals model. The Box-Cox transformation, the stepwise regression procedure, and standard error were used to select the functional form, predictor variables, and estimates for the timber removals model. This removals model was linked with TRIM for simulating the interactions between removals and inventory levels for forest industry and other private.

Sensitivity analysis showed that the percentage reduction of inventory and removals is directly related to the crown length reduction. The larger the crown length reduction, the greater the percentage reduction of the inventory. The percentage reduction of yield tables due to the crown length reduction is slightly less than the overall percentage reduction of the inventory but is slightly greater than the overall percentage reduction of removals. The quantitative information on atmospheric deposition impacts on crown variables is a key to the impact estimation for inventory and removals. (Abstract shortened with permission of author.)

Keywords: Air pollution, timber production modeling, VA.

47. Lu, Hsien-Chih. 1992. **Economic management of Wisconsin's northern hardwood forest stands: a mixed-species model**. Madison, WI: University of Wisconsin. 145 p. Ph.D. dissertation.

Source: DAI 53, no. 06B (1992): 2605. The primary objective of this study was to investigate economically sustainable stocking guides for the management of Wisconsin's northern hardwood stands. Seven stocking guides were studied both in a deterministic environment and in a stochastic environment.

As a first step, a mixed-species growth model was developed for northern hardwoods species aggregated by species, quality, and commercial value of trees. Based on this model, an economic guide was developed to maximize land expectation value. This guide was compared with Arbogast's, q-factor, diameter-limit, and high-grading guides in terms of their economic returns and their long-term effects on stand structure and species composition.

The study revealed that, in a steady state, long-term equilibrium situation, the economic guide yielded substantially higher land expectation value than the other guides and led the stand to a good condition. The Arbogast and q-factor guides gave the lowest land expectation values. The high-grading guide led to a very poor stand condition.

The influence of initial stand state on the forest value was investigated by deterministic simulation. The results of the simulations showed very small difference in forest values obtained from the economic guide and those obtained from the diameter-limit guides or high-grading guide. This is because forest value is largely dependent on the early harvests and very little on the long-term stand structure (due to discounting).

In the real world, uncertainty exists everywhere. By adding a random vector into the growth model, a Markov decision process (MDP) guide was formulated to take this uncertainty into account. This guide then was compared with the economic (deterministic) and other guides, in a stochastic environment. As in the deterministic case, the difference in forest values obtained from the economic policy and those obtained from the diameter-limit policies or high-grading policy was small. This confirms the problem inherent in the forest value criterion in judging forest management policies.

The advantage of linear programming models is that these models could contain more detailed information than the MDP model. However, the model ignores the uncertain

nature of stand growth and price fluctuations as well as the initial stand conditions. The advantage of an MDP model is that risk factors can be introduced and managers can work with different initial stand conditions. However, the “curse of dimensionality” limits detailed study of forest management.

Therefore, the recommendation of this study is to use the MDP guide when making the cutting decisions, while respecting the residual stand structure recommendations in the economic guide. [Further details included in Lu and Buongiorno (1993).]

Keywords: Diversity (tree species group), economics, WI.

48. Marcouiller, David William. 1992. **Development and use of a supply-determined social accounting matrix to evaluate economic impacts of forest productivity on distribution of regional factor income.** Stillwater, OK: Oklahoma State University. 284 p. Ph.D. dissertation.

Source: DAI 54, no. 03A (1992): 1033. Scope and method of study. The economic impact of industrial, nonindustrial, and public timber production was assessed using a mixed endogenous/exogenous supply-determined social accounting matrix with specific results focusing attention on issues of income distribution. This matrix was constructed for McCurtain County, Oklahoma during 1985. Data sources used during construction include mid-South forest inventory statistics specific to McCurtain County, Timber-Mart South, a U.S. Department of Agriculture hybrid input-output model, published data from the U.S. Department of Commerce and U.S. Department of Labor, and numerous studies dealing with income distribution and transfer payments. Experiments using the constructed social accounting matrix apply a prespecified exogenous shock consisting of volume increases in timber production with forward linkages to wood processing. A predicted real timber stumpage price effect was also analyzed. Impacts of these experiments on the regional economic structure were quantified using interdependency and supply-constrained fixed-price analysis.

Findings and conclusions. An annual timber production output increase of \$16 million will contribute [approximately] \$7 million to regional factor income. Roughly 80 percent of this finds its way into regional household income. Timber production significantly contributes to medium and high income households but has little impact on low income households. Forward linkages of timber production output change to wood processing leads to wood processing output change of \$145 million annually

which contributes [approximately] \$43 million to regional factor income. Wood processing industries contribute most significantly to medium income households with modest impact on low and high income households. A \$31 million timber stumpage real price increase impacts regional households in a more limited fashion due to significant leakages from the region. Leakages of real price increases from the region are most significant from timber stumpage on industrial private forest lands. The real price effect shows more significant impact on high income households as compared to the volume effect.

Keywords: Economics, OK, owner, timber production modeling.

49. Mathews, Nancy E. 1982. **The capability of U.S. Forest Service resources evaluation in assessing small mammal habitat.** Syracuse, NY: State University of New York, College of Environmental Science and Forestry. 138 p. M.S. thesis.

Source: Paper copy of thesis. [The author used multivariate statistics to investigate FIA data and small mammal populations. Factor analysis explained 88 percent of the variation with 285 variables across 34 plots. Habitats of 13 species were examined in relation to population estimates. Of these, *Glaucomys volans*, *Glaucomys sabrinus*, *Microtus pennsylvanicus*, and *Zapus hudsonius*—all with restricted habitats—were successfully modeled with FIA data. Consistent discriminators included woody stem density by life form class, deciduous vegetation volume, canopy openings, litter cover, and slope gradient. The author suggested continued refinement to increase FIA timber and habitat variables as indices of habitat, and felt most success was likely for wildlife species with restricted habitat requirements.]

Keywords: NY, small mammal survey, wildlife.

50. McGuire, Michael Noel. 2000. **Measuring the perception of scarcity of the veneer log resource in the Lake States: Illinois and Indiana.** East Lansing, MI: Michigan State University. 145 p. M.S. thesis.

Source: MAI 39, no. 02 (2000): 431. Forest industry professionals have expressed concern about physical scarcity and diminishing quality in veneer logs of the preferred species’ contradicting USDA Forest Service inventory results which report an expanding resource base. This study examined factors influencing economic supply of select white oak, select red oak, hard maple, ash, black

cherry, and black walnut veneer logs in the Lake States, Illinois, and Indiana. Increased competition due to international demand is placing additional pressure on available inventory. Changing demographics are acting to reduce supply as non-timber land uses increase in importance. Industry professionals were queried to quantify their perception of scarcity and determine which factors they consider most important. The dominant perception is that quality is decreasing. Profitable architectural and panel grade veneer logs are perceived to be diminishing while furniture grade veneer logs are not. Quantity is perceived to be decreasing in the large and medium diameter classes but increasing in the small diameter classes. Expectation is for future real prices ten years hence to increase between 20–30 percent. Factors for the perceived scarcity ranking highest in importance were increased international demand, previous high grading, landowner mistrust of loggers, and increased environmental regulations. Respondents agree that the world demand for eastern hardwoods is strong and will continue to grow.

Keywords: IL, IN, timber industry survey, timber quality.

51. McKnight, Susanna Akiko. 1994. **Assessing the impact of data quality on the results of spatial modeling using sensitivity analysis: a case study using Minnesota forest inventory data.** Syracuse, NY: State University of New York, College of Environmental Science and Forestry. 194 p. Ph.D. dissertation.

Source: DAI 56, no. 01B (1994): 0014. This thesis examined data quality's impact on a spatial model designed to determine the suitability of a study site for pulpwood management. The goal was to gain a better understanding of data quality's influence on Geographic Information System (GIS)-based decision-making through the use of geographical sensitivity analysis. The analysis focused on changes in resolution and attribute error.

The resolution sensitivity analysis involved comparisons between the original quadtree level 10 suitability map and suitability maps generated at quadtree levels 9, 8, 7, and 6. Comparison maps indicated that eliminated and misclassified areas increased with increasingly coarser resolution. The 53 operable stands depicted on the level 10 map had a total suitable cut volume of 35,135 cords. The level 9 map did not differ from the level 10 map based on these criteria. However, level 7 had 49, and level 6 had 38 stands. Overall, as quadtree level decreased, the number of stands decreased, in particular, the smaller stands disappeared. The exception was level 8 in which an elongated stand separated and resulted in an overestimate of 54 stands and a total cut volume of 35,219 cords.

Comparisons were also made in terms of misclassified areas that indicated cut losses or false decisions to cut stands. The percentage of area indicating cut loss or false cut increased with increasingly coarser resolution.

The attribute error analysis investigated the three management prescription variables of age, site index, and basal area per acre, and two error levels including [unknown code 1] and [unknown code 2] percent. The results indicated that differences exist among attributes in terms of their sensitivity to introduced error and the impact on the decision to cut stands. Age and site index attributes were more sensitive to error when compared with basal area per acre. Overall, the age variable displayed the most sensitivity to error based on the percentage of area impacting the cut decision and the frequency of change experienced by stands, particularly at the [unknown code 1] percent error level. Basal area per acre experienced the least overall frequency of change and impact in terms of the decision to clearcut stands. The explanation for the sensitivity of the age attribute is associated with two major factors: (1) the critical cutoff values of the decision trees, and (2) the predominant pulpwood species in the study site. An examination of the characteristics of each stand identified on the best and worst case maps for the six perturbation sets revealed that these stands were mostly comprised of black spruce, tamarack, and aspen. Studying the decision trees for these cover types revealed not only the cutoff values for age but also that age was used to determine the cutoff values for basal area per acre. Also, the average stand age for the study site was about 52 years while cutoff values for black spruce, tamarack, and aspen ranged between 20 to 80 years.

Several recommendations for improving GIS reliability and decision-making capabilities were discussed including the conceptual design for a visual error assessment interface. The significance of this research lies in its contribution to a better understanding of the data quality's influence on GIS-based decision-making, particularly for forest management applications.

Keywords: Geostatistics, GIS, MN.

52. McWilliams, William Haney. 1983. **A dynamic analysis of sawtimber availability in the Allegheny unit of Pennsylvania: the next three decades.** University Park, PA: Pennsylvania State University. 173 p. M.S. thesis.

Source: Pennsylvania State University. [The study involved estimation of potential sawtimber availability (Strauss and McWilliams 1987).]

Keywords: PA, timber production modeling.

53. Michael, Jeffrey Alan. 1999. **The Endangered Species Act and private landowner incentives**. Raleigh, NC: North Carolina State University. 129 p. Ph.D. dissertation.

Source: DAI 60, no. 09A (1999): 3449. Under the Endangered Species Act (ESA), it is not illegal both to take (kill) and damage the habitat of an endangered species. This dissertation examines the extent to which landowners have preemptively destroyed habitat by examining the case of the red-cockaded woodpecker (RCW), and endangered species that live in old growth southern pine forests. By preventing the establishment of an old growth pine stand, the landowner can insure that RCWs do not inhabit their land and avoid ESA regulations that limit or prohibit timber harvest activity. The primary, empirical thesis of the dissertation is that the closer a landowner is to known populations of RCWs, the more likely the landowner will take action to destroy the habitat for RCWs by “prematurely” cutting their pine forest. This prediction is theoretically derived using both a two-period utility maximization model, and a model of optimal forest rotation. Two empirical questions are addressed: (1) how does the potential for ESA regulation affect the harvest probability of a particular forest plot, and (2) how does the potential for ESA regulation affect the age at which a forest will be harvested. The data are 1,000 individual forest plots from the U.S. Forest Service’s Forest Inventory and Analysis, a survey of over 500 North Carolina forest landowners, and the location of all known RCW colonies. Probit regressions estimate the probability that a plot is harvested. OLS regressions, corrected for harvest selection bias, estimate the age at which a forest is harvested. In most estimates, increases in the proximity of a plot to RCWs increases the probability that the plot will be harvested and decreases the age at which the forest is harvested.

Keywords: NC, owner survey, timber production modeling, wildlife.

54. Mills, John R. 1987. **An evaluation of an inventory projection system: TRIM model predictions vs. forest inventory field measurements in North Carolina**. Corvallis, OR: Oregon State University. 88 p. M.S. thesis.

Source: Author. [This study used FIA growth and inventory estimates for natural pine stands in North Carolina. The study examined data for two successive occasions and compared that data with estimates from an age-based empirical yield projection model (Timber Resource Inventory Model or TRIM). The study concluded that empirical yield curves did not represent aggregate stand

growth for natural pine stands. Further details are in Mills (1989).]

Keywords: NC, timber production modeling.

55. Moisen, Gretchen Gengenbach. 2000. **Comparing nonlinear and nonparametric modeling techniques for mapping and stratification in forest inventories of the interior Western United States of America**. Logan, UT: Utah State University. 182 p. Ph.D. dissertation.

Source: DAI 61, no. 12B (2000): 6549. Recent emphasis has been placed on merging regional forest inventory data with satellite-based information both to improve the efficiency of estimates of population totals, and to produce regional maps of forest variables. There are numerous ways in which forest class and structure variables may be modeled as functions of remotely sensed variables, yet surprisingly little work has been directed at surveying modern statistical techniques to determine which tools are best suited to the tasks given multiple objectives and logistical constraints. Here, a series of analyses to compare nonlinear and nonparametric modeling techniques for mapping a variety of forest variables, and for stratification of field plots, was conducted using data in the Interior Western United States.

The analyses compared four statistical modeling techniques for predicting two discrete and four continuous forest inventory variables. The modeling techniques include generalized additive models (GAMs), classification and regression trees (CARTs), multivariate adaptive regression splines (MARS), and artificial neural networks (ANNs). Alternative stratification schemes were also compared for estimating population totals. The analyses were conducted within six ecologically different regions using a variety of satellite-based predictor variables.

The work resulted in the development of an objective modeling box that automatically models spatial response variables as functions of any assortment of predictor variables through the four nonlinear or nonparametric modeling techniques. In comparing the different modeling techniques, all proved themselves workable in an automated environment, though ANNs were more problematic. When their potential mapping ability was explored through a simple simulation, tremendous advantages were seen in use of MARS and ANN for prediction over GAMs, CART, and a simple linear model. However, much smaller differences were seen when using real data. In some instances, a simple linear approach worked virtually as well as the more complex models, while small gains were seen using more complex models in other instances. In real data runs, MARS performed (marginally) best most often for binary variables,

while GAMs performed (marginally) best most often for continuous variables. After considering a subjective “ease of use” measure, computing time and other predictive performance measures, it was determined that MARS had many advantages over other modeling techniques. In addition, stratification tests illustrated cost-effective means to improve precision of estimates of forest population totals. Finally, the general effect of map accuracy on the relative precision of estimates of population totals obtained under simple random sampling compared to that obtained under stratified random sampling was established and graphically illustrated as a tool for management decisions.

Keywords: Geostatistics, GIS, RMFIA, satellite remote sensing and FIA ground measurement.

56. Morse, Rachel L. 1999. **An intensification of the forest health monitoring program: a pilot study in two Indiana State parks.** West Lafayette, IN: Purdue University. 120 p. M.S. thesis.

Source: John Moser, Purdue University. In 1996, Indiana joined the national Forest Health Monitoring (FHM) program of the United States Forest Service. One aspect of this program includes the establishment and assessment of forest health detection plots. Periodic data collection of health indicators on these plots provides a means to establish baseline forest conditions and to monitor trends. This study examined the suitability, mechanics, initial data and adaptations for monitoring individual properties. Detection plots for the national program are located 18 miles apart on a systematic national grid. Due to the intense agricultural and urban fragmentation present in Indiana, 106 of the 144 detection plots in the State do not land on a forested condition. Establishing FHM detection plots in specific areas of interest provides forest health data for areas not well covered by the national grid.

A prototype set of 25 forest health monitoring plots was established in two Indiana State parks and a nearby privately owned parcel using a new protocol. This protocol randomly assigns plots over the entire private property and randomly assigns plots within high use zones in the two parks. State park properties represent a major segment of the public land in Indiana. At present no intensive long-term forest health monitoring occurs on these properties, but recent park efforts make this an appropriate time to study resource monitoring procedures.

All plots were assessed in 1997 and reassessed in 1998. Initial growth and mortality rates were established for each plot. From damage and crown vigor assessments, trees displaying characteristics of eminent mortality were

identified and potential forest health problems were discovered. These include a lack of regeneration of current cover type species and a high incidence of decay on beech trees. In addition, site quality data were collected concerning ambient ozone levels, lichen communities and soil quality. Ambient ozone levels for all study sites are high. Lichen community and soil quality procedures were pilot studies and detailed information concerning each is not yet available. The findings of this study are preliminary. Through further assessments of the same plots over time, trends in forest health for these study sites can be established.

[This report references traditional tree measures and nontraditional tree crown, lichen community and soil quality measures. It used a measurement protocol for what is now known as FIA Phase III plot sampling. Novel is the replication of regional monitoring procedures for site-level inventory and management. The procedure increases the number of objectives addressed by increasing the sample density and remeasurement period. The protocol does not replicate the FIA sample grid, as samples are randomly allocated within the sites studied.]

Keywords: FHM, IN, lichens, timber production modeling, tree crown health.

57. Murphy, Dennis Leland. 1981. **A decision support system approach to timber harvest scheduling.** St. Paul, MN: University of Minnesota. 200 p. Ph.D. dissertation.

Source: DAI 52, no. 08B (1991): 3972. Harvest scheduling is a decision which has critical importance for forest management organizations. Recent research addressing harvest scheduling has developed information systems which provide programmed decision output. In these systems, harvest scheduling is approached as a structured decision. Few information systems exist in forestry which have been designed to provide an alternative type of decision output: decision support.

An information system was designed to support a normative decision model of the harvest scheduling decision process for the Minnesota Department of Natural Resources. Support was provided for both the planning and operations levels of management. Two applications of a database management system were designed, incorporating available forest inventory data: a planning level inventory and a unit-area level inventory. The natural and logical database structure designs reflect two differences in the inventories: the specific data collected in each and the role of the inventory in the normative decision model.

The information system was applied to a case study of the State ownership class aspen forest type in the Minnesota Aspen Birch Survey Unit. Stand selection rules were developed to meet silvicultural or managerial objectives for the aspen type. The rules assigned priorities to timber management classes; the alternative rules required different levels of information detail with respect to the timber management classes. The classes were developed by partitioning the aspen plots according to relevant plot characteristics; the partitions produced different patterns of information which were then used in the assignment of harvest priorities.

A tree growth processor simulated timber harvests for each of the stand selection rules. The simulations projected yields over three 10-year planning periods. A timber management evaluation table summarized the predicted results for the alternative schedules. The schedules were ranked according to the following factors: the production of hardwood volume, softwood volume, and combined volume for the 30-year period; the discounted values projected for each alternative; and the interperiod continuity of the hardwood, softwood, and combined product volumes. This ranking provided a method to determine preferences for the alternative stand selection rules.

The decision support system enables the management personnel to explicitly test alternative harvest schedules by simulation of heuristic rules. The method provides an option for analysts who design timber management information systems.

Keywords: MN, tree growth modeling.

58. O'Brien, Renee Allen. 1987. **Prediction of secondary cavity-nester habitat: a test of the forest survey data base.** Logan, UT: Utah State University. 52 p. M.S. thesis.

Source: Paper copy of abstract from author. [The objectives of the study were to determine FIA data utility for identifying and evaluating secondary cavity-nester habitat, and to test the validity of an index of food and nesting habitat suitability. Sampling involved 1985 bird census counts at 12 FIA plots at each of two study areas (Kaibib Plateau and Mt. Trumbull). Individual habitat components (canopy cover, tree height, foliage volume, and snag density) and an index of habitat suitability were characterized using FIA inventory data. Individual habitat variables as well as suitability were then compared with actual bird numbers. Variation in summer habitat characterization was large, and likely due to timber management practices. Habitat suitability explained some

variation at Mt. Trumbull but none of the variation at Kaibib Plateau.]

Keywords: Birds, dead trees, RMFIA, wildlife.

59. Ohmann, Janet Lynn. 1996. **Regional gradient analysis and spatial pattern of woody plant communities in Oregon.** Corvallis, OR: Oregon State University. 196 p. Ph.D. dissertation.

Source: DAI 57, no. 03B (1996): 1577. Knowledge of regional-scale patterns of plant community structure and controlling factors is largely qualitative and based on numerous local studies. Data from a subsample of 10,000 field plots were used to quantify and map compositional gradients of woody plant communities across Oregon forests. Canonical correspondence analyses explained 9-14 percent of the total species variation at three geographic scales. Climate contributed most to total variance explained (44-58 percent), followed by geology (6-16 percent), disturbance (7-13 percent), and topography (4-8 percent). The dominant compositional gradient was associated with climate, from the lower elevation, moderate, maritime climate of the coast to the higher elevation, drier, continental climate of the interior. The second canonical axis followed a gradient from the warm, dry growing seasons of the interior valleys and eastern Cascades, to cooler, wetter mountainous areas. Only those parent materials that present extreme growing conditions, primarily ultramafic soils, were significant at the regional level.

Ecological relationships differed substantially among subregions within the State. Except for topography, which contributed more to explained variation at finer geographic scales, ecological differences among subregions overshadowed effects of geographic extent. Topographic effects were stronger and beta diversity greater in eastern Oregon, where moisture is more limiting for plant growth, and weakest near the coast where climate is more favorable. The secondary importance of topography, disturbance, and substrate can be attributed to their influence on relative abundances of species within a local area, rather than on species presence or absence within broader regions.

Community structure varied at a finer spatial scale in eastern than in western Oregon, and species turnover along gradients was greater for shrubs than trees. Amount of unexplained variation in the species data was high but not atypical of gradient analyses. Yet spatial structure in the species data that was uncorrelated with explanatory factors suggests potential to improve the canonical correspondence analysis models, particularly in eastern Oregon.

Study findings have implications for considering biological diversity in regional conservation strategies, in planning for global climate change, and in the design of regional inventory and monitoring programs.

Keywords: Diversity (woody plant), ecological landtype classification, GIS, OR, soils.

60. Okoye, Michael Anayo. 1997. **Ecological database development and analyses of soil variability in northern New England**. Durham, NH: University of New Hampshire. 172 p. Ph.D. dissertation.

Source: DAI 58, no. 12B (1997): 6467. The 1983 Forest Inventory and Analysis (FIA) data of the States of Maine, New Hampshire and Vermont (the study area) contain large amounts of field-measurements of many ecologically important variables. Despite the vast potential usefulness of the FIA data for scientific research, the data were until now, literally unused except for a few administrative purposes, because of problems in the way the data were organized, summarized, and coded for storage. The primary objective of this research was to solve the problems that had thus precluded these FIA data from use in scientific applications, and present the data in a form that is readily accessible and usable for research. This objective was achieved by adapting the un-summarized data in a relational database management system (RDMS) and Geographic Information System (GIS). RDMS-GIS technologies would make these data amenable to more types and multiple spatial scales of analyses than previously possible, thus providing the scientific community with an unusually large, high quality, and spatially referenced data set.

The FIA data also contain field and laboratory measurements of soil properties made at the geo-referenced FIA plot locations. These soil data also provided the basis for other studies in this dissertation. These studies included analyzing the spatial variability of selected soil attributes in the study area; evaluating the nature of the differences in specific soil properties among the ecological land classification map (ECOMAP) section and subsection units; and assessing the variability of specific soil properties in the NRCS-State Soil Geographic Database (STATSGO) of the study area. Both the ECOMAP and the STATSGO studies involved the use of GIS techniques and multivariate statistical methods for map unit analyses.

This dissertation also included more theoretical investigations relating to applied statistics and soil science. One of these addressed the unanswered question of whether or not it is necessary to use non-linear transformations prior

to computing variability statistics from non-normally distributed soil data, and explored the use of coefficient of variation as a semi quantitative index of nonnormality in soil variables. Another study looked at why and how error matrices and related statistics can be used as an effective, comprehensive quantitative method of evaluating soil classification and soil map quality.

Keywords: Custom software, GIS, ME, NH, soils (STATSGO), VT.

61. Othic, Scot T. 1981. **Conversion of forest land in the Missouri Ozark region**. Columbia, MO: University of Missouri. 90 p. M.S. thesis.

Source: University of Missouri. [Not available. Reference is Othic and others (1982).]

Keywords: Land use, MO.

62. Owens, Karen Elizabeth. 2001. **Development and analysis of current and presettlement forest cover mapping methods for the eastern Upper Peninsula of Michigan, Luce District**. Houghton, MI: Michigan Technological University. 215 p. Ph.D. dissertation.

Source: DAI 62, no. 03B (2001): 1158. Continuous forest cover maps for an area located in the Luce District of the Upper Peninsula of Michigan were generated from two different forest point datasets using different spatial and geostatistical interpolation methods. The two forest datasets interpolated were current Forest Inventory and Analysis (FIA) data collected in 1993 and pre-European settlement General Land Office survey (GLO) data. Given the relationship that exists between soil and site factors, like drainage and slope, and predominant forest types, ancillary soils information were utilized to provide neighborhoods of influence for each of the interpolation methods. Three interpolation methods were applied to the FIA data: Thiessen Polygons (TP), Inverse Distance Weighting (IDW), and Indicator Kriging (IK). The results of the three interpolation methods were compared using the FIA data to assess the differences in outputs and final maps. Final interpolated forest maps were then compared to a landcover map derived from Landsat TM imagery collected in 1991 and calculations of forest type areas generated by a FIAMODEL (Reed and others 2001) model to judge the appropriateness and success of each procedure. Based on the success of two of these methods, IDW and IK were applied to the GLO data. The interpolated output and final forest maps from the GLO data were also compared to assess any

differences in methods and their outputs. Final forest maps were compared to manually generated MNFI pre-European settlement maps to assess the differences. For both datasets, IDW performed the best in delineating all forest groups occurring in the study area while IK performed well for mapping only those forest groups occurring most frequently. IDW maintained the local spatial information and IK mapped more regional patterns of forest occurrence.

Keywords: Geostatistics, GIS, GLO, MI.

63. Pacheco Lopez, Gerardo. 1996. **Empirical modeling of timber supply in the United States**. Raleigh, NC: North Carolina State University. 215 p. Ph.D. dissertation.

Source: DAI 57, no. 12B (1996): 7292. Chapter 1 characterizes the US South forest resource from the perspective of empirical timber supply modeling. Summaries of relevant timber supply indicators at the South-wide, State, and survey region level, for the common forest types, species groups, and ownerships are provided as guidelines for the commonly used levels of aggregation in modeling. An assessment is made of the use of Eastwide data base data from the USDA Forest Service for timber supply modeling.

Results from a South-wide timber supply projection to the year 2020 are examined and compared against national projections in chapter 2. Individual State inventories were updated to 1994 as a common starting point for the projection. Only private ownerships were considered in the model. Softwood prices are projected to increase seven times and hardwood prices over two and a half times over the projection period. The largest projected price increases for softwoods occur during the decade 2010 to 2020. Inventory of softwoods is projected to decrease by 30 percent relative to the starting year, and hardwoods to increase only by 2 percent. South-wide softwoods growth to removal ratio is expected to decline from 0.94 to 0.71, and from 1.36 to 0.87 for hardwoods. Price projections are sensitive to growth per acre assumptions. Results are conservative in that they assume constant productivity levels in planted pine forest types.

Chapter 3 examines the effects of differing assumptions about the future productivity levels of pine plantations. Empirical models of growth and yield are developed for each of the major forest types with the purpose to evaluate the impact on empirical timber supply projections from possible increases in the productivity of pine plantations of 20, 40, and 60 percent by the year 2020. Total increases of 60 percent in pine plantation growth per acre projection

results in total softwood price increases (174 percent) that are less than one-fourth of those produced by the base projection (788 percent). Improvements can be made with better quality and availability of data on projected pine plantation areas and the extent of current and projected level of intensive management in pine plantations.

Keywords: Economics, SRSFIA, timber production modeling.

64. Parks, Peter John. 1986. **The influence of economic and demographic factors on forest land use decisions**. Berkeley, CA: University of California. 96 p. Ph.D. dissertation.

Source: DAI 48, no. 05A (1986): 1272. Forest land decisions in North Carolina and Oregon are related to economic and demographic factors through the use of discrete choice models. A trinomial probit model allowing correlation among land use alternatives and neighboring land owners is developed. Forest-nonforest land use transitions in North Carolina are shown via a binomial model to depend on economic returns, population density, concentration of population in urban areas, and the rates of forest growth. Land use allocation among forest, agriculture, and other uses in Oregon is shown via probit and logit models to depend on these factors and on correlation among alternatives.

A supply schedule for nonindustrial forest land (NIPF) is constructed from the North Carolina model and combined with a schedule of forest land demand to demonstrate that decreased forest land conversion is a response of land owners to economic incentives. Equilibrium levels of forest land are 8.4 percent below 1974 levels, indicating that USDA Forest Service projections of a 13.3 percent decrease for the State may be too high for this region.

The model for Oregon is used to evaluate the consistency between Forest Service projections of the private forest land base in Oregon and prices for Pacific Northwest softwood stumpage. Simulations using price projections of 1.01 percent per year bring about an increase in the forest land base similar in magnitude to increases in industrial forest lands seen from 1960 to 1970. In general, predictions of decreases in the forest land base appear exaggerated unless real increases in agricultural returns or transportation distances are also expected.

Keywords: Economics, land use, NC, OR, population density, timber production modeling.

65. Parresol, Bernard Ross. 1998. **Sample-based forest landscape diversity indices**. New Orleans: Louisiana State University and Agricultural and Mechanical College. 126 p. Ph.D. dissertation.

Source: DAI 59, no. 06B (1998): 2525 and author. Studies of spatial patterns of landscapes are useful to quantify human impact, predict wildlife effects, or describe various landscape features. A robust landscape index should quantify two distinct components of landscape diversity: composition and configuration. One category of landscape index is the contagion index.

A generalized measure of contagion is defined as a function of concentration. From this definition two contagion indices, Γ_1 (a new index) and Γ_2 (an entropy formulation), are derived from expected values of geometric random variables. A widely used relative contagion index, RC_2 is shown to be a scaled version of Γ_2 .

Distributional properties of $\hat{\Gamma}_1$, $\hat{\Gamma}_2$, and $\hat{\Gamma}_{2(scaled)}$ (i.e. \hat{RC}_2) are derived. They are shown to be asymptotically unbiased, consistent, and asymptotically normally distributed.

Variance formulas for $\hat{\Gamma}_1$, $\hat{\Gamma}_2$, and $\hat{\Gamma}_{2(scaled)}$ are derived using the delta method. A Monte Carlo study using subseries analysis and replicate histograms, for variance and distribution assessment, was done as a validity check.

Behavior of Γ_1 , Γ_2 , and RC_2 were investigated with simulated random, uniform, and aggregated landscapes. Both Γ_1 and Γ_2 provide acceptable measures of contagion. The index RC_2 is shown to be an index of evenness, and not of contagion. It is demonstrated that relativized contagion indices are mathematically untenable.

As an application, the pattern and changes in forest cover types over the last two decades were analyzed on three landscape level physiographic provinces of the State of Alabama: (i) The Great Appalachian Valley Province, (ii) The Blue Ridge-Talladega Mountain Province, and (iii) The Piedmont Province. The USDA Forest Service conducts periodic surveys of forest resources nationwide from plots distributed on a 3-mile by 3-mile (4.8-km by 4.8-km) grid randomly established within each county. Using forest inventory and analysis survey data on forest cover types, stratified by physiographic province, the $\hat{\Gamma}_1$ and $\hat{\Gamma}_2$ contagion values and their variances were calculated for each province for the survey years 1972, 1982, and 1990. One-way analysis of variance was used for hypothesis testing of contagion values across time and between provinces. Contagion values were very similar indicating similar processes operating across the physiographic provinces over the last two decades. In comparing $\hat{\Gamma}_1$ and

$\hat{\Gamma}_2$, use of $\hat{\Gamma}_1$ in analysis of variance gave a more conservative test of contagion.

Keywords: AL, geostatistics, patch indices.

66. Pelkki, Matthew Harold. 1992. **Developing conceptual information system models for natural resources**. St. Paul, MN: University of Minnesota. 226 p. Ph.D. dissertation.

Source: DAI 53, no. 01B (1992): 0026. Two techniques for information requirements determination were examined and compared during a case study of the Minnesota Department of Natural Resources Division of Forestry's data planning and database design projects. An accelerated technique was used to develop a data plan for the division of forestry, and an extended design process was used to develop the detailed conceptual data model for the division's forest inventory database.

Each process was observed and survey tools were used to evaluate user responses to each process. Evaluation criteria were established and applied to the results to evaluate the effectiveness of the two information requirements analysis techniques.

The results of these comparisons indicate that extended techniques are much more likely to produce high quality data models in either the data planning or data design process. Recommendations for selection of an analysis technique are presented, along with potential effects and interactions with novice facilitators and task complexity and size. The study also introduces a conceptual information model for forest data, and examines the presence and impact of artifacts on conceptual database models.

Keywords: Custom database, MN.

67. Piazza, Marco. 2000. **Diversity-productivity relations in the northern hardwoods of Wisconsin and Michigan**. Madison, WI: University of Wisconsin. 54 p. M.S. thesis.

Source: J. Buongiorno, University of Wisconsin. [This study examined timber productivity by tree species group.]

Keywords: Diversity (tree species group), MI, timber productivity, WI.

68. Plantinga, Andrew J. 1988. **The determinants of changes in nonindustrial private forest landowners**. Madison, WI: University of Wisconsin. 60 p. M.S. thesis.

Source: J. Buongiorno, University of Wisconsin-Madison. [A subsequent paper (Plantinga and others 1989) referenced between-survey changes in FIA estimates of forest area for Michigan, Minnesota, and Wisconsin, and associated that data with ownership, population, and income levels.]

Keywords: MI, MN, owner, population density, WI.

69. Powell, Douglas S. 1990. **Temporal and spatial variation in tree demography and species composition based on forest inventories of Maine**. Durham, NC: Duke University. 267 p. Ph.D. dissertation.

Source: DAI 52, no. 02B (1990): 0627. This study addressed three general problems: (1) present an ecological description of Maine's forests, (2) characterize population parameters under various biotic, abiotic, and disturbance conditions, and (3) investigate relationships between disturbance and species composition.

Data were from 769 permanent plots measured in 1957, 1969, and 1981 as part of ongoing statewide forest inventories. While data provided new characterizations of forest land by climate, soil, slope, elevation, and productivity, ordination techniques revealed that some environmental variables important for explaining forest community structure were not gathered. Analyses identified problems with productivity classifications and which site variables provided redundant information. Species abundances best fit a geometric series distribution, supporting the niche pre-emption hypothesis of division of community resources.

A four-stage matrix population model estimated population growth and survival/mortality rates for balsam fir, red spruce, and red maple. Elevation, soil site quality, and rooting depth had no consistent influence on population parameters. Higher stocking levels led to lower population growth and survival rates, and shade tolerance was not a dominant factor determining species response. Harvest had a greater impact than natural disturbance. Balsam fir was affected most by disturbance. The assumption of time-homogeneous transition probabilities in stationary Markov chains is invalid in many situations, and projections can vary widely without proper accounting of disturbance. Results showed a decline of spruce-fir populations between 1957 and 1981, which may be explained by multiple factors (e.g., species longevity, disturbance, and air pollution).

A new technique of coupling detrended correspondence analysis and Euclidean distance dissimilarity measure was used to evaluate relationships between disturbance and species composition of red spruce-balsam fir stands. Much

of the variation of successional paths across the 23-year period was due to various types and severities of disturbance, but many other factors were important. There were no significant differences between shorter intervals with respect to compositional change. Results indicated that cutting changed composition more than natural disturbance. Increased spruce budworm activity resulted in an increased rate of succession, with balsam fir declining relative to red spruce. More specific data on disturbance would enhance the value of forest inventories in studying forest succession.

Keywords: Air pollution, diversity (tree species), ecological landtype classification, ME, soils.

70. Ramirez-Maldonado, Hugo. 1988. **On the relevance of geostatistical theory and methods to forest inventory problems**. Athens, GA: University of Georgia. 179 p. Ph.D. dissertation.

Source: DAI 49, no. 09B (1988): 3531. The theory and methods of geostatistics are presented and discussed in the context of forest inventory. Geostatistics provides a theoretical framework to evaluate resources based on the identification of regionalized variables, which are in turn assumed to be realizations of random functions (stochastic or random fields) in order to allow their evaluation under probabilistic sampling. Geostatistical methods account for spatial correlation within the sample. Many forest characteristics can be identified as regionalized variables and their evaluation can be accomplished using such theory and methods.

The geostatistical methods can provide more precise estimates than methods which assume independence among the sampling units because forest sampling units are correlated if they are close together with a correlation that diminishes with distance. The independent-plot estimation method is a particular case of this broader class and represents the absence of such spatial correlation.

The basic tool in geostatistics is the variogram function, which is the variance of the difference between two observations when interpreted as a random function. This variance is assumed to be a function of the distance between the two realizations. The appropriate modeling of this function is a crucial step in geostatistics.

The variogram for basal area measured by the Bitterlich method (point sampling) can be efficiently fitted to the spherical model. The smoothness of the function produced by this method of measurement is inversely related to the basal area factor (BAF), and the univariate variance is almost linearly related to it. Smoother functions yield

smaller estimation variances, so that disregarding other considerations a small BAF should be preferable over a larger one.

The geostatistical methods are shown to be appropriate for analyzing the 10-point cluster sampling plan used by the U.S. Forest Service and, in general, they can be recommended for any two-stage sampling scheme.

A new theoretical framework for the traditional point sampling procedure based on the Bitterlich method of measurement is presented. This approach expresses point sampling as a multinomial process, for which explicit and feasible variance formulas can be deduced.

Keywords: Geostatistics (subplot), GIS.

71. Randolph, KaDonna C. 2000. **An evaluation of forest health monitoring analytical techniques and data for two Indiana State parks.** West Lafayette, IN: Purdue University. 134 p. M.S. thesis.

Source: Author. The effectiveness of the US Forest Service Forest Health Monitoring Program analytical techniques for documenting change was examined with data from a small-scale study in two Indiana State parks, Shades and Turkey Run. Three aspects of the FHM analyses were examined: (1) height prediction and volume estimation, (2) changes in crown characteristics, and (3) annual growth and mortality estimation. Additionally, present volumes and a ratio describing the diameter distribution of dead trees were calculated for each park.

It was found that the FHM height prediction procedure over predicted the heights for six species groups: hemlock, red maple, sugar maple, white oaks, and two mixed hardwood groups. Improvements in the predicted heights were made for all but one of these groups when the FHM conditioning process was omitted from the height prediction procedure. Volumes estimated with both sets of heights were not significantly different from each other.

Three measures of crown condition were examined for change over time and equality of change over time between the parks. No significant changes over time ($\alpha = 0.10$) were found in either park for crown dieback, softwood foliage transparency, and crown density. There was no significant change over time in hardwood foliage transparency in Turkey Run State Park. An estimated increase of 1.841 percent in foliage transparency was detected for hardwoods in Shades State Park. Further examination revealed that the significant changes were in hickory and black cherry trees. The tests for equality of change over time between the parks resulted in no significant differences.

Annual growth was estimated as 266.09 cubic feet per acre in Shades, and 66.79 cubic feet per acre in Turkey Run. In Shades, annual mortality was estimated as 30.45 cubic feet per acre. No mortality was recorded between 1997 and 1999 in Turkey Run. Present live volume in Shades and Turkey Run was estimated as 4786.16 cubic feet per acre and 4792.70 cubic feet per acre, respectively. The diameter distribution of dead trees indicated that mortality in Shades was most likely the result of natural thinning and in Turkey Run, the result of natural senescence.

[This report references traditional tree growth and mortality measures and nontraditional dead tree and tree crown measures. It used a measurement protocol for what is now known as FIA Phase III plot sampling. The replication of regional monitoring procedures for site-level inventory and management is novel. The procedure increases the number of objectives addressed by increasing the sample density and remeasurement period. The protocol does not replicate the FIA sample grid, as samples are randomly allocated within the sites studied.]

Keywords: Dead trees, FHM, IN, timber production modeling, tree crown health.

72. Resh, Sigrid. 1994. **Assessing the availability of timberland for harvest in the Lake States.** East Lansing, MI: Michigan State University. 201 p. M.S. thesis.

Source: MAI 33, no. 05 (1994): 1444. Both public and private owners of timberland choose not to harvest timber due to various market conditions, resource conditions, management objectives, and concerns regarding the effects of harvesting. Timber supply analyses based on forest inventory data do not typically reflect these exclusions from timberland causing an overestimation of available timberland for timber production. Land managers of the Lake States' national forests, DNRs, counties, and private lands are surveyed for their expert judgment concerning current and the year 2020 availability of lands for timber harvest and factors affecting the availability. Additional information is also provided pertaining to the predictions of cover types on lands not available for harvest in the year 2020 as well as management trends on public and private forest land. Statewide summaries show that timberland available for harvest is predicted to decrease on both public and private lands. Social constraints and environmental factors are the major factors perceived to be causing the predicted decrease.

Keywords: Harvest probability, MI, owner survey.

73. Riley, Gretchen. 2000. **Evaluation of Landsat TM generated forest-type map for tax appraisal purposes.** College Station, TX: Texas A&M University. 33 p. M.S. thesis.

Source: Texas A&M University, 2000 thesis R56. A tax appraisal system of private timberland based on the productivity value of the timber relies on current, accurate information about the land being assessed. Historically, such information has been supplied by aerial photos and field surveys. These methods are time-consuming, expensive, often out-of-date, and must be converted to digital data in order to be utilized in a Geographic Information System (GIS). This study hypothesized that satellite-based products and technology would generate a forest-type map that would provide accurate acreage estimates of forest types for tax appraisal purposes. Accuracy of over 91 percent was achieved for a forest-type map generated from leaf-off Landsat TM imagery relative to aerial photo reference data. Forest-type data obtained through traditional methods were compared to TM data of various minimum mapping units and determined to be less precise than the satellite forest-type data. Elimination of the pine-hardwood mixed forest type for individual tracts and making each tract have percentage estimates of the pine and hardwood components may be a more precise evaluation of land cover due to the finer resolution of satellite imagery.

Keywords: GIS, satellite remote sensing, TX.

74. Rosson, James Forrest, Jr. 1999. **An analysis of the temporal dynamics in tree species diversity for major tree taxa of two States in the midsouth, United States of America.** Knoxville, TN: University of Tennessee. 226 p. Ph.D. dissertation.

Source: DAI 60, no. 09B (1999): 4375. An analysis of the temporal dynamics of tree species diversity was made for empirical forests of the States of Arkansas and Mississippi, USA. These two States each had four comprehensive, variable radius plot measurements over a period of three decades. In addition to tree species data, the surveys provided three physiographic categories, three ownership categories, and five stand-size classes. Two measures of tree species diversity were applied to the survey data: (1) tree species richness; and (2) the McIntosh measure of evenness. The Sorensen quantitative index of similarity was used to contrast tree species changes between survey periods.

Repeated measures ANOVA tests were conducted to test for significant differences in diversity measures across time and between specific group strata. All tests were conducted at

the 0.05 probability level. Maps showing spatial distribution were created to show patterns of the three diversity measures across each State. Major findings from this study showed tree species richness levels have declined at the State level for Arkansas and Mississippi. This was confirmed by examination of the empirical evidence and results from the repeated measures ANOVA test ($p = 0.0001$). Arkansas tree species richness declined by 3.4 percent since 1968, and Mississippi tree species richness declined 10.6 percent from its highest level in 1977.

An additional important revelation was the notable impact plantations were having on tree species richness at the State level. Tests were conducted to discern differences in species richness by contrasting data sets which included plantations with data sets that excluded plantations. The data showed that the increasing implementation of plantation forestry is having a negative impact on the overall average tree species richness for each State.

The absence of harvesting allowed forest land to increase in tree species richness. Plots that had no harvesting activity over the four survey measurements (survivor plots), significantly increased in tree species richness. Arkansas tree species richness increased on these plots by 21.6 percent between 1968 and 1995 while Mississippi increased 43.8 percent from 1967 to 1994.

Tree species richness has declined in these two mid-South States during four survey measurements covering the mid 1960s to the mid 1990s. The study did not use a causal inference design but did test statistical hypotheses to confirm real differences in the data. Corroborative evidence, supported by empirical evidence in the data, suggests that intense and increasing forestry practices (harvesting and plantation forestry) have attained a level high enough to contribute to the reduction in overall tree species diversity in Arkansas and Mississippi. (Abstract shortened by UMI.)

Keywords: AR, diversity (tree species), land use intensity (harvest and tree plantations), MS.

75. Rubin, Benjamin Dana. 1999. **Predicting growth rate and relative importance of common tree species in the Adirondacks from environmental variables.** Syracuse, NY: State University of New York, College of Environmental Science and Forestry. 88 p. M.S. thesis.

Source: MAI 37, no. 05 (1999): 1399. Environmental conditions that affect a tree's success do so by modifying its energy profit. Therefore, environmental variation throughout a population should explain variation in energy profit, and hence population success. I evaluated population success

based on patterns of importance value (IV) and radial growth rates of 12 common tree species in the Adirondack Mountains along 7 environmental gradients, including: air temperature, soil moisture, solar radiation, site productivity, stand age and stand basal area. Air temperature was the best predictor of IV for most species. Air temperature, soil moisture, stand age and stand basal area were the best predictors of growth rate. Significant trends were more common for growth rate than IV on private land. Analysis of IV on an independent dataset found more distinct patterns of IV on protected State land than on private land. Analysis of a third dataset revealed that tree diseases are associated with reduced growth rates. [The study uses data from FIA, FHM's Adirondack survey in 1996, and the Huntington Wildlife Forest Continuous Forest Inventory (HCFI).]

Keywords: Ecological landtype classification, FHM, NY, tree growth modeling, tree species.

76. Scarpa, Riccardo. 1999. **Assessing the amenity value of forests, with applications to Wisconsin and Ireland.** Madison, WI: University of Wisconsin. 140 p. Ph.D. dissertation.

Source: DAI 61, no. 02B (1999): 613. The objective of this research is the valuation of the amenity function of forests. In Wisconsin northern hardwoods forests, the goals are (i) to develop a method to compute the amenity value (non-timber value) of uneven-aged forests; (ii) to determine how individual stand characteristics, and those of its owner, influence non-timber value; (iii) to apply the methods to the maple-birch forest type. In Irish forest parks, the goals are (i) to estimate willingness to pay for recreation with stated and revealed-preference methods; (ii) to investigate the effects of forest attributes on these estimates, with particular regards to the effects of nature reserves and the practice of benefit transfer; and (iii) to compare estimates of recreation values obtained by different methods and correlate them with aesthetics indices.

The proposed measure of non-timber value (NTV) for Wisconsin uneven-aged forests is the opportunity cost of timber revenue foregone. This is revealed by the actual harvest decisions of the owner, in contrast with the potential profit-maximizing decision. This concept is applied to Wisconsin plots of the USDA Forest Inventory. The actual revenues are computed for each plot, and subtracted from the profit-maximizing revenues predicted with the model of Lin and Buongiorno (1998), giving data on the magnitude and distribution of non-timber value throughout the State. Hedonic pricing is used to estimate the amenity value of different forest characteristics.

In the Irish application, data from a large scale forest recreation survey are used to estimate models of stated willingness to pay for forest recreation from discrete choice contingent valuation. An estimated model is used to predict benefits from creation of nature reserves in forests currently without one. The reliability of benefit transfer from CV models is investigated. Benefit estimates from CV analyses are compared with analog estimates based on the travel cost method. In both sets of estimates the effect of forest attributes is investigated. Finally, welfare estimates are compared across methods and with alternative quality indices of aesthetic value. Benefit estimates are found to be congruent with economic theory and positively correlated. CV is found to produce benefit estimates often transferable between forests.

Keywords: Amenity valuation, economics, opportunity cost, recreation, WI, willingness-to-pay.

77. Schreder, Peter Todd. 2000. **Overstory/understory relationships in old growth grand fir habitat types of northeast Oregon.** College Station, TX: Texas A&M University. 64 p. M.S. thesis.

Source: Texas A&M University, 2000 Thesis S37. Information regarding the dynamics of overstory/understory relationships in managed forests is required to support ecologically-based management of multi-resource production systems. The goal of this project was to define overstory/understory relationships existing on northeast Oregon industrial forests. Greater understanding of the impact of silvicultural practices on forest fauna is needed. Information is also needed on how to acquire data to develop ecologically-based multi-resource management plans. This project establishes quantitative relationships between overstory density and understory composition, production, and structure, and relates these to herbivore carrying capacity and productivity in managed forests. For this study, 76 stands in grand fir and mixed conifer forests were sampled randomly in two forested allotments. Plot clusters were established in each of the selected forest stands using a four-plot cluster design (Scott and Bechtold 1995). Plots were evaluated for trees per hectare, tree height, tree live crown ratio, diameter at breast height, shrub density and cover, and herbaceous grass and forb yield and cover. The resulting data were analyzed statistically and a number of relationships appeared to exist between tree overstory and understory vegetation. Separating forest stands into forest ecotypes appeared to enhance the number of relationships as well as enhance the significance of overstory/understory relationships. Several attributes of tree overstory appeared to significantly influence understory vegetation and ground

surface attributes of forest stands in northeastern Oregon industrial forests. In planning future timber harvest, consideration should be given to the spatial arrangement of tree overstory and the physical dimension of trees left in a stand. If predictive equations developed in this study are valid, shrub and herbaceous understories valuable as food habitat for a number of herbivore users can be developed. Consequently, any negative effect of timber harvest on these herbivores can be mitigated. [This report references several measurement protocols for what is now known as FIA Phase III plot sampling. Novel is the modeling of overstory/understory relationships. The protocol does not replicate the FIA sample grid, as samples are randomly allocated within the sites studied.]

Keywords: Ecological landtype classification, FHM, herbaceous vegetation, OR, shrubs.

78. Schulte, Benedict Joseph. 1997. **The SouthPro computer program: effects of uneven-aged silviculture on the stand structure, species composition and economic returns on loblolly pine stands.** Madison, WI: University of Wisconsin. 199 p. M.S. thesis.

Source: J. Buongiorno, University of Wisconsin. [Findings from the author's thesis appeared in Schulte and others (1998, 1999). From Schulte and others (1999), nonlinear programming models of uneven-aged loblolly pine were developed to identify management regimes which optimize: 1) soil expectation value (SEV), 2) species group (softwoods, hard hardwoods, soft hardwoods) diversity, or 3) annual sawtimber yields. Model was calibrated with FIA data from 991 mixed-aged, naturally generated loblolly pine remeasurement plots. This variation on growth and yield modeling recognized three species groups (loblolly pine and other softwoods, soft hardwoods, and hard hardwoods), 13 diameter-at-breast-height size classes, and three timber productivity classes. Results indicated that maximum yield varied with potential productivity. Optimizations in which SEV is maximized subject to species group diversity constraints suggested tradeoffs between economic returns and diversity objectives.

SouthPro is a Microsoft Excel add-in program that simulates the management, growth, and yield of uneven-aged loblolly pine stands in the Southern United States. This manual provides suggestions for working with Excel, describes program installation and activation of SouthPro, and gives background information on the SouthPro growth model. The manual includes a comprehensive tutorial that explains how to start the program, enter simulation data, generate BDq

distributions, manipulate setup files, execute single and multiple simulations, plot summary statistics, and produce stock-and-cut tables and marking guides. Limitations of the model and appropriate interpretations of its predictions are discussed.]

Keywords: Diversity (tree species group), economics, SOFIA, timber productivity, tree growth modeling.

79. Scott, Charles Thomas. 1977. **Unequal probability sampling for updating inventory estimates.** Athens, GA: University of Georgia. 62 p. M.S. thesis.

Source: Not available.

Keywords: Sample design (updating).

80. Scott, Charles Thomas. 1981. **Design of optimal two-stage multiresource surveys.** St. Paul, MN: University of Minnesota, Department of Forestry. 138 p. Ph.D. dissertation.

Source: DAI 42, no. 06B (1981): 2153. Many public and private organizations are becoming involved in multiresource surveys, and many others are sampling multiple attributes of a single resource. Planners of these surveys are faced with many choices with respect to sampling design, some of which are: (1) selection rule; (2) selection probabilities; (3) stratification rule; (4) number of sampling units to be selected; (5) number of subunits within a sampling unit; (6) distance between subunits; and, (7) size of subunits. The survey planner is asked to choose the best combination of these based on the costs involved and the variance structures of the populations being sampled. For any but the simplest of problems, this is a difficult task.

A multiresource two-stage sampling design model is presented which attempts to optimize the first stage sample allocation and second-stage sampling unit design for several resource attributes simultaneously. The objective is assumed to be to minimize total survey cost, subject to specified precision levels on the attributes of interest. Equal probability selection is assumed at each stage. An integer nonlinear programming technique is used. Applications of the design model to the U.S. Forest Service Northeastern Forest Resource Survey are presented.

Keywords: NEFIA, sample design (multicriteria).

81. Sheffield, Raymond Marshall. 1978. **Techniques for using regional multiresource inventory data to evaluate nongame bird habitat.** Raleigh, NC: North Carolina State University. 76 p. M.F. report.

Source: North Carolina State University and author. [The objectives of this study were to adapt literature-based breeding habitat accounts to indices associated with FIA measurements and timber management activities. The author suggested qualitative indices—good, acceptable, poor, and unsuitable—based on measures interpreted from a literature review of nine bird species' breeding habitats. In Sheffield (1981), each timberland sample was grouped into habitat classes based on the number of criteria satisfied for the species. The author applied these criteria as an example to characterize area and ownership class of South Carolina forests for nine bird species. The author also used maps to illustrate the distribution of potential habitat suitability of FIA timberland sample plots. FIA attributes included live tree stocking, density (stems and basal area), and stand age; understory tree and shrub cover (foliage profile estimation procedures); fire occurrence; physiographic condition, and nearby permanent or temporary water.]

Keywords: Birds, habitat suitability index, SC, shrubs, water, wildlife.

82. Shifley, Stephen Richard. 1990. **Analysis and modeling of patterns of forest ingrowth in the North Central United States.** St. Paul, MN: University of Minnesota. 168 p. Ph.D. dissertation.

Source: DAI 51, no. 09B (1990): 4131. Ingrowth is defined as the number or volume of trees that periodically grow into the smallest measured size class of a forest stand. This work presents a model to predict the number of ingrowth trees at a variable threshold diameter for six forest vegetation types. The model is based on observations on 2,373 remeasured inventory plots from 8 sources in Missouri, Illinois, Indiana, and Ohio.

The number of ingrowth trees decreases significantly with increasing threshold diameter. Linear estimators of the number of ingrowth trees as a function of stand density and size structure characteristics, when restricted to observations for a single forest type and threshold diameter, were often significant ($\alpha = 0.05$) but R-square values were low, generally less than 0.3. The concept of crown competition factor was used to set a biologically realistic upper limit on the number of ingrowth trees. Maximum crown competition values were estimated, and the difference between the maximum crown competition factor and a stand's current

crown competition factor was used to predict the maximum possible number of ingrowth trees at a given threshold diameter. The actual number of ingrowth trees [per acre per decade] was estimated for six forest types as a function of the maximum possible number of ingrowth trees and the threshold diameter.

Fitted models were highly significant for all forest types and the general shape of the response surface is biologically realistic. Precision of the estimates is low, due to the large variation found in ingrowth observations. On average, 65 percent of the ingrowth trees are of the same species as one of the trees present in the overstory of the parent stand. The percent distribution of ingrowth trees by species group was calculated for each stand and used to calibrate a system of models predicting the percentage of ingrowth trees in each of 31 species groups. Predictions are based on the species groups found in the parent stand. The coefficients developed for this system of models can be used to compute the relative frequencies of ingrowth trees in each of 31 possible ingrowth species groups. Graphical comparisons show a high degree of correspondence between the observed ingrowth species distribution and the distribution predicted from this system of equations.

Keywords: IL, IN, MO, NCFIA, OH, tree growth modeling.

83. Shih, Tian-Ting. 1992. **A spatial and ecological decision support system for central upland hardwood management.** West Lafayette, IN: Purdue University. 236 p. Ph.D. dissertation.

Source: DAI 54, no. 01B (1992): 0016. Due to the increasing demands of non-timber values and natural conservation in forestry from the public, forest management becomes more complex. As multiple resource management has been emphasized in the current forestry issues, more textual and spatial data and more complicated and broader knowledge on managing these interacted resources are required.

Knowledge-based systems (KBS), which have the ability to store valuable and relevant knowledge from field experts and research papers, are playing an important role in the decision-making process. Geographic Information Systems (GIS), which have efficient spatial analysis capabilities, can be used to combine conventional information systems and maps when managing forest resources. The inventory data of forest resources can be easily stored, retrieved, manipulated, and updated from database systems (DBS) to provide the basic inputs to GIS and KBS. To fully utilize the advantages of these computer-based information systems (CBIS), decision support systems (DSS) can be used to

provide a framework which can more effectively connect the spatial data analysis with needed textual data and supporting knowledge bases.

A spatial and ecological forest management decision support system was designed to support decision-making on sound silvicultural and management prescriptions for the central hardwoods from ecosystem and multiple-use aspects. In this research, this system was built by fully integrating the concepts and techniques of DBS, KBS, and GIS. Through spatial simulations and ecosystem approaches, a specific ecological site classification system (ESCS) was developed to delineate forest tracts into ecological landtypes. Based on these ESC landtypes, the current forest conditions, the desired forest conditions, and the management constraints can be retrieved and manipulated by several knowledge-based inventory and information extraction programs. After these processes, these programs will provide geo-referenced silvicultural and management recommendations on multiple forest resources.

With a user-friendly forest management decision support system (FMDSS) user menu, the user can control these system operations and request printing of textual outputs and displaying of basic, analyzed, and simulated spatial imagery. These results provide valuable information to support forest managers' decision-making on their forest properties.

Keywords: Custom software design, custom database, ecological landtype classification, GIS.

84. Sieg, Gregory Edwin. 1988. **Incorporating GIS topographic information in forest inventory estimates.** Blacksburg, VA: Virginia Polytechnic Institute and State University. 79 p. M.S. thesis.

Source: Virginia Polytechnic Institute and State University. [Forest inventories.]

Keywords: Forest surveys, GIS.

85. Smith, Jonathan Henry. 1992. **Utility of a vector Geographic Information System to model the effects of climate change: an example on New York State's forests.** Syracuse, NY: State University of New York, College of Environmental Science and Forestry. 169 p. M.S. thesis.

Source: MAI 31, no. 03 (1992): 1121. This study identifies the benefits of using a vector Geographic Information System (GIS) to model the impacts of climate change on New York State's forests. Global climate change threatens

the composition and survival of ecosystems by killing the present vegetation and determining which new species may colonize an area. In order to gauge the effects of climate change, models must be formulated now if we are to successfully manage our forests through any impending crisis. GIS are thought to be one part of the modeling solution.

Biomass figures for six species were calculated for plots from New York State, from U.S. Forest Service inventory data. Growing degree days were calculated for 125 weather stations, in and around the State. A Triangular Irregular Network was produced from the weather station data and used to calculate the growing degree days at the location of the plots. This data and the biomass were then used to simulate the effects of increasing temperature on the biomass of the plots. The model was run with and without an increase of 3 degrees Celsius over 50 years.

Keywords: Biomass, climate change (biophysical), GIS, NY.

86. Smith, Marie-Louise. 2000. **Landscape-scale prediction of forest productivity by hyperspectral remote sensing of canopy nitrogen.** Durham, NH: University of New Hampshire. 70 p. Ph.D. dissertation.

Source: DAI 61, no. 04B (2000): 1748. Foliar nitrogen concentration represents a direct and primary link between carbon and nitrogen cycling in terrestrial ecosystems. Although foliar N is used by many ecosystem models to predict leaf-level photosynthetic rates, it has rarely been examined as a direct scalar to stand-level carbon gain. Significant improvements in remote sensing detector technology in the last decade now allow for improved landscape-level estimation of the biochemical attributes of forest ecosystems.

In this study, relationships among forest growth (aboveground net primary productivity (ANPP) and aboveground woody biomass production (AWBP)), canopy chemistry and structure, and high resolution imaging spectrometry were examined for 88 long-term forest growth inventory [FIA] plots maintained by the USDA Forest Service within the 300,000 ha White Mountain National Forest, New Hampshire.

Analysis of plot-level data demonstrates a highly predictive relationship between whole canopy nitrogen concentration (g/100 g) and aboveground forest productivity (ANPP: $R^2 = 0.81$, $p < 0.000$; AWBP: $R^2 = 0.86$, $p < 0.000$) within and among forest types. Forest productivity was more strongly related to mass-based foliar nitrogen concentration than with either total canopy N or canopy leaf area.

Empirical relationships were developed among spectral data from the Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) and field-measured canopy nitrogen concentration (mass basis). Results of this analysis suggest that hyperspectral remote sensing can be used to accurately predict foliar nitrogen concentration, by mean of a full-spectrum partial least squares calibration method, both within a single scene ($R^2 = 0.84$, $SECV = 0.23$) and across a large number of contiguous images ($R^2 = 0.82$, $SECV = 0.25$), as well as between image dates ($R^2 = 0.69$, $SECV = 0.25$).

Forest productivity coverages for the White Mountain National Forest were developed by estimating whole canopy foliar N concentration from AVIRIS spectral response. Image spatial patterns broadly reflect the distribution of functional types, while fine scale spatial variation results from a variety of natural and anthropogenic factors. This approach provides the potential to increase the accuracy of forest growth and carbon gain estimates at the landscape level by providing information at the fine spatial scale over which environmental characteristics and human land use vary.

Keywords: Biomass, NFS, NH, satellite remote sensing and FIA ground measurement, soils.

87. Sousa, Claudio Ney Martins de. 1994. **Modeling economic impacts of climate change on U.S. forests.** College Station, TX: Texas A&M University. 149 p. M.S. thesis.

Source: Texas A&M University, 1994 Thesis S725. Climate change is expected to modify forest growth. As a result, the forestry sector of the United States could be affected. The primary objective of this study was to examine the economic impacts of climate change on the U.S. forestry sector to develop estimates of the magnitude of climate change benefits and costs in the U.S. forestry sector. Secondarily, this study developed a methodology using a forestry sector model to develop such estimates. A set of possible climate change scenarios was chosen and an existing forest sector model was used to run these scenarios. After analyzing the results, it was concluded that climate change can significantly alter the welfare of the forestry sector; however, the economic implications of climate change vary substantially depending on the assumptions about how climate affects trees. Total welfare impacts range from losses of 162 billion dollars to gains of 136 billion dollars. Because of the broad range of economic impacts, this research identifies the need for further investigation of the impacts of climate change on forest biological dynamics.

Also, the impacts on welfare tend to be, larger in the future; depicting an intergenerational problem. Three additional findings are important. First, the management intensity under which producers choose to operate as well as the regional distribution of production are shown to be sensitive to climate change. Producers intensify management intensity when climate-induced productivity is decreased and reduce management when productivity is increased. Production shifts to the North in most scenarios. Second, public cut and Canadian imports were found to affect the economic impacts of climate change on the U.S. forestry sector. Third, the methodology used proved to be valuable in studying the economic impacts of climate change on U.S. forests. The model depicts important economic adjustments to the conditions imposed by climate change. Namely, production levels, price levels, management intensity, and the regional distribution of production vary as climate change modifies the conditions of the market. Any modeling framework conceived to study the economic impacts of climate change on U.S. forests ought to have these features. [Direct use of FIA data is uncertain.]

Keywords: Climate change (economics), United States.

88. Straka, Thomas James. 1981. **A long-run timber output projection model for the nonindustrial private forest sector.** Blacksburg, VA: Virginia Polytechnic Institute and State University. 181 p. Ph.D. dissertation.

Source: DAI 43, no. 01B (1981): 0004. The nonindustrial private forest sector controls 58 percent of the Nation's commercial forest area. Timber output from the NIPF has been a major forest policy issue throughout this century. A long-run regional timber output projection model was developed for the NIPF sector. The model was based upon two key assumptions: (1) forest management intensity and timber output are inversely related to the forest landowner's alternative rate of return, and (2) for the NIPF sector, the alternative rate of return is inversely related to the size of forest holding.

The timber output model was based on a cross classification of NIPF land by its physical characteristics (e.g., forest type) and economic characteristics (e.g., landowner's alternative rate of return). The stratification objective was to create strata with a uniform timber output response to changes in the above characteristics. If the total forest resource is thought of in terms of a matrix, each characteristic serves as a stratification dimension, creating a matrix composed of "homogeneous timber output response cells." The values of each cell can be used as observations in a regression analysis projecting NIPF timber output.

For the NIPF, the size of forest holding would be a primary stratification dimension. Due to the relationships described above, stratification by size of forest holding constitutes stratification by the landowner's alternative rate of return. Also, since the forest resource is physically uniform, the expected rate of return (marginal value growth percent) of the forest will be uniform within a cell. NIPF landowners base their timber output decision on the relationship between the expected and alternative rates of return, resulting in a convenient forest policy analysis tool. The model was applied to a study region, Virginia's Coastal Plain, with satisfactory results.

Keywords: Timber production modeling, VA.

89. Sullivan, Neal H. 2001. **An algorithm for a landscape level model of mast production.** Columbia, MO: University of Missouri. 293 p. Ph.D. dissertation. http://www.snr.missouri.edu/~sullivan/dis_direct.html. [Date accessed: October].

Source: University of Missouri. Masting is the reproductive habit inherent to some tree species where populations produce large seed crops in some years and small seed crops in others. This dissertation addresses two areas of oak mast production: i) formulating an approach to modeling mast production at a landscape scale and ii) evaluating the impact on tree growth when trees allocate resources to mast production. The model of mast production operates upon the predictions of forest structure and composition over large areas and long time-spans generated by the landscape model LANDIS. Forest inventory data (of local and national origin) are used to characterize the predicted size structure and species composition of oak subgenera based on stand age and ecological land type. This information is used to predict the potential mast production based on a diameter-acorn production relationship and assumed probabilities of inherent tree-level variability in mast production. Estimates of potential mast production are further stochastically modified to incorporate annual variation due to hypothesized: i) climatic conditions (freezing temperatures, humidity, and the temperature regime) during critical phases of flowering and acorn development, ii) random mast-limiting events (hail, insects, wind, and drought), and iii) phenological differences in acorn development between the red and white oak groups (*Erythrobalanus* and *Lepidobalanus*).

Sensitivity analysis suggests that estimates of the proportion of trees in each subgenus strongly influenced estimates of mast production. Estimates of mast production were less sensitive to the modeled diameter-age relationship and tree-

density estimation. The model was tested on a 3,216 ha landscape southern Missouri. The masting model generates predictions that are within one order of magnitude of values observed in other studies (50 to 500 kg ha⁻¹) and comparisons of differences in mast production among ecological land types also conform to results from other studies. Due to the high degree of variability associated with the age-diameter relationship, a better description of the relationship would improve the model.

Intensive measurement of changes in diameter on *in situ* branches and correlated acorn production provided the most reliable indicator of the hypothesized tradeoff between mast production and vegetative growth. More data and more intensive data would be required to quantify the trade-off between acorn production and the subsequent year shoot growth.

Keywords: Mast production modeling, MO, tree species, wildlife.

90. Thiede, Gerald Joseph. 1979. **An interactive forest inventory, supply and demand model for timber roundwood in Wisconsin.** Madison, WI: University of Wisconsin. 167 p. Ph.D. dissertation.

Source: J. Buongiorno, University of Wisconsin. [Portions are published in Thiede and Buongiorno (1982).]

Keywords: Timber production modeling, WI.

91. Tredinnick, John. 1995. **A spatial equilibrium approach to forecasting State timber supply in the Southern United States.** Gainesville, FL: University of Florida. 163 p. M.S. thesis.

Source: Virginia Polytechnic Institute and State University. [This study used a national model to project State level resource and market conditions, as reported in Tredinnick and Carter (1995).]

Keywords: Timber production modeling.

92. Tuazon, Raul Naranja. 1992. **An econometric analysis of nonindustrial timber supply: implications of demographic change.** Berkeley, CA: University of California. 105 p. Ph.D. dissertation.

Source: DAI 53, no. 10A (1992): 3615. This study develops a market model of aggregate nonindustrial timber supply for California that explicitly includes landowner characteristics

that have been shown to influence individual harvest decisions. A supply equation incorporates aggregate measures of landowner income, age and parcel size, along with price and inventory, within an econometric supply and demand model. The model is a quasi-spatial, time series-cross sectional analysis using county-level data. Alternative demand equations are used to test the model's sensitivity to assumptions about sources of timber supply, monopsony and other market imperfections.

The results indicate that the level of inventory has the most consistent effect on nonindustrial timber supply. Increasing inventory will most likely lead to increasing supply, all other factors being constant. The elasticity of supply with respect to inventory levels ranges from 0.57 to 0.77. Stumpage price does not have a clear, strong effect on nonindustrial timber supply, based on the results of this study. These results are plausible, given past theoretical and empirical studies of landowners.

Landowner income and age showed consistent, negative effects on timber supply, although the estimated parameters were not highly significant. The results provide an indication of the relative trade-offs between increases in inventory and increases in landowner income and age. Elasticity of supply with respect to income was estimated at -0.87.

The results are not sensitive to assumptions about market competitiveness. County-level data allowed for a more detailed analysis of nonindustrial timber supply than what has been used in the past. It is unlikely that a more disaggregated data set would be reasonably available or provide additional insight into market level dynamics. The study results must be tempered with the understanding that county-level data may not adequately reflect landowner characteristics, and may introduce intervening variables such as county zoning or local attitudes towards timber harvesting.

It is unlikely that econometric modeling of timber markets, by itself, will add a great deal to current discussions about sustainable forest systems, landscape integrity and natural diversity. A better understanding of market forces and landowner behavior regarding timber supply must be placed within the greater context of sustainable ecosystem management.

Keywords: CA, economics, harvest probability (county), owner survey.

93. Vollmer, Mary A. 1986. **Developing regional information from forest survey data: a pilot study using Tug Hill**. Syracuse, NY: State University of New York,

College of Environmental Science and Forestry. 186 p. M.S. thesis.

Source: State University of New York, Thesis V619. [Forest surveys.]

Keywords: Forest surveys.

94. Watts, Stephen Earl. 2001. **Determining forest productivity and carbon dynamics in southeastern Ohio from remotely-sensed data**. Columbus, OH: Ohio State University. 138 p. Ph.D. dissertation.

Source: DAI 61, no. 12B (2001): 6258. There has been a great deal of interest recently in using forests to sequester carbon emitted by burning of fossil fuels. However, accurate data on net primary productivity and biogeochemical cycling of regional forests with good spatial resolution are currently unavailable within Ohio. Basing this study on southeastern Ohio ecosystems, there were four major objectives. First, develop methodology to utilize the Forest Inventory and Analysis (FIA) and State Soil Geographic (STATSGO) data at a spatial resolution of 30 m. Second, determine how well data on forest productivity correlate with remotely-sensed and soil characteristics data at a spatial resolution of 30 m. Third, use the above correlations to predict forest productivity at a spatial resolution of 30 m from remotely-sensed and soils data. Fourth, calculate the predicted aboveground annual carbon storage in the forests of southeastern Ohio at a spatial resolution of 30 m from the forest productivity data.

Land cover, slope, and aspect were used to select the FIA plots that had the best spatial accuracy. Interpolation techniques were used to smooth the boundaries between soil classification units. There was a significant correlation between remotely-sensed soil characteristics variables and annual basal area increment (adjusted $R^2 = 0.40$, $p < 0.001$). Validation of this model also showed a significant correlation ($R^2 = 0.30$, $p < 0.001$). Predicted annual basal area increment in forested areas ranged from 0 to 1.12 m² per ha with a mean of 0.14 m² per ha, resulting in an estimate of 103,381 M2 for the entire study area, which was 26 percent higher than when calculated from the FIA database. Although nonforested areas were not included in the data analyses, the mean annual predicted annual basal area increment (0.02 m² per ha) was significantly lower in non-forested areas than in forested areas. Predicted aboveground annual biomass increment in forested areas ranged from 0 to 6475 kg per ha with a mean of 1401 kg per ha, resulting in a total of 1,029,228,000 kg for the study area. Predicted aboveground annual carbon increment in forested areas ranged from 0 to 3224 kg per ha with a mean

of 698 kg per ha, resulting in a total of 512,556,000 kg for the entire study area. The total annual aboveground carbon storage was approximately one-fourth the annual carbon emissions from a single coal-fired power plant located in the study area.

Keywords: Biomass, climate change (biophysical), OH, satellite remote sensing, soils (STATSGO).

95. Wayman, Jared Paul. 2000. **Landsat TM-based forest area estimation using iterative guided spectral class rejection**. Blacksburg, VA: Virginia Polytechnic Institute and State University. 69 p. M.S. thesis. <http://scholar.lib.vt.edu/theses/available/etd-05262000-13410035/unrestricted/WaymanETD.pdf>. [Date accessed: September 2001].

Source: Virginia Polytechnic Institute and State University. In cooperation with the USDA Forest Service Southern Research Station, an algorithm has been developed to replace the current aerial-photography-derived FIA Phase 1 estimates of forest/non-forest with a Landsat Thematic Mapper-based forest area estimation. Corrected area estimates were obtained using a new hybrid classifier called Iterative Guided Spectral Class Rejection (IGSCR) for portions of three physiographic regions of Virginia. Corrected area estimates were also derived using the Landsat Thematic Mapper-based Multi-Resolution Land Characteristic Interagency Consortium (MRLC) cover maps. Both satellite-based corrected area estimates were tested against the traditional photo-based estimates. Forest area estimates were not significantly different (at the 95 percent level) between the traditional FIA, IGSCR, and MRLC methods, although the precision of the satellite-based estimates was lower. The estimated percent forest area and the standard error (respectively) of the estimates for each region and method are as follows: Coastal Plain- Phase 1 66.06 and 1.08 percent, IGSCR 68.88 and 2.93 percent, MRLC 69.84 and 3.08 percent; Piedmont- Phase 1 63.87 and 1.91 percent, IGSCR 65.52 and 3.50 percent, MRLC 59.19 and 3.83 percent; Ridge and Valley- Phase 1 69.74 and 1.22 percent, IGSCR 70.02 and 2.43 percent, MRLC 70.53 and 2.52 percent.

Map accuracies were not significantly different (at the 95 percent level) between the IGSCR method and the MRLC method. Overall accuracies ranged from 80 to 89 percent using FIA definitions of forest and non-forest land use. Given standardization of the image rectification process and training data properties, the IGSCR methodology is objective and repeatable across users, regions, and time and outperforms the MRLC for FIA applications.

Keywords: Air photo and satellite remote sensing, VA.

96. Weiler, Katherine S. 1994. **Demographic change and forest resources: implications for the Lake States**. West Lafayette, IN: Purdue University. 80 p. M.S. thesis.

Source: Paper copy of report. [This report's chief value is an extensive literature review linking population to forest density and associated commodity, ecological, public-use, amenity, spiritual values. The author used AtlasGIS, and AtlasPro with data sets (Census Bureau summary tape files 3a, and county-level FIA area statistics for Michigan, Minnesota, Wisconsin) to examine relationships with forest area change. Preliminary comparisons were made by National Forest System (NFS) and non-NFS, and Standard Metropolitan Statistical Association (SMSA) and non-SMSA counties by SMSA region. Results were inconclusive. Correlations between population growth and FIA forest area change suggested an inverse linear relationship between population growth and forest area for NFS and SMSA counties, but not for all counties in a given State.]

Keywords: Amenity valuation, MI, MN, NFS, population density, WI.

97. Wendt, Daniel G. 1999. **Relating landscape indices of forest fragmentation to large scale forest assessment data**. St. Cloud, MN: St. Cloud State University. 77 p. M.S. thesis.

Source: Author. Recent developments in the Forest Service's Forest Inventory and Analysis (FIA) system make it possible and more feasible to collect forest fragmentation data [i.e., size, amount of edge and connectivity between forest patches] on a large-scale basis and to include this data in the inventory database. Land use/land cover maps produced from Landsat TM data by the national GAP program for Illinois and Indiana are used to produce forest fragmentation indices. The index values are sampled by use of the new FIA hexagon grid, then summarized and presented in tables according to FIA unit and ecological section. Distribution maps of the fragmentation indices were also produced. The FIA data is compiled for each hexagon, as well as the fragmentation indices, to find any relationships existing between the data sets.

Keywords: IL, IN, patch indices, satellite remote sensing.

98. Williams, Richard Alan. 1990. **Determining the availability of hardwood timber on non-industrial private forest land in southeast Texas.** College Station, TX: Texas A&M University. 212 p. Ph.D. dissertation.

Source: DAI 52, no. 02B (1990): 0602. In some areas of the South, including southeast Texas, non-industrial private forest (NIPF) lands are becoming increasingly important as sources of hardwood fiber as hardwood timber inventory declines on forest industry company lands. The objective of this study is to understand the motivation and characteristics of NIPF owners who sell hardwood timber in southeast Texas. This study, conducted in 1989, focused on the timber sale decisions, attitudes, and outlooks of NIPF landowners in a 12 county area of southeast Texas.

Data used for this study includes USDA Forest Service periodic inventory data and a questionnaire administered to a random sample of NIPF landowners. The USDA Forest Service inventory data for the 12 county area indicates 4.4 million acres of timberland (65 percent of the total land area) with 1525 million cubic feet of hardwood timber. In the study area, forest industry companies control 62 percent of the timberland acres and 58 percent of the hardwood timber. NIPFs own 32 percent of the timberland acres and 36 percent of the hardwood timber, and public ownership has 6 percent of the hardwood timber volume and 6 percent of the timberland acres. The hardwood timber inventory in the 12 county area is decreasing as removals exceed growth, but appears to be sufficient to support current removal rates well into the future.

Questionnaire responses from 400 NIPF landowners revealed that 71 percent of them sold hardwood timber prior to 1989, and these landowners owned 92 percent of the NIPF acres in the sample. Fifty-two percent of the NIPF owners indicated a willingness to sell hardwood timber within the next 20 years, on ownerships containing 75 percent of the NIPF acres in the sample.

Price was found to be statistically significant in determining the quantity of hardwood pulpwood that would be available. A supply curve developed from questionnaire data revealed an elastic supply relationship for hardwood pulpwood. A subsample of 48 of the surveyed NIPF owners were willing to sell hardwood timber at \$6.07 per cord, representing 20 percent of the hardwood acres in the subsample. At [approximately] \$13.85 per cord, 50 percent of the hardwood acres were available for harvest.

Keywords: Harvest probability, owner survey, timber, TX.

99. Woodcock, Hillary. 1993. **White ash decline in Massachusetts: the role of site and climate factors.** Amherst, MA: University of Massachusetts. 169 p. Ph.D. dissertation.

Source: DAI 54, no. 02B (1993): 0574. White ash increased in basal area between 1962 to 1979 on continuous forest inventory (CFI) plots in Massachusetts, but 20 percent of 82 ash plots (>10 percent basal area ash) were classified as decline (from growth and mortality rates). Reclassification of 18 plots on the basis of percent crown dieback in 1991 validated the decline classification system and indicated little change in plot decline status in the past decade. Mortality of dominant and co-dominant trees was associated with sites characterized by a high landscape position and soils shallow to bedrock ($R^2 = 0.6926$, $p = 0.0007$). Ephemeral streams were common; these sites would be prone to fluctuations in moisture supply. Similar relationships were identified on three 2 ha intensive study sites. Distribution of decline-prone microsite types and decline of ash was highly heterogeneous on the study sites (but not on the CFI plots).

Tree-ring analysis showed that trees growing on "decline-prone" sites were sensitive to drought (measured by growing year Palmer Drought Severity Index) and indicated that the present episode of decline on these sites began in the 1960s, the most severe drought period since 1836. Ash yellows was identified on one and possibly the second of the two study sites with ash decline, and on two of the three decline CFI plots resampled in 1991.

Sites with a SI > 80 supported healthy trees in 1991. For sites with a SI < 80, a decline index estimated from landscape position and soil moisture predicted the distribution of decline on the two intensive study sites on which ash decline was present and shows promise as a method of evaluating sites for their potential for ash decline.

The relationship between decline and site factors was unique to white ash among several species tested (i.e. it was species-specific). On ash decline sites, red oak and sugar maple increased in relative importance.

Keywords: Climate change (biophysical), MA, soils, timber productivity.

100. Wu, Chin-Shien. 1994. **Assessing the economic effects of streamside management zones on the forestry sector.** Auburn, AL: Auburn University. 165 p. Ph.D. dissertation.

Source: DAI 55, no. 07B (1994): 2467. The purpose of this study is to assess the economic effects of designating streamside management zones (SMZ's) on current timber supplies and prices and projecting those impacts into the future (2010). This study focused on southeast Alabama, a 21 county region established as a unique Forest Inventory and Analysis (FIA) region by the USDA Forest Service. The project required five Landsat Multispectral Scanner (MSS) scenes acquired from the Landsat earth resources satellite. The remotely sensed imagery covers all of southeast Alabama. From that imagery, a supervised classification was undertaken using the GRASS GIS software package for the purpose of this study.

This study examines the effects of establishing SMZ's at three different average widths, 10 meters, 15 meters, and 25 meters. A Landsat MSS-based classified forest type map of southeast Alabama was used to calculate area in the SMZ's by forest type and county. Combining FIA volume per acre with the area in SMZ's estimated from the GIS analysis, yields estimates of timber volume in the SMZ's.

The Southeastern Regional Timber Supply (SERTS) model, an economic timber supply projection model, was run on an IBM 486 microcomputer and a twenty-year timber supply projection was made for southeast Alabama from 1990 to 2010. The impact of establishing SMZ's on timber inventory and price projections increases as the projection proceeds through time. The impact of establishing SMZ's on softwood inventory projections is greater than on hardwood inventory projections during the projection years. The constant harvest/acreage scenario leads to a significant decrease (16 percent) in softwood inventory and a softwood price rise, and an increase (32 percent) in hardwood inventory and hardwood price declines to the end of the projection (2010). The South's Fourth Forest harvest/acreage scenario leads to a significant decrease (19 percent) in softwood inventory and a softwood price rise, and an increase (32 percent) in hardwood inventory and hardwood price declines towards the end of the projection (2010). In both scenarios, the effects of removing SMZ volumes on timber price projections are very obvious for softwood but less obvious for hardwood.

Keywords: AL, economics, GIS, proximity, satellite remote sensing, water.

101. Zhai, Yushin. 1999. **An analysis of forest fires in the South Central United States**. Mississippi State. MS: Mississippi State University. 47 p. M.S. thesis.

Source: MAI 38, no. 04 (1999): 919. Factors influencing the probability of fire occurrence in the South Central United

States were investigated using the Geographic Information System (GIS) and a multinomial logit model. Forest Inventory and Analysis (FIA) data at the plot-level were merged with census data at the census-tract level to create a data set containing demographic, geographic, and timber-related characteristics for each FIA plot. Fires occurring during the 2 years prior to the most recent FIA surveys were typed as wildfire, prescribed fire, or unidentified fire. A multinomial logit model was employed to estimate the relationships between plot characteristics and the probability of each fire category. Wildfires are more likely to occur on public forestlands in pine or mixed pine-hardwood stands, in sapling or seedling sized trees, and where there is easy access. Prescribed fire is more likely to be used on public or industrial forests, in pine or mixed pine-hardwood stands, in recently harvested areas, on flat terrain, in sparsely populated areas, and readily accessible areas.

Keywords: GIS, population density, SOFIA.

102. Zhang, Quanfa. 1998. **The impacts of natural disturbance and human activities on a forested landscape in the eastern Upper Peninsula of Michigan**. Houghton, MI: Michigan Technological University. 126 p. Ph.D. dissertation.

Source: DAI 59, no. 04B (1998): 1427. In this study, the General Land Office (GLO) survey notes (1840-1856), current land cover generated from Landsat TM Imagery (1991), and US Forest Service, Forest Inventory and Analysis plots (1991-1992) were used to reconstruct the presettlement forest and examine changes in forests of the Luce District in the eastern Upper Peninsula of Michigan over the past 150 years. Also, a spatially explicit model in a Geographic Information System (GIS) was developed to investigate the impacts of stand-replacing disturbances on landscape patterns.

Interpretation of the GLO notes in the Luce District demonstrated that the presettlement landscape was a mixed conifer matrix (39 percent of total area), interspersed primarily with northern hardwoods (29 percent), wetlands (14 percent), fire-susceptible pinelands (13 percent), and other cover types (5 percent). Boreal forest species comprised 66 percent of the total witness trees in the Luce District. The GLO surveyors recorded 104 fires and 126 windthrows which accounted for 3.1 and 2.8 percent of the total length of the surveyed lines. Calculated rotation periods for the entire Luce District were 480 years for fire and 541 years for windthrow, and 7.5 percent, 24.4 percent, and 68.1 percent of the presettlement forest were in the stand initiation, stem exclusion, and old forest stages

(including both understory reinitiation and old-growth stages), respectively.

Notable changes in species composition over the last 150 years are characterized by the increase of red maple (*Acer rubrum*; +14 percent) and the decline of tamarack (*Larix laricina*; -11 percent), hemlock (*Tsuga canadensis*; -7 percent), white pine (*Pinus strobus*; -6 percent), and beech (*Fagus grandifolia*; -5 percent).

Simulation of a homogeneous 100 * 100 pixel landscape with an arbitrary 500 year rotation period indicates that landscape composition (proportion of the landscape area allocated to various stages of stand development) is stable, regardless of contagion, variation in annual disturbed area, or hazard (i.e., the probability distribution of disturbance of a given stand in relation to stand age). Variation in the disturbed area generates a highly dynamic landscape in terms of proportion of stands in different stages of development, especially in the earlier stages of succession. Disturbance hazard basically re-allocates portions of the landscape into various successional stages, and contagion produces fewer patches with larger maximum and average patch size in the earlier stages of stand development. (Abstract shortened by UMI.)

Keywords: Geostatistics, GIS, MI, patch indices, tree species.

103. Zhou, Xiaoping. 1998. **Methods for improving timber inventory projections in Alabama.** Auburn, AL: Auburn University. 102 p. Ph.D. dissertation.

Source: DAI 59, no. 08B (1998): 3802. A new regional timber inventory projection system (DPSupply) is presented in this dissertation. This new system uses dynamic programming to identify the optimal decision rule for determining available harvest based on stumpage net present value over a range of specified price levels. The final harvest quantity decision is made based on the market demand for stumpage products and cutting priorities are based on highest net present value. Once a schedule of available harvests is determined, harvests are simulated and a residual inventory estimate is produced for each future period in the projection. A comparison of the model's projection of inventory with FIA's 1990 estimate of inventory for Alabama is provided and indicates that model estimates fall within a 95 percent confidence interval of the FIA estimates. An example projection of Alabama's inventory through 2010 is also provided.

The primary data for this system include data from the USDA Forest Inventory and Analysis (FIA) work unit, the

Alabama Department of Revenue (severance tax) and Timber-Mart South (stumpage prices). The two most recent FIA surveys are used to develop sets of dbh (diameter at breast height) and volume growth models by forest type and size class, and to build sets of product proportion functions. The Timber-Mart South data were used to construct price equations for stumpage valuation. Timber removal levels are estimated based on the severance tax information.

The DPSupply system has the ability to project inventory at the product level (sawtimber or pulpwood). A multinomial logit model was used to estimate sets of product proportion functions to determine product volume in each stand for each forest type and size class. This technique provides a powerful tool for inventory projection research. All product proportion function models contain the same variables, and the models are used in the MANAGE module of the DPSupply system to calculate net present value for each plot based on the plot's mix of products. They are also used in the HARVEST module of the program to determine the set of harvestable acres that should be used to meet individual product level demands. The product proportion function method appears robust enough to have broad application, including adapting it to projection systems that are age based (rather than d.b.h. based).

Severance tax data were used with the FIA removals data to determine actual annual removal levels. Using an adjustment procedure developed through this research, a comparison of south Alabama adjusted removal levels with other specifications of removals highlights the importance of jointly using the FIA data and severance tax data to provide more accurate inventory projections.

Keywords: AL, economics, timber production modeling.

Titles Listed by Year

Between 1974 and July 2001, graduate student reports associated with FIA data averaged four per year, with more occurring in recent years. A quick scan of titles reveals that the variety of subjects has also increased over the years. For example, timber appears in 23 reports, with the last entry in 1999—an average of 0.9 per year. The term “diversity” appears for the first time in 1995; landscape also first appears in 1995, and seven times thereafter—an annual average of 1.2 reports.

1975

A quantitative evaluation of winter deer browse in southern New Hampshire forests (Barnes #4).

1976

(No reports.)

1977

The biological and economic potential of Minnesota's commercial forest land to produce timber (Jakes #39).

Unequal probability sampling for updating inventory estimates (Scott #79).

1978

Techniques for using regional multiresource inventory data to evaluate nongame bird habitat (Sheffield #81).

1979

An interactive forest inventory, supply and demand model for timber roundwood in Wisconsin (Thiede #90).

Timber supply from private nonindustrial forests: an economic analysis of landowner behavior (Binkley #8).

1980

Forest management opportunities and associated regional impacts for northeastern Minnesota (Erkkila #26).

1981

A decision support system approach to timber harvest scheduling (Murphy #57).

A long-run timber output projection model for the nonindustrial private forest sector (Straka #88).

Conversion of forest land in the Missouri Ozark region (Othic #61).

Design of optimal two-stage multiresource surveys (Scott #80).

The supply of timber from nonindustrial private forests (Knapp #42).

1982

Adaptation of the stand and tree evaluation and modeling systems of the forest resource evaluation program in the Central States (Caprata #14).

Forest management and timber industry market equilibrium (Cohan #19).

The capability of U.S. Forest Service resources evaluation in assessing small mammal habitat (Mathews #49).

1983

A dynamic analysis of sawtimber availability in the Allegheny unit of Pennsylvania: the next three decades (McWilliams #52).

DYNARIP: a technique for regional forest inventory projection (Bechtold #5).

1984

A comparison of diameter growth for selected tree species among physiographic regions of Georgia (Bolton #10).

A methodology for comparing published regional field plot data to inventory plot data for natural hardwood stands in the Coastal Plain of South Carolina (Heym #37).

An analysis of the use of national land use inventories for regional avian habitat assessments (Brooks #13).

Forest acreage trends in the Southeast: econometric analysis and policy simulations (Alig #2).

Nonindustrial forests, public policy and long-term timber supply in the South (Brooks #12).

Private timber supply projections for western Oregon and Washington: a comparison with 1980 RPA timber supply estimates (Flick #29).

Regional production, structure, and factor demand in the U.S. lumber industry (Abt #1).

1985

Forest area estimation using cluster sampling in single and two phase survey designs (Benessalah #7).

1986

Developing regional information from forest survey data: a pilot study using Tug Hill (Vollmer #93).

The influence of economic and demographic factors on forest land use decisions (Parks #64).

1987

A timber supply analysis for southwest Virginia (Clements #18).

An evaluation of an inventory projection system: TRIM model predictions vs. forest inventory field measurements in North Carolina (Mills #54).

Prediction of secondary cavity-nester habitat: a test of the forest survey data base (O'Brien #58).

1988

A decisionmaking framework for assessing atmospheric deposition impacts on regional forest inventory (Liu #46).

An economic analysis of harvest behavior: integrating ownership and forest characteristics (Dennis #23).

Incorporating GIS topographic information in forest inventory estimates (Sieg #84).

On the relevance of geostatistical theory and methods to forest inventory problems (Ramirez-Maldonado #70).

The determinants of changes in nonindustrial private forest landowners (Plantinga #68).

1989

A dynamic matrix model for updating forest resource inventories (Birdsey #9).

1990

A comprehensive sampling system for forest inventory based on an individual tree growth model (Hansen #35).

Analysis and modeling of patterns of forest ingrowth in the North Central United States (Shifley #82).

Determining the availability of hardwood timber on nonindustrial private forest land in southeast Texas (Williams #98).

Temporal and spatial variation in tree demography and species composition based on forest inventories of Maine (Powell #69).

1991

Valuation of forest-based nonmarket outputs: a cost-price approach (Erkkila #27).

1992

A spatial and ecological decision support system for central upland hardwood management (Shih #83).

Aerial photographic sampling for statewide resource inventory (Catts #16).

An econometric analysis of nonindustrial timber supply: implications of demographic change (Tuazon #92).

Developing conceptual information system models for natural resources (Pelkki #66).

Development and use of a supply-determined social accounting matrix to evaluate economic impacts of forest productivity on distribution of regional factor income (Marcouiller #48).

Economic management of Wisconsin's northern hardwood forest stands: a mixed-species model (Lu #47).

Utility of a vector Geographic Information System to model the effects of climate change: an example on New York State's forests (Smith #85).

1993

A probabilistic evaluation of the harvesting behavior of private timberland owners in eastern Texas (Bell #6).

Empirical evidence on efficiency in forest-related markets (Carter #15).

Rural industrial location models for the wood processing industry in Northeastern United States of America (Frazer #31).

White ash decline in Massachusetts: the role of site and climate factors (Woodcock #99).

1994

A modeling approach to spatial constraints in forest management (Borges #11).

A tree height model for 34 species of the north central region of the U.S. (Compte #20).

An econometric analysis of softwood stumpage supply response to potential regional environmental changes (Gunter #34).

Assessing the availability of timberland for harvest in the Lake States (Resh #72).

Assessing the economic effects of streamside management zones on the forestry sector (Wu #100).

Assessing the impact of data quality on the results of spatial modeling using sensitivity analysis: a case study using Minnesota forest inventory data (McKnight #51).

Demographic change and forest resources: implications for the Lake States (Weiler #96).

Empirical validation of a forest inventory based aesthetic value model (Freimund #32).

Hardwood timber in Mississippi: recent trends in the resource and its use (Faulkner #28).

Modeling economic impacts of climate change on U.S. forests (Sousa #87).

1995

A spatial equilibrium approach to forecasting State timber supply in the Southern United States (Tredinnick #91).

Economics and diversity of trees and landscape in northern hardwood forests: implications of deterministic and stochastic models (Lin #45).

Using forest inventory and analysis data to interpret spatial patterns in a forest management scheduling model (Kapple #41).

1996

Empirical modeling of timber supply in the United States (Pacheco Lopez #63).

Impacts of tornados and hurricanes on the community structure and dynamics of North and South Carolina forests (DeCoster #22).

Modeling and analysis of AVHRR data for biogenic emission inventory system (BEIS) (Ediriwickrema #25).

Regional gradient analysis and spatial pattern of woody plant communities in Oregon (Ohmann #59).

The influence of urbanization on timber harvest probability in Mississippi and Alabama (Barlow #3).

1997

A remote sensing methodology for testing the applicability and implementation of landscape partitioning systems with Advanced Very High Resolution Radiometer satellite data (Cooke #21).

Analysis of wood availability from forest inventory and analysis data using a Geographic Information System (Jorgensen #40).

Ecological database development and analyses of soil variability in northern New England (Okoye #60).

Hedonic estimation of nonindustrial private forest landowner amenity values (Lee #44).

Spatial and dynamic analysis of timber and biomass supply in Minnesota (Husain #38).

The Southpro computer program: effects of uneven-aged silviculture on the stand structure, species composition and economic returns on loblolly pine stands (Schulte #78).

1998

A growth model for Wisconsin's and Michigan's northern hardwoods, and management implications (Kolbe #43).

Methods for improving timber inventory projections in Alabama (Zhou #103).

Projecting Michigan's aspen timber resource (Cherry #17).

Sample-based forest landscape diversity indices (Parresol #65).

The impacts of natural disturbance and human activities on a forested landscape in the eastern Upper Peninsula of Michigan (Zhang #102).

1999

An analysis of forest fires in the South Central United States (Zhai #101).

An analysis of the temporal dynamics in tree species diversity for major tree taxa of two States in the midsouth, United States of America (Rosson #74).

An intensification of the forest health monitoring program: a pilot study in two Indiana State parks (Morse #56).

Assessing the amenity value of forests, with applications to Wisconsin and Ireland (Scarpa #76).

Financial returns on timberlands in Mississippi from 1977 to 1994 (Hartsell #36).

Predicting growth rate and relative importance of common tree species in the Adirondacks from environmental variables (Rubin #75).

Relating landscape indices of forest fragmentation to large scale forest assessment data (Wendt #97).

The Endangered Species Act and private landowner incentives (Michael #53).

Updating forest monitoring systems estimates (Franco-Lopez #30).

2000

An evaluation of forest health monitoring analytical techniques and data for two Indiana State parks (Randolph #71).

Comparing nonlinear and nonparametric modeling techniques for mapping and stratification in forest inventories of the Interior Western United States of America (Moisen #55).

Diversity-productivity relations in the northern hardwoods of Wisconsin and Michigan (Piazza #67).

Efficacy of forest health monitoring indicators to evince impacts on a chemically manipulated watershed (Eckhoff #24).

Evaluation of Landsat TM generated forest-type map for tax appraisal purposes (Riley #73).

Landsat TM-based forest area estimation using iterative guided spectral class rejection (Wayman #95).

Landscape-scale prediction of forest productivity by hyperspectral remote sensing of canopy nitrogen (Smith #86).

Measuring the perception of scarcity of the veneer log resource in the Lake States: Illinois and Indiana (McGuire #50).

Overstory/understory relationships in old growth grand fir habitat types of northeast Oregon (Schreder #77).

2001 (January-July)

An algorithm for a landscape level model of mast production (Sullivan #89).

Determining forest productivity and carbon dynamics in southeastern Ohio from remotely-sensed data (Watts #94).

Development and analysis of current and presettlement forest cover mapping methods for the eastern Upper Peninsula of Michigan, Luce District (Owens #62).

Landscape scale forest composition and spatial structure: a comparison of the presettlement General Land Office survey and the 1990 forest inventory in northeastern Minnesota (Friedman #33).

Keyword Index

This section lists the keywords I assigned to citations. The two-letter postal code refers to the State of the report's study region, if known. The five- or six-letter code references the States corresponding to a particular FIA survey unit, as follows:

Keyword	Study region	State postal code
NCFIA	North Central	KS, IL, IN, MI, MN, MO, ND, NE, SD, WI
NEFIA	Northeastern	CT, DE, KY, MD, ME, MA, NH, NJ, NY, OH, PA, RI, VT, WV
PNWFIA	Pacific Northwest	CA, OR, WA
RMFIA	Rocky Mountain	AZ, CO, ID, MT, NM, NV, UT, WY
SEFIA	Southeast	FL, GA, NC, SC, VA
SOFIA	South Central	AL, AR, LA, MS, OK, TN, TX
SRSFIA	Southern	AL, AR, FL, GA, KY, LA, MS, NC, OK, SC, TN, TX, VA

The PNWFIA also surveys Alaska, Hawaii, and U.S. territories of the Pacific Ocean; and SRSFIA surveys Puerto Rico and other U.S. territories of the Caribbean Basin, but there are no known theses or dissertations associated with FIA surveys in these areas.

Other acronyms in the keyword list are:

Name	Acronym
Breeding Bird Survey	BBS
Forest Health Monitoring	FHM
Generic Environmental Impact Statement	GEIS
Geographic Information System	GIS
General Land Office	GLO
National Forest System	NFS
State Soil Geographic Database	STATSGO

In the following index, citations are listed after each of the keywords with the author's surname, year, and the citation number:

agricultural land (Husain 1997 #38)

air photo (Benessalah 1985 #7, Catts 1992 #16, Kapple 1995 #41)

air photo and satellite remote sensing (Wayman 2000 #95)

air pollution (Ediriwickrema 1996 #25, Eckhoff 2000 #24, Liu 1988 #46, Powell 1990 #69)

AL (Barlow 1996 #3, Parresol 1998 #65, Wu 1994 #100, Zhou 1998 #103)

amenity valuation (Cohan 1982 #19, Freimund 1994 #32, Knapp 1981 #42, Scarpa 1999 #76, Weiler 1994 #96)

amenity valuation and timber production modeling (Lee 1997 #44)

AR (Birdsey 1989 #9, Rosson 1999 #74)

BBS (Brooks 1984 #13)

biomass (Husain 1997 #38, Jorgensen 1997 #40, Smith 1992 #85, Smith 2000 #86, Watts 2001 #94)

birds (Brooks 1984 #13, O'Brien 1987 #58, Sheffield 1978 #81)

browse (Barnes 1975 #4)

CA (Tuazon 1992 #92)

climate change (biophysical) (Smith 1992 #85, Watts 2001 #94, Woodcock 1993 #99)

climate change (economics) (Gunter 1994 #34, Sousa 1994 #87)

custom database (Pelkki 1992 #66, Shih 1992 #83)

custom software (Bechtold 1983 #5, Jorgensen 1997 #40, Okoye 1997 #60)

custom software design (Shih 1992 #83)

dead trees (O'Brien 1987 #58, Randolph 2000 #71)
 decision support system (Borges 1994 #11)
 diversity (all vegetative species) (Eckhoff 2000 #24)
 diversity (landscape) (Lin 1995 #45)
 diversity (tree species) (Powell 1990 #69, Rosson 1999 #74)
 diversity (tree species group) (Lin 1995 #45, Lu 1992 #47, Piazza 2000 #67, Schulte 1997 #78)
 diversity (woody plant) (Ohmann 1996 #59)
 ecological landtype classification (Ohmann 1996 #59, Powell 1990 #69, Rubin 1999 #75, Schreder 2000 #77, Shih 1992 #83)
 econometrics (Gunter 1994 #34)
 economic haul distance (Frazer 1993 #31),(Clements 1987 #18) (omitted)
 economics (Abt 1984 #1; Alig 1984 #2; Carter 1993 #15; Cohan 1982 #19; Dennis 1988 #23; Erkkila 1980 #26, 1991 #27; Faulkner 1994 #28; Gunter 1994 #34; Hartsell 1999 #36; Husain 1997 #38; Jakes 1977 #39; Knapp 1981 #42; Lee 1997 #44; Lin 1995 #45; Lu 1992 #47; Marcouiller 1992 #48; Pacheco Lopez 1996 #63; Parks 1986 #64; Scarpa 1999 #76; Schulte 1997 #78; Sousa 1994 #87; Tuazon 1992 #92; Wu 1994 #100; Zhou 1998 #103)
 FHM (Eckhoff 2000 #24, Morse 1999 #56, Randolph 2000 #71, Rubin 1999 #75, Schreder 2000 #77)
 financial maturity (Hartsell 1999 #36)
 forest surveys (Heym 1984 #37, Sieg 1988 #84, Vollmer 1986 #93)
 GA (Bolton 1984 #10)
 GEIS (Freimund 1994 #32, Kapple 1995 #41)
 geostatistics (Franco-Lopez 1999 #30, McKnight 1994 #51, Moisen 2000 #55, Owens 2001 #61, Parresol 1998 #65, Zhang 1998 #102)
 geostatistics (subplot) (Ramirez-Maldonado 1988 #70)
 GIS (Barlow 1996 #3, Borges 1994 #11, Franco-Lopez 1999 #30, Frazer 1993 #31, Friedman 2001 #33, Jorgensen 1997 #40, Kapple 1995 #41, McKnight 1994 #51, Moisen 2000 #55, Ohmann 1996 #59, Okoye 1997 #60, Owens 2001 #61, Ramirez-Maldonado 1988 #70, Riley 2000 #73, Shih 1992 #83, Sieg 1988 #84, Smith 1992 #85, Wu 1994 #100, Zhai 1999 #101, Zhang 1998 #102)
 GLO (Friedman 2001 #33, Owens 2001 #61)
 habitat suitability index (Sheffield 1978 #81)
 harvest probability (Resh 1994 #72, Williams 1990 #98)
 harvest probability (county) (Tuazon 1992 #92)
 harvest probability (plot) (Barlow 1996 #3, Bell 1993 #6, Cherry 1998 #17, Dennis 1988 #23)
 herbaceous vegetation (Schreder 2000 #77)
 IL (Caprata 1982 #14, McGuire 2000 #50, Shifley 1990 #82, Wendt 1999 #97)
 IN (McGuire 2000 #50, Morse 1999 #56, Randolph 2000 #71, Shifley 1990 #82, Wendt 1999 #97)
 land use (Alig 1984 #2, Othic 1981 #62, Parks 1986 #64)
 land use intensity (harvest and tree plantations) (Rosson 1999 #74)
 lichens (Eckhoff 2000 #24, Morse 1999 #56)
 location modeling (biomass industry) (Husain 1997 #38)
 location modeling (timber industry) (Frazer 1993 #31)
 MA (Woodcock 1993 #99)
 mast (Barnes 1975 #4)
 mast production modeling (Sullivan 2001 #89)
 ME (Eckhoff 2000 #24, Okoye 1997 #60, Powell 1990 #69)
 MI (Cherry 1998 #17, Kolbe 1998 #43, Owens 2001 #61, Piazza 2000 #67, Plantinga 1988 #68, Resh 1994 #72, Weiler 1994 #96, Zhang 1998 #102)
 MN (Benessalah 1985 #7, Borges 1994 #11, Erkkila 1980 #26, Franco-Lopez 1999 #30, Freimund 1994 #32, Friedman 2001 #33, Husain 1997 #38, Jakes 1977 #39, Kapple 1995 #41, McKnight 1994 #51, Murphy 1981 #57, Pelkki 1992 #66, Plantinga 1988 #68, Weiler 1994 #96)
 MO (Othic 1981 #62, Shifley 1990 #82, Sullivan 2001 #89)
 MS (Barlow 1996 #3, Faulkner 1994 #28, Hartsell 1999 #36, Rosson 1999 #74)
 NC (Carter 1993 #15, Catts 1992 #16, DeCoster 1996 #22, Lee 1997 #44, Michael 1999 #53, Mills 1987 #54, Parks 1986 #64)
 NCFIA (Compte 1994 #20, Shifley 1990 #82)
 NEFIA (Brooks 1984 #13, Frazer 1993 #31, Scott 1981 #80)
 NFS (Borges 1994 #11, Carter 1993 #15, Smith 2000 #86, Weiler 1994 #96)
 NH (Barnes 1975 #4, Dennis 1988 #23, Knapp 1981 #42, Okoye 1997 #60, Smith 2000 #86)

NY (Jorgensen 1997 #40, Mathews 1982 #49, Rubin 1999 #75, Smith 1992 #85)
 OH (Shifley 1990 #82, Watts 2001 #94)
 OK (Cooke 1997 #21, Marcouiller 1992 #48)
 operability (Faulkner 1994 #28)
 opportunity cost (Lee 1997 #44, Scarpa 1999 #76)
 OR (Flick 1984 #29, Ohmann 1996 #59, Parks 1986 #64, Schreder 2000 #77)
 owner (Alig 1984 #2, Bell 1993 #6, Binkley 1979 #8, Marcouiller 1992 #48, Plantinga 1988 #68)
 owner survey (Dennis 1988 #23, Michael 1999 #53, Resh 1994 #72, Tuazon 1992 #92, Williams 1990 #98)
 PA (McWilliams 1983 #52)
 patch indices (Parresol 1998 #65, Wendt 1999 #97, Zhang 1998 #102)
 planning (spatial constraints) (Borges 1994 #11)
 PNWFIA (Cohan 1982 #19)
 population density (Barlow 1996 #3, Parks 1986 #64, Plantinga 1988 #68, Weiler 1994 #96, Zhai 1999 #101)
 proximity (Barlow 1996 #3, Borges 1994 #11, Wu 1994 #100)
 recreation (Erkkila 1991 #27, Freimund 1994 #32, Scarpa 1999 #76)
 reforestation program impact (Brooks 1984 #12)
 remote sensing (Catts 1992 #16)
 RMFIA (Moisen 2000 #55, O'Brien 1987 #58)
 sample design (Hansen 1990 #35)
 sample design (air photo) (Benessalah 1985 #7, Catts 1992 #16)
 sample design (multicriteria) (Scott 1981 #80)
 sample design (updating) (Scott 1977 #79)
 satellite remote sensing (Cooke 1997 #21, Ediriwickrema 1996 #25, Riley 2000 #73, Watts 2001 #94, Wayman 2000 #95, Wendt 1999 #97, Wu 1994 #100)
 satellite remote sensing and FIA ground measurement (Franco-Lopez 1999 #30, Moisen 2000 #55, Smith 2000 #86)
 SC (DeCoster 1996 #22, Sheffield 1978 #81)
 SEFIA (Alig 1984 #2, Bechtold 1983 #5)
 shrubs (Eckhoff 2000 #24, Schreder 2000 #77, Sheffield 1978 #81)
 small mammal survey (Mathews 1982 #49)
 SOFIA (Schulte 1997 #78, Zhai 1999 #101)
 soils (Ohmann 1996 #59, Powell 1990 #69, Smith 2000 #86, Woodcock 1993 #99)
 soils (STATSGO) (Okoye 1997 #60, Watts 2001 #94)
 spatial constraints (Borges 1994 #11)
 SRSFIA (Brooks 1984 #12, Gunter 1994 #34, Pacheco Lopez 1996 #63)
 timber (Williams 1990 #98)
 timber and recreation modeling (Erkkila 1991 #27)
 timber industry survey (McGuire 2000 #50)
 timber production modeling (Abt 1984 #1, Bechtold 1983 #5, Binkley 1979 #8, Carter 1993 #15, Cherry 1998 #17, Cohan 1982 #19, Erkkila 1980 #26, Faulkner 1994 #28, Flick 1984 #29, Gunter 1994 #34, Husain 1997 #38, Jakes 1977 #39, Kapple 1995 #41, Knapp 1981 #42, Lee 1997 #44, Liu 1988 #46, Marcouiller 1992 #48, McWilliams 1983 #52, Michael 1999 #53, Mills 1987 #54, Morse 1999 #56, Pacheco Lopez 1996 #63, Parks 1986 #64, Randolph 2000 #71, Straka 1981 #88, Thiede 1979 #90, Tredinnick 1995 #91, Zhou 1998 #103)
 timber production modeling (age class) (Brooks 1984 #12)
 timber production updating (Birdsey 1989 #9, Franco-Lopez 1999 #30)
 timber productivity (Piazza 2000 #67, Shulte 1997 #78, Woodcock 1993 #99)
 timber quality (McGuire 2000 #50)
 timber supply (Jorgensen 1997 #40)
 tree crown health (Eckhoff 2000 #24, Morse 1999 #56, Randolph 2000 #71)
 tree growth modeling (Bolton 1984 #10, Caprata 1982 #14, Kolbe 1998 #43, Lin 1995 #45, Murphy 1981 #57, Rubin 1999 #75, Schulte 1997 #78, Shifley 1990 #82)
 tree measurement modeling (Compte 1994 #20, Hansen 1990 #35)
 tree species (Friedman 2001 #33, Powell 1990 #69, Rosson 1999 #74, Rubin 1999 #75, Sullivan 2001 #89, Zhang 1998 #102)
 tree species group (Lin 1995 #45, Lu 1992 #47, Piazza 2000 #67, Schulte 1997 #78)

tree species susceptibility (DeCoster 1996 #22)

TX (Bell 1993 #6, Cooke 1997 #21, Riley 2000 #73, Williams 1990 #98)

United States (Abt 1984 #1, Sousa 1994 #87)

VA (Clements 1987 #18, Liu 1988 #46, Straka 1981 #88, Wayman 2000 #95)

VT (Okoye 1997 #60)

WA (Flick 1984 #29)

water (Sheffield 1978 #81, Wu 1994 #100)

weather damage (DeCoster 1996 #22)

WI (Hansen 1990 #35, Kolbe 1998 #43, Lin 1995 #45, Lu 1992 #47, Piazza 2000 #67, Plantinga 1988 #68, Scarpa 1999 #76, Thiede 1979 #90, Weiler 1994 #96)

wildlife (Barnes 1975 #4, Brooks 1984 #13, Mathews 1982 #49, Michael 1999 #53, O'Brien 1987 #58, Sheffield 1978 #81, Sullivan 2001 #89)

willingness-to-pay (Scarpa 1999 #76)

Discussion and Conclusions

Titles and keywords indicate topics that graduate students, their advisors, and institutions deemed important enough for 2 to 5 years of scholarly research. Research subjects from the citations listed are concentrated in three disciplines: economics, Geographic Information System, and timber production. Economics and timber production alone accounted for over 40 percent of the citations.

The organizing structure of citations in this report can be used to provide effective input to new strategies and approaches to current issues regarding forest resource inventories, as shown in the following examples:

- Multiple citations listed for each keyword suggest issues and approaches of wide interest; e.g., timber production modeling.
- Keywords for similar subjects but with slight variation suggest research likely to benefit from a synthesis; e.g., harvest probability by plot and by county.
- Keywords with disparate terms suggest novel interdisciplinary approaches; e.g., amenity valuation and timber production modeling.
- Keywords with few or no citations suggest regions or topics that have not been well studied. These areas present opportunities for future research in association

with FIA data; e.g., agricultural land, boreal forests, tropical inventories, and nontimber forest products.

One-third of the graduate degrees represented in the citations were granted by research institutions in States with regional FIA survey unit offices: Minnesota (University of Minnesota, 15; St. Cloud State University, 1); North Carolina (North Carolina State University, 6; Duke University, 2; University of North Carolina, 1); Mississippi (Mississippi State University, 6); Oregon (Oregon State University, 5); Pennsylvania (Pennsylvania State University, 2); and Utah (Utah State University, 2).

Predominant States for graduate study, with their associated citations, included: Minnesota (14), Wisconsin (9), Michigan (8), North Carolina (7), Indiana (5), and New Hampshire (5). Alabama, Illinois, Mississippi, New York, Oregon, and Texas had four reports each. There were 3 or fewer study regions reported for the other 38 States and none in U.S. territories.

Since I used methods to assess inclusion based on available information, particularly for M.S. abstracts, the predominance of some subjects, research institutions, and study regions may be a result of the influence of contributors and cooperating reviewers, or may, to some extent, reflect the availability of electronic access to abstracts, indexes, and online university catalogs. As a result, the distribution of subjects, research institutions, and study regions may have been inadvertently limited.

Nevertheless, the somewhat limited mix of subjects for graduate reports are of concern for the following reasons:

- Few citations focus on topics associated with range, recreation, water, wildlife, and integrated approaches.
- Underrepresented subjects include soils, water, shrub and herbaceous vegetation, and other nontree attributes.
- The regions studied up to now may be omitting important economic, physical, and social environments or may not be ecologically representative of the rest of the United States.
- Underrepresented ecological conditions occur in States dominated by rangeland such as Nevada, areas undergoing rapid urbanization such as Florida, or regions heavily influenced by cropland or livestock production such as the Upper Midwest.

The FIA administrators may wish to promote graduate research among cooperating universities in underrepresented subjects and ecological conditions. At the very least, this

review suggests the need for better documentation to support FIA data-associated research in subjects and ecosystems strategic to FIA's mandate to conduct comprehensive assessments.

Acknowledgments

I am especially grateful to FIA employees, graduate student advisors at forestry schools, and others who assisted in confirming FIA data uses or providing paper copies of thesis abstracts. Reviewers of an earlier draft included Mark Hansen, North Central Research Station (NCFIA); John Moser, Purdue University and Renee O'Brien, Rocky Mountain Research Station (RMFIA); John Mills and Susan Willits, Pacific Northwest Research Station (PNWFIA); Charles Scott, Northeastern Research Station (NEFIA); and Bill Van Hees, PNWFIA—Alaska.

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Graduate M.S. theses and Ph.D. dissertations were searched to provide a body of information associated with the U.S. Department of Agriculture, Forest Service, Forest Inventory and Analysis (FIA) database. Authors' abstracts were included if available in electronic form and published since 1974. Novel technical and nontraditional FIA data uses, as well as the geographic region of the reported studies, were highlighted in keywords and annotations. The search yielded the 103 citations included in this report. Dominating efforts were in economics, Geographic Information Systems, timber production, and selected States, with a broadening array of subjects in more recent years. Research institutions in States with regional FIA survey unit offices granted one-third of the graduate degrees. Providing an overview of the uses of FIA data in student research, the results show that a body of knowledge based on the data is evolving, whereas the distribution of subjects and study regions has been somewhat limited.

Keywords: Bibliography, dissertation, historical synthesis, interdisciplinary, MRI (multi-purpose resource inventory), thesis.



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