SOFEW
Southern Forest Economics Workers

Competitiveness of Southern Forest Products Markets in a Global Economy: Trends and Predictions

Proceedings of the
Southern Forest Economics Workshop 2004

March 14-16, 2004
St. Augustine, Florida

Editors:
Janaki R.R. Alavalapati
Douglas R. Carter
School of Forest Resources Conservation
University of Florida

Preface

These are the Proceedings of the 34th Annual Southern Forest Economics Workshop, held at the Casa Monica Hotel in St. Augustine, Florida on March 14-16, 2004. The Workshop was sponsored by the School of Forest Resources and Conservation, University of Florida, Gainesville.

SOFEW 2004 focused on the overall competitive trends of southern forests products markets, and included presentations on timber supply, timber markets, timber pricing, timber inventory, environmental services, land use and values, wood products and technology, forest legislation, forest dependency, private forest landowner issues, regional impact analysis, and international trade and other forestry issues. The 105 attendees were treated with 52 excellent presentations and 4 research posters. We would like to thank all the presenters for their quality presentations and participants for their valuable comments on research presentations. Without them the workshop would not have been a success!

We would also like to extend our special appreciation to Tim White, Director, School of Forest Resources and Conservation for providing resources and logistical support needed to make the workshop a reality and for his warm welcome address. Our special thanks also to our invited keynote speakers Joseph Buongiorno and David Newman who presented papers on "Global Context for the United States Forest Sector" and "Competitive Pressures on Southern U.S. Forestry", respectively. We also would like to sincerely thank the following moderators for their time and effort in conducting the sessions very effectively: Sun Chang, Jeff Prestemon, Daowei Zhang, Steverson Moffat, Tom Harris, Marty Luckert, Larry Teeter, Brett Butler, Bill White, Weihuan Xu, Pete Stewart, Susan Stein, Matthew Pelkki, Jianbang Gan, Michael Dunn, Sashi Kant, and Steve Grado.

As with any successful meeting, much of the responsibility and credit goes to people behind the scenes. Julie Helmers and Scott Sager deserve special credit for handling the registration. We appreciate Fauzia Zamir, Troy Timko, and Jensen Montambault for their technical support and other assistance. Special thanks also to Fauzia Zamir and Troy Timko for their assistance in organizing the papers for these Proceedings. Finally, we would like to thank all authors and co-authors for submitting quality manuscripts.

Janaki R.R. Alavalapati
Douglas R. Carter
December 2004.

Table of Contents

Global Context for the United States forest sector in 2030

James Turner, Joseph Buongiorno, Shushuai Zhu

Department of Forest Ecology and Management
University of Wisconsin-Madison
1630 Linden Drive
Madison, WI 53705
Tel: 608-262-0091
Fax: 608-262-9922
Email: jbuongio@wisc.edu

Jeffrey Prestemon

Forestry Sciences Laboratory, SRS
USDA Forest Service
PO Box 12254 (mail)
3041 Cornwallis Road (deliveries)
Research Triangle Park, NC 27709
Tel: 919-549-4033
Fax: 919-549-4047
Email: jprestemon@fs.fed.us

Global Context for the United States Forest Sector in 2030

Abstract

The purpose of this study was to identify markets for, and competitors to, the United States forest industries in the next 30 years. The Global Forest Products Model was used to make predictions of international demand, supply, trade, and prices, conditional on the last RPA Timber Assessment projections for the United States. It was found that the United States, Japan and Europe would remain important markets out to 2030, but China would grow into the world's largest importer of roundwood and manufactured products. Mexico would become an important importer of sawnwood and papers; and the Republic of Korea of wood panels and pulp. The United States' share of exports of industrial roundwood and paper and paperboard would increase, while its exports of sawnwood would decline, replaced by exports from Canada, Finland, Austria, Chile, and New Zealand. Besides Finland and Austria, Indonesia, Malaysia and Thailand would remain the main competitors to U.S. exports of wood based panels.

Keywords: International trade, forest products, forecasting, competition, modeling, markets.

OBJECTIVES

This study addressed the following questions: What might the global forest sector look like in thirty years time? Who will be important markets for particular forest products? Who will be the major exporters of forest products? And, how competitive will the United States' forest industries be compared with other major forest product exporters?

To that end, the objective of the study was to identify markets for, and competitors to, United States forest products in thirty years time. The aim was to give information to United States forest industries about potential markets for their products, and also identify countries that may directly compete with the United States for a share of these markets.

The prediction of United States markets and competitors was made with the Global Forest Products Model (GFPM, see Buongiorno et al. 2003). These predictions were made based on a particular set of assumptions regarding future development within the United States forest sector. These assumptions were drawn from the findings of the RPA Timber Assessment (Haynes 2003). The study therefore complemented the RPA Timber Assessment by describing in more detail its global context in terms of international trade and foreign market growth.

This paper will first summarize briefly the RPA Timber Assessment, what it is, and what information it provides. It will then describe enough of the GFPM to understand how it was used to predict global forest product markets. This will be followed by results regarding the trends in United States forest product consumption, production and trade, predicted with the GFPM. These trends will be compared with those in other countries to detect the main markets for the United States industries, and their main competitors.

THE RPA TIMBER ASSESSMENT

A thorough analysis of the future of the United States forest sector is contained in the most recent RPA Timber Assessment performed by the USDA Forest Service. The purpose of this assessment was to predict the wood resource situation in the United States out to 2050 and to provide an indication of the suitability of these resources to meet the United States' demand for forest products.

The RPA Timber Assessment makes a number of assumptions that influence supply, demand and trade of forest products. Assumptions influencing United States demand include macroeconomic activity, such as economic growth, employment, and exchange rates. Supply assumptions include area of forestland, investment in land management, and harvest from National Forests.

Assumptions were also made regarding trends in United States export and import shares of forest products. Essentially the RPA Timber Assessment exogenously set United States forest product imports and exports with the rest of the world.

So the focus of the RPA Timber Assessment was on the United States, and on its trade with Canada. This study complemented the RPA Timber Assessment by describing in more detail its global context by allowing developments in overseas markets, linked to the United States through international trade, to influence developments in the United States' forest sector. This was done with the Global Forest Products Model.

THE GLOBAL FOREST PRODUCTS MODEL

The GFPM captures the global context of the United States by taking into account the numerous and complex links between countries and industries.

The GFPM forecasts forest product trade, demand, supply and prices for 14 forest product groups. These forecasts are the solution of a competitive equilibrium in each year. In the GFPM a competitive equilibrium is when prices for each product in each country are such that the supply is equal to the demand for each commodity.

The 14 forest products in the GFPM are linked as inputs and outputs, so that changes in demand for one product affect supply, demand and prices for other products. For example, production of printing and writing paper requires wood pulp, other fiber pulp and waste paper, while production of wood pulp uses industrial roundwood and production of waste paper comes from the recycling of paper products. So, the demand for industrial roundwood is influenced by the demand for printing and writing paper via the demand for pulp for paper production. The availability of waste paper also influences the demand for industrial roundwood as it partly determines the amount of pulp needed to produce paper products.

The GFPM predicts the changes in markets for these 14 forest products for 180 countries, all linked through trade. From year-to-year the supply and demand for products change due to assumptions about the evolution of technology, for example the amount of industrial roundwood needed to produce 1 cubic meter of particleboard, and changes in government policies, for example the United States harvests from National Forests.

Elasticities, which represent the responsiveness of demand and supply of forest products to changes in prices, and in the case of demand, economic growth, are also important assumptions in the GFPM. These assumptions were adjusted to make the projections of United States and Canadian demand and supply comparable to the RPA Timber Assessment projections. The most important of these assumptions is growth in United States gross domestic product, as this influences the growth in United States demand for forest products.

Additional assumptions were the shifts in wood supply (for constant prices) for Canada and the United States, the rate of waste paper recovery, and the income elasticities of demand for newsprint, plywood and fiberboard. Shifts in wood supply were estimated from the RPA Timber Assessment projections of United States and Canadian timber harvests. The United States waste paper recovery rate was set to 50% throughout the projections from 2000 to 2030. That is, the United States is assumed to recover 50% of its total paper and paperboard consumed each year. The elasticities of demand with respect to country income for plywood, fiberboard and newsprint were set lower to capture the RPA assumption that oriented strand board is substituting for the use of plywood and fiberboard in construction, and electronic media are substituting for newspaper.

PROJECTIONS TO 2030

With these assumptions, the GFPM was used to make projections of each country's supply, demand, trade and prices of forest products, for each year to 2030.

Predicted United States consumption, production and trade

Fig. 1 shows the trend in United States industrial roundwood consumption, production and trade from 1961 to 2030. Trends from 1961 to 2001 are historical data from the Food and Agriculture Organization. Those from 1999 to 2030 are projections made using the Global Forest Products Model. Fig. 1 shows that United States exports of industrial roundwood are projected to grow above historical export levels. This occurs as United States roundwood harvests exceed the consumption of roundwood in the production of forest products.

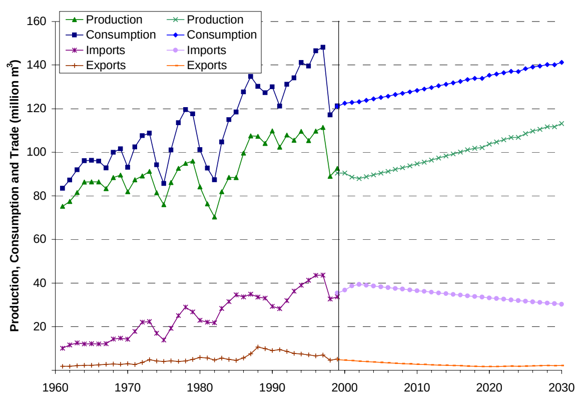


Fig. 1 U.S. industrial roundwood.

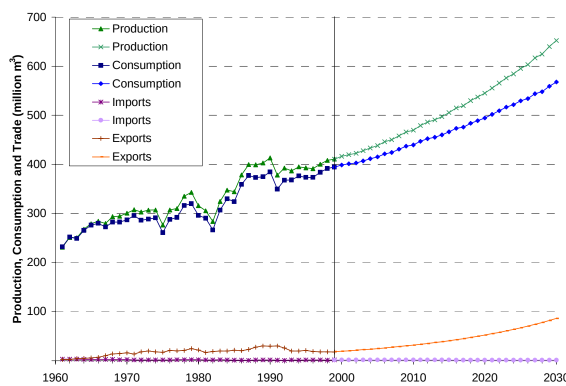


Fig. 2 U.S. sawnwood.

Fig. 2 shows that the growth in United States sawnwood production exceeds the growth in consumption, resulting in a decline in United States sawnwood imports. The GFPM also forecasts that United States exports of sawnwood will decline, continuing the trend that began in the late 1980s.

For United States wood based panels (plywood, particleboard and fiberboard), the GFPM forecasts show lower growth in United States production and consumption than during the 1990s (Fig. 3). As such the growth in imports of wood based panels is slower. United States exports of wood based panels are predicted to remain roughly at their 2000 level.

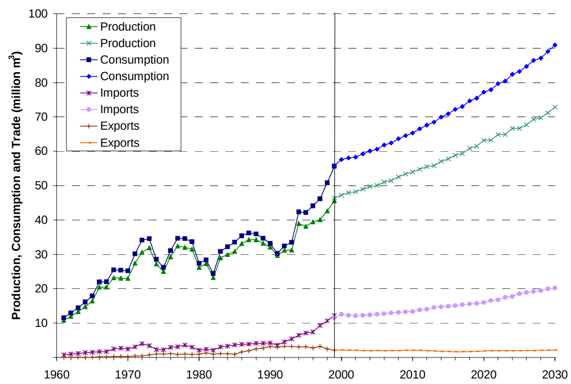


Fig. 3 U.S. wood panels

For wood pulp (mechanical and chemical pulp), the GFPM projections show slightly stronger growth in U.S. wood pulp production and consumption than during the 1990s (Fig. 4). Imports and exports of wood pulp would remain unchanged from 2000 to 2030.

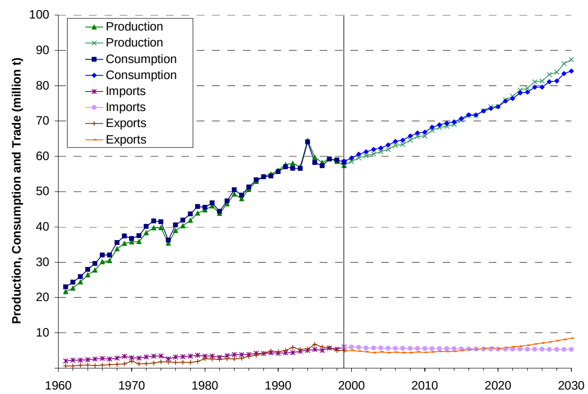


Fig. 4 U.S. pulp

Fig. 5 shows the U.S. trends for paper and paperboard (newsprint, printing and writing paper, and other paper and paperboard). The projections largely continue the historical trends, though more rapid growth in production compared with consumption leads to growth in United States paper and paperboard exports.

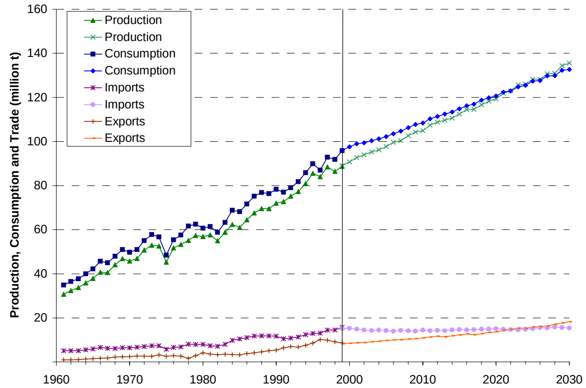


Fig. 5 U.S. paper and paperboard

Projected United States exports and main competitors

Table 1 shows the value of United States forest product exports in real million US dollars in 1999 and 2030. These values were calculated based on GFPM projections of global commodity prices. For example, the U.S. exported $772 million worth of wood based panels in 1999. The rank refers to how valuable United States' exports are relative to other countries. For example the United States was the second largest exporter of industrial roundwood in 1999, in value.

The main result to take from this table is that the value of United States exports of all commodities, except sawnwood, would increase. This growth in the value of exports is a combination of price increases, and growth in export volume. The especially large growth in the value of paper exports is most likely due to strong growth in real paper prices predicted by the GFPM, driven by rapid growth in China's demand for paper.

The decline in the value of United States sawnwood exports, and little change in the value of woodbased panel exports, raises the question of which countries are taking the United States' share of global exports of these commodities. Table 2 shows that among the current major exporters of sawnwood that strongly increase their exports out to 2030 Finland's exports increase 300% between 1999 and 2030, and those of Austria increase 350%. Emerging competitors to the United States are Chile and New Zealand, both increasing the value of their sawnwood exports by nearly 400%.

The export value and rank of competitors to United States in wood based panel exports are in Table 3. Current major exporters of wood based panels that increase their exports out to 2030 are Indonesia, Malaysia and Austria. Emerging competitors to United States wood based panel exports are Finland and Thailand. Finland increases the value of its exports by nearly 150%, and Thailand by over 400%.

Emerging world markets

The GFPM projections also indicate where the major markets for the different products will develop. Here they are measured by the value of imports. In particular, Table 4 shows the value of China's forest product imports in real million US dollars in 1999 and 2030. These values were calculated based on GFPM projections of China's imports and global commodity prices.

The value of China's imports of industrial roundwood in 1999 was just over $1 billion, and the GFPM predictions suggest that this could grow more than 15 times by 2030, in real dollars, net of inflation. The strong growth in Chinese GDP, which is part of the GFPM scenario, leads China to experience extraordinary growth in its imports of all product categories. By 2030, China would rank first as importer of all products.

The GFPM projections also reveal smaller, but still significant emerging markets, countries with low forest product imports in 1999, but larger imports in 2030. In particular, Table 5 shows that the value of Mexican imports of sawnwood increase 350% from 1999 to 2030, while Mexican imports of paper increase by over 500%. South Korea's imports of wood based panels and wood pulp are also projected to increase substantially in value, with imports of wood based panels increasing by over 400%, and imports of wood pulp increasing over 550%.

Table 1. Value and rank of U.S. exports.

	1999		**2030**	
Commodity[1]	**Value**[2]	**Rank**	**Value**	**Rank**
Roundwood	$1,497	2	$11,857	2
Sawnwood	$1,210	6	$666	12
Wood panels	$772	7	$851	12
Wood pulp	$1,966	2	$5,529	3
Paper	$6,345	4	$24,656	4

[1] Wood based panels - plywood, particleboard and fiberboard. Wood pulp - mechanical and chemical pulp. Paper - newsprint, printing and writing paper and other paper and paperboard. Roundwood refers to industrial roundwood only. [2] Millions of 1997 U.S. dollars.

Table 2. Value and rank of sawnwood exporters competing with the U.S.

	1999		**2030**	
Country	**Value**[1]	**Rank**	**Value**	**Rank**
Canada	$9,469	1	$11,005	1
Finland	$1,963	3	$7,902	2

Austria	$1,532	4	$6,849	3
Chile	$387	11	$1,637	7
New Zealand	$357	12	$1,740	6

[1] Millions of 1997 U.S. dollars.

Table 3. Value and rank of wood panel exporters competing with the U.S.

	1999		2030	
Country	**Value[1]**	**Rank**	**Value**	**Rank**
Indonesia	$2,531	2	$4,684	5
Malaysia	$2,129	3	$6,038	2
Austria	$608	8	$3,088	7
Finland	$497	10	$1,215	11
Thailand	$257	12	$1,373	9

[1] Millions of 1997 U.S. dollars.

Table 4. Value and rank of China's imports.

	1999		2030	
Commodity	**Value[1]**	**Rank**	**Value**	**Rank**
Roundwood	$1,049	2	$17,443	1
Sawnwood	$822	8	$10,612	1
Wood panels	$1,946	3	$11,641	1
Wood pulp	$1,462	3	$23,413	1
Paper	$8,813	2	$67,567	1

[1] Millions of 1997 U.S. dollars.

Table 5. Emerging importers of forest products.

		1999		2030	
Country	**Commodity**	**Value[1]**	**Rank**	**Value**	**Rank**
Mexico	Sawnwood	$258	12	$1,183	9
	Paper	$1,272	11	$7,712	7
S Korea	Wood panels	$539	9	$2,848	3
	Wood pulp	$896	6	$5,931	2

[1] Millions of 1997 U.S. dollars.

CONCLUSION

The United States, Japan, and Europe are projected to remain important importers of forest products out to 2030. Rapid economic growth in China will result in its becoming the world's largest importer. Important emerging markets for forest product imports are Mexico, for solid wood and paper products; and the Republic of Korea for industrial roundwood, plywood, wood pulp, and recovered paper. The predicted growth in Mexican imports of forest products presents an opportunity for expanding U.S. exports, which may be strengthened by the North American Free Trade Agreement.

The GFPM projections show the U.S. will increase the value and its share of exports of industrial roundwood and other paper and paperboard by 2030. At the same time there would be a decline in the value of U.S. exports of sawnwood, and printing and writing paper. Finland, Austria, Chile and New Zealand are projected to gain some of the U.S. share of sawnwood exports. Finland and Thailand are emerging exporters of wood based panels that would increase their share of world exports at the expense of the U.S. These projections could be affected by future policies, for example if the U.S. government decided to prevent a large growth of raw wood exports.

A shortcoming of this study is that it was done after the RPA Timber Assessment. A better approach might be to combine the RPA Assessment models and the GFPM, through an exchange of information as the RPA scenarios are being developed. The GFPM would provide the RPA models with data on the international context, while the RPA models would feed the GFPM with information on U.S. trends likely to affect its competitiveness worldwide. This would then increase the likelihood that the RPA projections fully reflect the complex links of the U.S. forest sector with the rest of the world through trade.

ACKNOWLEDGMENTS

This research was supported in parts by McIntire-Stennis grant E456, USDA-CREES grant 2003-35400-13816, SRS grant 04-CA-11330143-045, the School of Natural Resources at the University of Wisconsin-Madison, and the USDA Forest Service, Southern Research Station.

LITERATURE CITED

Buongiorno, J., S. Zhu, D. Zhang, J. Turner, and D. Tomberlin. 2003. The Global Forest Products Model: Structure, Estimation and Applications. Academic Press, San Diego, CA. 301 pp.

Haynes, R.W., Technical Coordinator. 2003. An Analysis of the Timber Situation in the United States: 1952 to 2050. A Technical Document Supporting the 2000 USDA Forest Service RPA Assessment. United States Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR. 254 pp.

How Competitive is the Southern Timber Industry? An Examination of Georgia's Pulp and Paper Sector

by
Thomas G. Harris, Jr.[1]
Jacek Siry [2]
Sara Baldwin [3]

1 Publisher, Timber Mart-South and Professor of Forest Business. Warnell School of Forest Resources. University of Georgia. Athens, GA 30602. Phone 706-542-2832 - email harris@smokey.forestry.uga.edu
2 Assistant Professor, Warnell School of Forest Resources. University of Georgia. Athens, GA 30602. Phone 706-542-3060 - email jsiry@smokey.forestry.uga.edu
3 Research Coordinator, Timber Mart-South. Warnell School of Forest Resources. University of Georgia. Athens, GA 30602. Phone 706-542-4760 email - sbaldwin@smokey.forestry.uga.edu

How Competitive is the Southern Timber Industry? An Examination of Georgia's Pulp and Paper Sector

Abstract

This paper reviews global competitive conditions with implications for the Southern Pulp and Paper Sector. Initial stages of this study focus on timber based markets and the linerboard sector of the pulp and paper industry with emphases on Georgia.

Key Words: markets, prices, southern pine

Four overriding issues shape how the Southern Timber Industry competes internationally: 1) World timber supply/demand 2) trade globalization 3) Forest Industry consolidation and 4) a major shift in forestland ownership.

The World population is growing at about 1.3 percent per year and World forest area is declining at about 0.2 percent per year. In the resulting decline of forest area per capita, the impact of continued demand for forest products varies by region, economy and forest-type. In general, most forest losses were in the tropics while the temperate and boreal forests show stability or expansion. Managed forests have increased in importance. The United Nations Food and Agricultural Organization (FAO) estimates that plantation forests account for less than 5 percent of the World's total forestland but produce an increasingly higher proportion of global roundwood requirements. Global per capita use of wood is declining as forest product manufacturing becomes more efficient and fuel wood use declines in developing economies. [1]

The U.S. has about 6 percent of the World's forestland and 8 percent of its timber inventory. From this base, the U.S. produces about 27 percent of global industrial roundwood. The U.S. is also the World's largest consumer of wood products with per capita consumption about six times the World's average.[2]

The timber resources of the U.S. are concentrated along the West coast, in the South, and in the Northeast, despite its urbanization. Nearly 90 percent of U.S. timber production came from privately owned forests in 2000, up from about 80 percent in 1990. As policy curtailed harvest from public land, mostly in the West, production increased on private land in the South. The South, with its high levels of harvests from Virginia, through the Carolinas, to east Texas and Arkansas, produces 18 percent of the World's industrial roundwood with just 2 percent of the World's forestland and roughly 2 percent of the World's forest inventory. One of the South's big producing states, such as Georgia or Alabama, has just slightly less production than Sweden or Finland.

The U.S. South faces heightened global competition and increasingly global markets compared to twenty years ago. The value of global trade for value added forest products has increased. In 1980, between 15 and 20 percent of sawnwood, panels, paper and board were traded internationally. By 2000, that number had risen to between 25 and 30 percent. Global forest industry trade means that the strength of the U.S. dollar may influence timber and other forest product prices. As shown in Figure 1, the rising trade-weighted exchange rate since the mid-80s has an inverse relationship to the falling forest product balance of trade. [3]

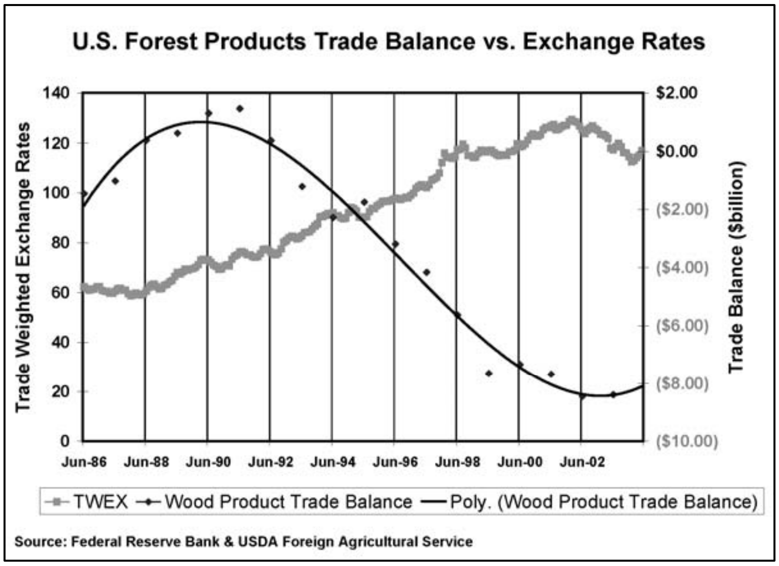


Figure 1 Globalization: U.S Forestry Exports are Inversely Related to the Dollar

Most of the competitive disadvantages of the South relate to higher costs.

- Changing paper demand
- High labor costs
- High fiber costs
- High tax rates

The U.S. is still the largest paper and paperboard market, consuming more than 300 KG per person annually. Developed markets such as Canada and Japan use more than 200 KG per capita while developing markets such as China and Russia use less than 30 KG per person. The expectation for increased consumption in the developing markets pulls new investment and production to the growing markets. Slow growth and reduced consumption in developed economies drive curtailment and cost cutting.

U.S. pulpwood consumption in the South has decreased since the 1990s. Worldwide pulp prices have been on a downward trend since 1995. Delivered conifer pulpwood prices have risen in the South since 1995 but have decreased in most of the other wood pulp producing regions, thus reducing Southern competitiveness.

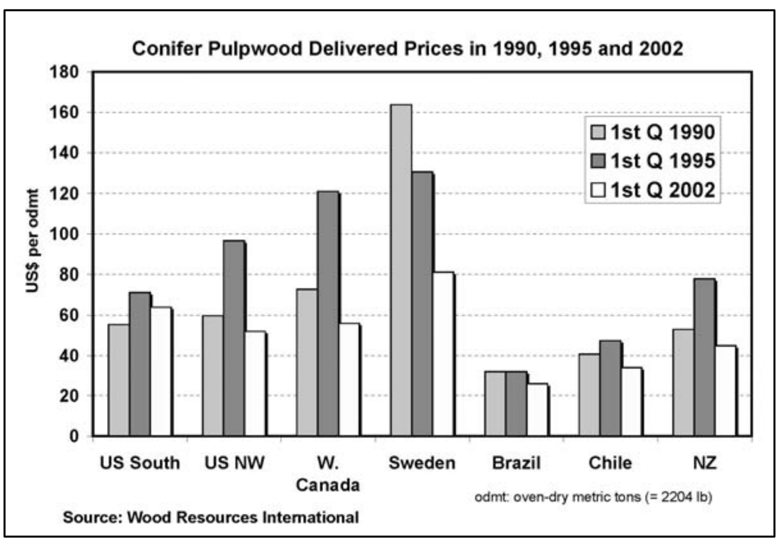


Figure 2: Conifer Pulpwood Delivered Prices in Competing Markets

Global trade may limit price appreciation for U.S. forest products. For example, between 1995 and 2002, wood fiber costs in the U.S. South dropped slightly, but they dropped dramatically in the U.S. Northwest, and western Canada. Sweden had a major decline in the U.S. dollar value of their wood fiber, as did Brazil, Chile and New Zealand. As shown in Figure 2, by early 2002, near the peak of the strong dollar, the South had lost a substantial cost advantage in the World markets.[4]

In 2004, the weakening dollar means current wood costs delivered to a southern pulp mill are slightly below those delivered to a Swedish mill. U.S. imports of wood products have stabilized or declined and exports have edged upward.

Since 1999, the Forest Industry has implemented major consolidation and restructuring, mostly in the name of improving "global competitiveness." Table 1 shows that several of the greater consolidations occurred in some of the key pulpwood markets, such as tissue and linerboard. Companies have also concentrated production, shutting some mills and making improvements to others. Plywood production has ceded ground to Oriented Strand Board (OSB.)

Table 1: U.S. Consolidation/Restructuring Big Plays 1999 to 2004 Is it Working?	
Georgia-Pacific:	+ Fort James & Plywood mills from L-P – The Timber Co. (Timberland) & OSB mill – Brunswick and New Augusta mills to Koch
International Paper:	+ Union Camp & Champion – Timberland & OSB mills to Norbord
Weyerhaeuser:	+ MacMillan-Bloedel/Trus-Joist & Willamette - Timberland
Temple-Inland:	+ Gaylord Container – Timberland
Bowater:	+ Alliance Forest Products - Timberland
Louisiana-Pacific:	+ OSB mill from G-P – Timberland & Plywood mills to G-P
Mead & Westvaco:	– Timberland & Stevenson Mill to Smurfit-Stone
Plum Creek:	+ & - Timberland
Rayonier:	+ & - Timberland

The record of consolidation also indicates a relatively new move, a major divestiture of forest industry timberland. This policy has increased the acreage in private hands and removed many "higher and better use" acres from forest production. The rise in institutional investment in timberland and the increase in the size of the major timberland management organizations (TIMOs) since the 1980s has created a "global" pool of buyers and vehicles for trading in timberland. Differences in timber growing regions have increasingly become "portfolio characteristics" to be measured and watched. The consequences of such land ownership changes for traditional private forest landowners remain uncertain.

	Table 2: U.S. Land Holdings	2003 million acres
1	Top 10 TIMOs	9.4
2	International Paper	8.3
3	Plum Creek Timber Co. (REIT)	8.1
4	Weyerhaeuser	6.8
5	Boise Cascade	2.4
6	MeadWestvaco	2.2
7	Temple-Inland	2.0
8	Rayonier (REIT)	2.0
9	Potlatch	1.5
10	Sierra Pacific	1.5
	Total	**44.2**

Table 2 shows the relative timberland holdings at the end of 2003 between the major forest industry owners. In this case, the Top Ten TIMOs include: Hancock Natural Resources Group, The Forestland Group, Molpus Woodlands, Forest Investment Associates, RMK Timberland Group (formerly Wachovia Evergreen), Campbell Group, Wagner Forest Management, Fountain Investments, Prudential Timber, and Forest Systems.

Timberland ownership impacts corporate profits as well as fiber cost. Property tax burden reduction has provided at least part of the incentive for large corporate owners to divest. Georgia, for example, limits “current use” tax relief to only 2,000 acres of a landowner’s holding and industrial landowners are not eligible. A shift to private ownership may allow more acres to qualify for tax relief. A transfer to entities such as pension funds can influence income tax receipts at both Federal and State levels. Two of the listed public corporations have shifted their ownership configuration to a more tax-advantaged real estate investment trust (REIT) structure. Plum Creek converted from a master limited partnership (MLP) to a REIT in 1999. Rayonier converted at the beginning of 2004. Both companies have been buying as well as selling timberland in the current market and state that the REIT structure increased profits as well as shareholder value.

The future competitive advantage for the South depends on a favorable combination:

- Location near active markets
- Terrain
- Climate
- Solid infrastructure
- Good management skills
- Good government
- A unique system of private land ownership and timber ownership.

Specific issues and challenges to Georgia Pulp and Paper production include several product categories as well as links to Gross National (State) Product.

- Linerboard production has changed and producers have moved much production to countries-of-origin for imports rather than making containers in the U.S.

- Pulp production has competition in Brazil and the Southern Cone. Some technical evaluators argue against the superiority of the highly touted eucalyptus pulp.
- Newsprint suffers from reduced newspaper circulation. Advertisers increasingly prefer coated paper for marketing their products.
- Printing and writing paper grades face challenges from electronic media.

We expect that the South will continue to be a strong fiber-producing region on the World scale. Published timber prices, such as Timber Mart-South's Southeast Average Stumpage series in Figure 3, provide an index to the South's well-established open market for timber.

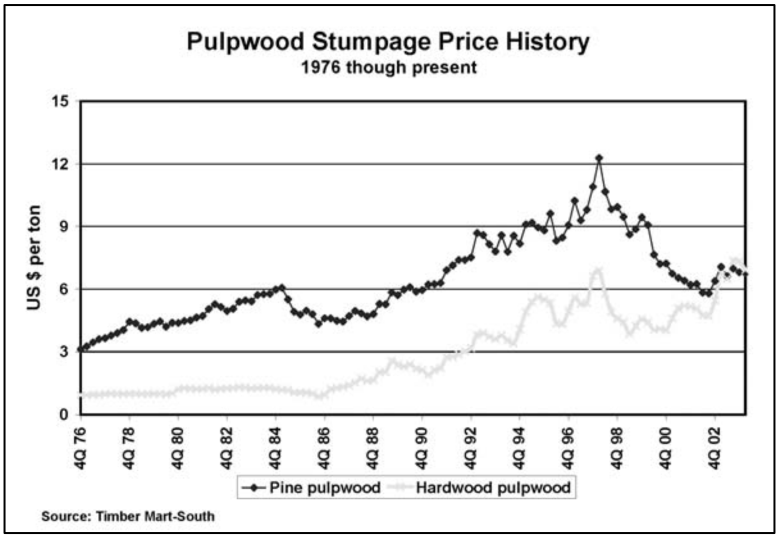


Figure 3: South-wide Average Pulpwood Stumpage Prices 1976 to Present

The South and Georgia in 2004 have both an abundant supply of pulpwood and a market system that has kept pulpwood stumpage prices low. Pine prices have been nearly the same, when adjusted for inflation, for the last quarter of the Twentieth Century. While supply costs still concern Pulp and Paper manufacturers in the South and Georgia, such stability in a major commodity can ensure the profitability of capital improvements designed to improve competitiveness.

Sources:

United Nations Food and Agricultural Organization, Global Forest Resource Assessment 2000, Rome, Italy. 2001.

Smith, W.B. Vissage, Sheffield & Darr. Forest Resources of the United States, 1997 . USDA Forest Service**.** St. Paul MN. www.fs.fed.us/pl/rpa/ GTR-NC-219. 2001.

USDA Trade Reports http://www.fas.usda.gov/ustrade/

Harris, Thomas G. Jr. Melton, Baldwin & Ekstrom, Global Wood Fiber Markets: impact on the U.S. South, Forest Landowner Volume 62, Number 1. 2003

A Comparison of Four Forest Inventory Tools in Southeast Arkansas

Brandon Tallant and Dr. Matthew Pelkki

Abstract

During the summer of 2003, timed measurements on 6,469 trees and 422 fixed radius plots were collected in an operational setting of a fixed radius plot forest inventory in the Gulf Coastal Plain of Arkansas. This project tested the efficiency of the Haglof Vertex III and a Suunto percent/degree clinometer in combination with a combination loggers'/diameter tape and 30 inch metal tree calipers when used in conducting a forest inventory.

The study found calipers to be faster than a loggers' tape when measuring tree diameter at breast height. The sonar-based hypsometer was found to be faster than manual hypsometers when measuring tree height. The sonar-based hypsometer was faster than a loggers' tape when establishing 1/5 acre fixed plot radii. Also, the caliper/sonar-based hypsometer was the fastest tool combination to conduct a forest inventory. A general linear model was also estimated to predict plot time that had an adjusted R^2 of 0.79. It was found that the increased efficiency (27%) of the caliper/sonar-based hypsometer offset its high initial cost, with a break even point of 1,009 plots.

Key words: forest inventory, plot time, time study, tools

A Comparison of Four Forest Inventory Tools in Southeast Arkansas

Brandon Tallant[1] and Dr. Matthew Pelkki[2]

New technology is constantly becoming available to assist managers in performing forest inventories. This new technology comes at a substantially higher initial cost than that of traditional equipment, and there is little or no evidence of equipment ease of use, efficiency, or accuracy. This project tested the efficiency of the Haglof Vertex III (sonar-based hypsometer) and a Suunto percent/degree clinometer (manual hypsometer) in combination with the combination loggers'/diameter tape (loggers' tape) and 30 inch metal tree calipers (calipers) when used in fixed radius circular plot forest inventories in the Gulf Coastal Plain of Arkansas.

Diameter Measurement

The most common tree measurement made by foresters is diameter at breast height. A variety of tools exist to measure this tree attribute with varying degrees of accuracy, precision, cost, operational simplicity, etc. (Clark and others 2000). The diameter measurement tools used in this study were a combination loggers-diameter tape and a 30-inch metal tree caliper. Moran and Williams (2002) noted that when irregularly shaped trees are measured with d-tapes, convex deficits occur where the tape passes over areas of the tree surface that have depressions. When compared to caliper measurements, Brickell (1970) found that d-tape girth measurements result in cross-sectional area bias larger than calipers. This is because measurements made with the d-tape are based on the perimeter of a circle and any departure from true circular form increases the ratio between the circumference and area according to the amount of departure from the circular form (McArdle 1928). When using tree calipers, it is common practice to record the diameter as the arithmetic mean of the two readings. Clark and others (2000) found that both tools, when used properly, provide comparable results with the majority of the bias caused by mathematical models that do not accurately represent stem cross sections.

Height Measurement

An important part of a timber inventory is the accurate determination of tree height. This is costly and often difficult to obtain; the general policy thus far has been to select the method that gives the lowest acceptable level of accuracy (Rennie 1979). The hypsometers used in this study are the Suunto clinometer (manual hypsometer) and the Haglof Vertex III. Both the manual and sonar hypsometers use trigonometric principles to determine tree height. Several studies have compared the accuracies of different hypsometers. Rennie (1979) found the Suunto manual hypsometer to be more precise and faster than the Abney level, the Christen hypsometer, or the Blume-Leiss hypsometer, all with 100-foot tapes. A study by Williams and others (1994) found the manual hypsometer to show significant negative bias only in the 0-33 ft height class. Wing and others (2004) found the Haglof Vertex to estimate tree height within 4.25 feet for 70 to 90 foot tall trees. They also found its average distance error to be less than 0.70 feet for targets ranging from 24 to 100 feet.

1. Graduate Student, University of Arkansas-Monticello, School of Forest Resources, P.O. Box 3468,110 University Court, Monticello, AR 71656, tallant@uamont.edu, (870)460-1793(v); (870)460-1092(fax)

2. Associate Professor, University of Arkansas-Monticello, School of Forest Resources, P.O. Box 3468, 110 University Court, Monticello, AR 71656, Pelkki@uamont.edu, (870)460-1949 (v); (870)460-1092(fax)

Time Studies

Binot and others (1995) found the d-tape to be faster than the calipers. Based on an average of 34 trees, average person-seconds required to use the instruments were reported as 755 for diameter tape and data collector, 826 for diameter tape and tally sheet, 876 for caliper and data collector, and 917 for caliper and tally sheet. In other words, the time required for the d-tape and data collector required 755 seconds per 34 trees or 22 seconds per tree of two persons combined. The d-tape was faster than the calipers, because it only required one measurement versus two with calipers.

Hunt (1959) timed each height measurement with a stop watch to one-tenth second. The time required to measure a tree was determined as follows:

1) The operator assumed his position over the stake corresponding to the tree measured.
2) As he raised the instrument to his eye, the recorder started the watch.
3) The operator called out the instrument reading to the tree base and then to the first live limb.
4) The watch stopped when the recorder received the latter reading.
5) The two readings and the consumed time were recorded.

When using a tape, Rennie (1979) found the use of the Suunto clinometer with tape to be a faster instrument to determine tree height than the Abney level or Blume-Leiss. The average times required to measure 94 trees using different pieces of equipment were 200 minutes for the Abney level with tape, 146 minutes for the Blume-Leiss with tape, 125.5 minutes for the Suunto manual hypsometer with tape, 173.5 minutes for the Suunto manual hypsometer with pole, 79 minutes for the hand-held Christen hypsometer, and 107 minutes for the Christen hypsometer on a staff.

None of the research conducted thus far has combined the inventory instruments and studied how they work when used together, how much time they require in an operational setting when used together, or how stand conditions affect the time requirements in operational settings. This study will combine both height and diameter measurement inventory instruments, use them in an actual forest inventory, time the entire process, and make conclusions on their efficiency through time studies to include the initial cost of the equipment. This information will then be used to create a regression equation that will include the diameter and height measurement instruments used, as well as stand conditions to compute the time required to complete a forest inventory.

METHODS

Study Area

The study included four stand of timber in Ashley, Bradley, and Drew Counties, Arkansas. The first stand, located in Drew County, was a mature pine stand that had recently been thinned of most hardwoods and contained mostly mature pine trees; initially it was an old field plantation. The second stand, located in Bradley County, was an uneven-aged pine/hardwood stand that had not been actively managed. The next stand, also located in Bradley

County, was a middle aged pine plantation. The final stand was located in Ashley County. It was an uneven-aged pine stand that had recently been thinned of all hardwoods. This stand was an old forest that was put into production in 1994 as an uneven-aged pine forest. As the stands were all located in the Coastal Plain of Arkansas, there was little to no elevation changes in the topography.

Inventory Methods

All stands were inventoried at 7.5% intensity using 1/5th acre circular plots in the summer of 2003. Each stand was inventoried four consecutive times using different combinations of inventory tools. All inventories of each stand were completed using the same distance between cruise lines and plots on a line. At the beginning of each cruise method, the distance to the starting line and distance to the first plot of each line were randomly selected. Every tree with a diameter at breast height (DBH) greater than 4.6 inches was measured. Trees were measured to the nearest 1/10th inch; those with a diameter between 4.6 and 8.5 inches were considered pulpwood. Pine trees with a DBH greater than 8.6 inches were considered sawtimber sized trees, and hardwood trees with diameters greater than 11.6 inches were considered sawtimber sized trees. Three attributes of each tree that fell within the 1/5th acre circular plot were recorded, they included diameter at breast height to the nearest 1/10th inch, total height to the nearest foot, and an ocular estimation of the number of merchantable height (10-ft pulpwood sticks or 16-ft sawlogs). Merchantable pulpwood above sawtimber was not estimated.

Trees per acre and stand volumes were determined using these measurements. Each of the four inventories was completed using a different combination of the following diameter and height measurement tools:

Diameter	-Loggers' Tape (combination loggers/diameter tape)
	-Calipers (30 inch metal tree calipers)
Height	-Sonar-based hypsometer (Haglof Vertex III)
	-Manual hypsometer (Suunto percent and degree clinometer).

A particular equipment combination was used until the entire inventory was completed. Also, research personnel (4 persons) rotated positions daily according to a randomized schedule.

Equations developed by Clark and others (1986) were used to determine the top diameters of trees. The cubic foot volume of pine trees in the mature pine stand were determined using equations from Van Deusen an others (1981) because the stand was old-field plantation grown loblolly pine. All other stand pine volumes were determined using equations from Amateis and Burkhart (1987). This equation was used because it was developed for loblolly pine trees in cutover site-prepared plantations. Hardwood tree volumes were determined using equations from Clark and others (1991).

Inventory crew

An inventory crew consisted of two individuals. The first role was that of the cruiser, this person measured tree attributes and determined plot boundaries for all plots. Tree attributes included diameter at breast height, total tree height, and merchantable height. The next person on the inventory crew was the tallyperson. This person was responsible for pacing from plot to plot, determining cruise lines, determining plot center, recording temperature, brushiness, weather, recording information called out by the cruiser, and recording the total time required to complete individual plots. Brushiness was a subjective ocular estimation of the brush in the plot; it was used to help determine if brush was a contributing factor to the time required to complete steps in the inventory process. Weather was recorded as hot, windy, rainy, or normal. The difference between hot and normal weather was determined by the tallyperson.

Two additional persons followed the inventory crew and recorded times for all activities completed by the cruiser. Timer A and Timer B recorded the time required to complete the activities of the cruiser and the tallyperson. Timer A measured the time to find the starting line, plot radius determination, DBH, total height, and recovery time. Timer B measured travel time, acquisition time, separation, and merchantable height.

Timing Process

In addition to tree attributes, times (in seconds) to complete each task in the inventory process were recorded. The inventory process was divided into three levels of work that consisted of a total of 13 tasks. The order of tasks in an actual field setting may vary from the order of tasks used in this study. This set order was necessary in order for the timers to gather the information required for this project. Figure 1, presents a timber inventory operation process chart that depicts processes and measurements made in a forest inventory regardless of the instrument used.

Each day the total work time was recorded. It was started when the group left the designated corner of the property and ended when the group walked back to that same point. This designated corner did not change from day to day or from tool combination to tool combination. All breaks taken during the process were also recorded, so they could be accounted for in the plot total time and total daily time. With the exception of equipment failures, the times to complete inventory plots are delay-free times.

Regressions

The data were then randomly split into a regression dataset and a validation data set to develop and validate the regression equations. Residuals that were three standard deviations away from the mean were considered outliers and eliminated before regression models were fit. SAS® was used to fit a regression model that estimated the time required to inventory a plot. Mallows Cp and PRESS statistics were used to narrow regression models.

RESULTS/DISCUSSION

A total of 422 1/5th acre plots collectively containing 6,469 trees were used in means testing and model fitting. Out of this sample, 105 plots and 1,608 trees were randomly selected and included in the validation dataset. The remaining 317 plots and 4,861 trees were used in fitting and testing all regression equations. Table 1 shows the time to measure inventory plots with different equipment combinations summary statistics.

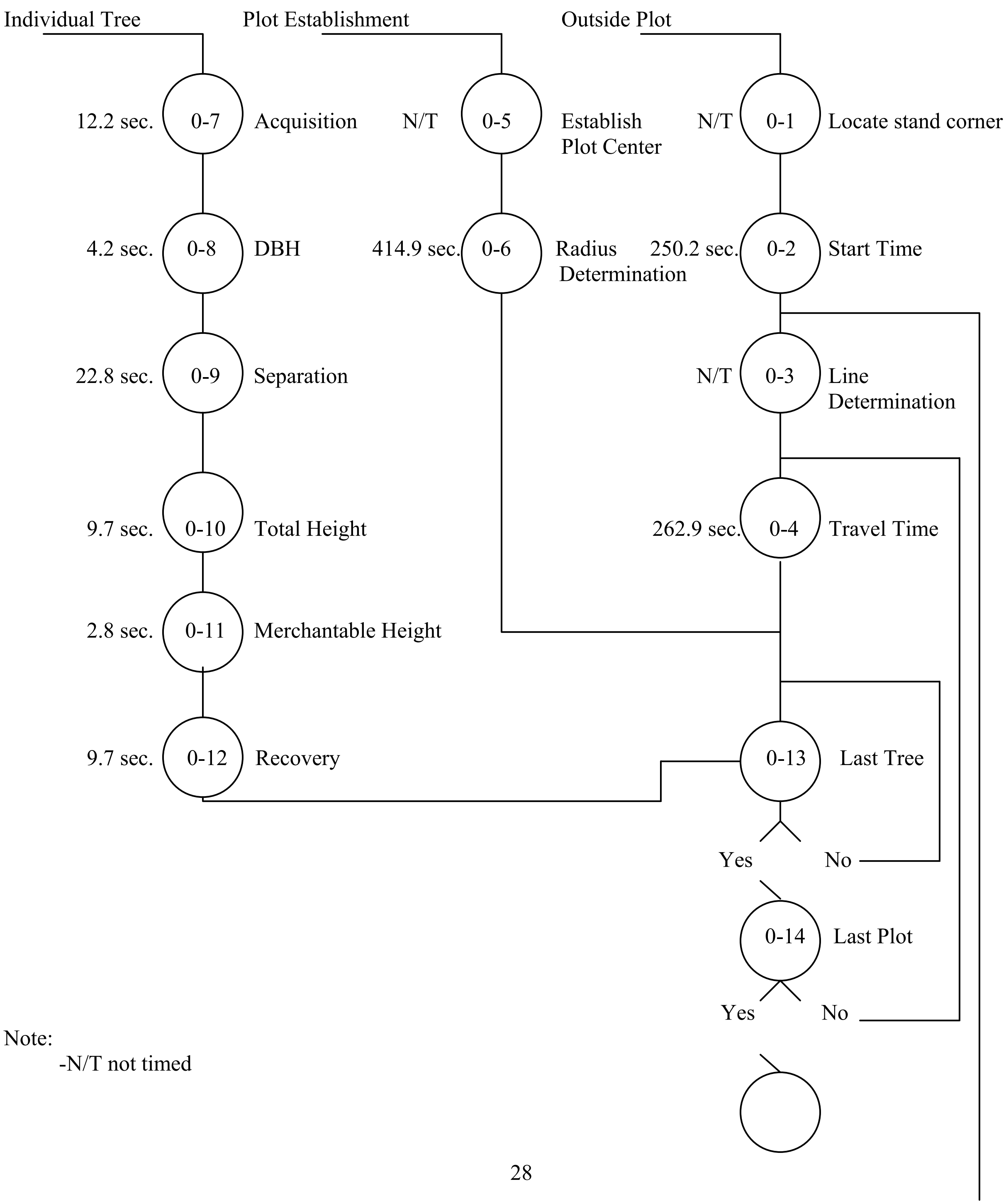
Table 1. Time to measure 1/5th acre fixed radius inventory plots with different equipment combinations summary statistics.

Combination	N	Mean (min.)	Std. Dev.	Std. Err.

Caliper/sonar-based hypsometer	104	20.54	11.989	1.176
Caliper/manual hypsometer	106	24.02	13.038	1.266
Loggers' tape/sonar-based hypsometer	107	24.00	14.252	1.378
Loggers' tape/manual hypsometer	104	24.23	13.341	1.308

Time Study

A t-test showed a significant difference in the hypothesis that time to measure the DBH of a tree using the loggers' tape was less than or equal to the time with calipers for all species combined (p-value <0.0001, $\alpha=0.05$). Data support rejecting the null hypothesis and concluding



Note:
-N/T not timed

Summary:

Event	Number	Time
Operations	16	average time shown
Inspections	0	0

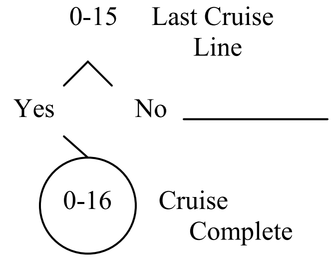


Figure 1. Timber Inventory Operation Process Chart

Charted by: Brandon Tallant 2-15-2003

that it is faster to measure a tree once with tree calipers than with a loggers' tape. Table 2 shows the summary statistics and two-sample t-test on the means of DBH measurement times using different equipment. The mean times to measure a tree with calipers and logger's tape are 2.0 and 6.5 seconds respectively.

Table 2. DBH times summary statistics and means tests.

Group	N	Mean (sec.)	Std. Dev.	Std. Error
All species combined				
Caliper	3167	2.0	2.22	0.04
Loggers' Tape	3303	6.5	5.47	0.10

t-statistic	**p-value**
36.18	<0.0001

Tree calipers are faster than loggers' tapes because of the positioning motions required to operate them. Operators in this study only measured tree diameters once. As seen in Table 2, the standard error of time is higher for the loggers' tape than of tree calipers regardless of the species group being measured. Tree calipers require less time and have a smaller standard error. This is because regardless of tree size or any vines that may be on the tree, the process of measuring that tree with a caliper does not vary. The standard error is higher with the loggers' tape which is due to not only tree size but also vines or other obstacles to the worker. When using a loggers' tape, the tape must be placed around the tree underneath any vines that may be in the way which requires more time. Also, some operators must walk around larger trees if their arms will not reach around the DBH of the tree. Both of these situations increase the time required to measure a tree.

Table 3 shows the summary statistics and t-test on the times recorded during the tree height measurement processes using the manual and sonar-based hypsometers for all species combined. The sum of tree height times included separation, total height, merchantable height, and recovery of equipment for any given tree. A p-value of <0.0001 at $\alpha=0.05$ rejected the null hypothesis that the time to measure the total height of a tree with a manual hypsometer is less than or equal to the time to measure the total height of a tree with the sonar-based hypsometer.

Table 3. Tree height measurement process times (all species combined) summary statistics and means test using the manual and sonar-based hypsometers.

Group	N	Mean (sec.)	Std. Dev.	Std. Error
Sum of tree height times				
Manual hypsometer	3213	53.2	16.50	0.29
Sonar-based hypsometer	3256	41.1	13.28	0.23

t-statistic	**p-value**
32.417	<0.0001

The mean times to measure the height of a tree with the manual hypsometer and sonar-based hypsometer were 53.2 and 41.1 seconds, respectively. As seen in Table 3, on average the sonar-based hypsometer was twelve seconds faster at measuring height than manual hypsometers. Upon further investigation, every process in measuring a tree was significantly faster with the sonar-based hypsometer when all species were combined.

Table 4 shows the summary statistics and means tests for the plot boundary establishment times. It would seem as though the loggers' tape would require more time to establish plot radius than the sonar-based hypsometer, because the operator is required to return to the plot center after every distance measurement. Data suggest the loggers' tape is faster with a mean time of 273.8 seconds versus 324.9 seconds when using the sonar-based hypsometer.

Quite often in forest inventories there is brush, trees, and other obstructions between the operator and the plot center. Although the sonar based hypsometer will take readings through some brush, it will not work on areas that have very dense vegetation between the sonar based hypsometer and transponder. These obstructions interfere with the sonar-based hypsometer and require the operator to maintain the same position, but move the instrument vertically or horizontally before a distance measurement is taken.

Table 4. Plot boundary establishment times (all stands combined) summary statistics and means test using loggers' tape and sonar-based hypsometer.

Group	N	Mean (min.)	Std. Dev.	Std. Error
Loggers' Tape	209	4.58	2.963	0.205
Sonar-based hypsometer	206	5.54	3.936	0.274

t-statistic	**p-value**
-2.815	0.0026

Plot Level Regression

The final model form of the equation that best predicted total plot time is as follows:

$$\hat{T}p_i = b_o + b_1 S2 + b_2 M3 + b_3 B + b_4 PSTPA + b_5 NPSTPA \quad (1)$$

where: $\hat{T}p_i$ = predicted time to measure plot i in minutes,

b_o, b_1, b_2, b_3, b_4, and b_5 = parameter estimates,

S2 = pine hardwood stand,

M3 = caliper/sonar-based hypsometer,

B = heavy brush,

PSTPA = pine sawtimber trees per acre, and

NPSTPA = non-pine sawtimber trees per acre.

Table 5 shows the regression coefficients and fit statistics for Equation 1. This equation had an adjusted R^2 of 0.7997 and the lowest PRESS value of any other potential plot level equations. A paired t-test showed a significant difference in the hypothesis that the actual time to measure a plot was less than or equal to the predicted time (p-value = 0.0297). Table 6 shows the summary statistics and the paired t-test for the means of actual versus predicted total plot time in minutes.

The intercept term in the plot level regression (Equation 1) is 7.33 minutes. This regression was normalized on the mature pine stand and loggers' tape/manual hypsometer tool combination and does not include breaks taken in the plots. Regardless of the number of trees in the plot, the technician was still required to determine which trees were in the plot and which

Table 5. **Regression coefficients and fit statistics for the plot level equation (Equation 6).**

Parameter Coefficient	Parameter	Estimate	Std. Error	Pr > t
b_0	Intercept	7.33	0.774	<0.0001
b_1	pine/hardwood stand	4.09	1.055	0.0001
b_2	caliper/sonar hypsometer	-3.79	0.756	<0.0001
b_3	brush	2.47	0.740	0.0010
b_4	PSTPA	0.21	0.016	<0.0001
b_5	NPSTPA	0.19	0.006	<0.0001

Adjusted R^2 = 0.7997

Table 6. Actual versus predicted total plot time summary statistics and paired t-test using plot level regression.

Group	N	Mean (min.)	Std. Dev.	Std. Error
Actual Time	103	21.9	14.52	1.43
Predicted Time	103	23.0	11.79	1.16

t-statistic	p-value
-2.205	0.0297

trees were outside the plot, which on average required 5.06 minutes (Table 4). Plot boundary establishment explains a portion of the intercept term.

Simply being in a pine/hardwood stand would increase the time to complete a plot by 4.09 minutes. The presence of hardwood trees also had a positive influence on time in the tree-level regression. The significance of this stand may be due to its very large trees, both pine and hardwood. Due to the large size of both pine and hardwood trees in this stand, an operator would be required to walk around the large trees diameter in order to determine DBH.

Next, if the operator employed the use of the caliper/sonar-based hypsometer combination of equipment, the plot would be measured 3.79 minutes faster than if any other combination of tools were used. This is due to the faster tree measurement time as discussed in the tree level equation. All other tool combinations were found to be insignificant predictors of plot time.

Brush contributed 2.47 minutes to the time required to inventory a plot. Brush interferes with the equipment and makes the technician work harder to move through and take measurements through it. It was expected that brush would have a positive impact on total plot time.

Every tree in any given plot adds time to the total plot time. Pine sawtimber trees required more time to measure than any other tree. Consequently, every pine sawtimber tree per acre adds 0.21 minutes to the total plot time. Each additional non-pine sawtimber tree per acre added 0.19 minutes to the total plot time. A model with trees per acre of all species combined was attempted but it only explained 17% of the variation in the total plot time.

The plot level regressions predicted total plot time was significantly different than the actual observed time. Even though the predicted time is not the same as an actual observed time, forest managers can still use the equal in a forest inventory planning setting if the time is adjusted appropriately. When averaged over the 107 plots in the validation dataset, the plot level regression overestimated the actual time by 1.05 minutes per plot. The average time of the validation dataset was 21.05 minutes while the test dataset average was 23.04 minutes. The difference in these averages could explain why the regression overestimates the validation dataset. Since the dataset was randomly chosen, the different average times were unavoidable.

To calculate the economic efficiency of including the sonar-based hypsometer and tree calipers in a forest inventory, the plot level regression results of two inventories, one with the sonar-based hypsometer/caliper combination and one with manual hypsometer/loggers' tape, where simulated in a pine stand using normal weather conditions, heavy brush, 37 pine sawtimber trees per acre, and 5 non-pine sawtimber trees per acre. The estimated time required with the manual hypsometer/loggers' tape was 15.6 minutes, while the estimated time required with the sonar-based hypsometer/tree calipers was 11.7 minutes.

If two forest technicians worked 8 hours, they could complete 27 plots in a day's time using the manual hypsometer/loggers' tape if they averaged 3 minutes travel time between plots. Under the same conditions, the same forest technicians could complete 34 plots in a day's time if they employed the use of the sonar-based hypsometer and tree calipers. The annual costs of the inventory methods are shown in Table 7. Using the sonar-based hypsometer/caliper combination a forest manager could decrease the cost per plot by $1.28 over the course of a year's time and expect a 27% increase in worker production. The additional investment in the sonar-based hypsometer would be returned in the first 1,094 plots after the original 6,000 plots expected under the use of loggers' tape/manual hypsometer combination in the forest inventory.

Table 7. Annual costs of different inventories using the plot level regression.

Inventory Method	Plots/ yr	Work Hrs/ yr	Annual Technicians' Salary	Cost/ plot
Manual hypsometer/loggers' tape	6,500	2,000	$40,000	$5.95
Sonar-based hypsometer/caliper	8,000	2,000	$40,000	$4.67

Conclusions

The sonar-based hypsometer is a viable alternative to manual hypsometers that does increase the efficiency of those employing its use. Results presented in this study were based on data collected in the growing season when foliage was at its maximum. It seems likely that measurements taken in the winter, when foliage is at its minimum, would further increase time savings of the sonar-based instrument. Forest managers employing technicians to inventory stands on a continual basis should consider the use of sonar-based instruments.

From a planning perspective, the equation to estimate plot time should prove useful to forest managers. Predicting time to perform inventories should allow managers to more accurately plan how much inventorying can be completed by technicians. Equations can also act as quality control measures, ensuring that the inventory personnel are working efficiently.

The biggest strength of this study was that it focused on the times required to inventory forests in an operational setting, including all aspects of the inventory. It was designed around the inventory without modifying the motions or movements of forest workers. For this reason, the results of the study can be used by forest managers with confidence. No portion of the inventory was modified for ease in collecting data. Future research should concentrate on the use of more technologically advanced dendrometers and hypsometers in an operational setting. Many new pieces of equipment are tested for accuracy and precision, but not for improved efficiency of forest workers.

LITERATURE CITED

Amateis, RL., and Burkhart, HE. 1987. Cubic-Foot Volume Equations for Loblolly Pine Trees in Cutover, Site-Prepared Plantations. Southern Journal of Applied Forestry. 11:190-192.

Binot, JM., Pothier, D., Lebel, J. 1995. Comparison of relative accuracy and time requirement between the caliper, the diameter tape and an electronic tree measuring fork. The Forestry Chronicle 71(2): 197-200.

Brickell, JE. 1970. More on Diameter Tapes and Calipers. Journal of Forestry 68:169-170.

Clark, A, III. Phillips, DR; Frederick, DJ. 1986. Weight, volume, and physical properties of major hardwood species in the Upland-South. Res. Pap. SE-257. Ashville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station. 55pp.

Clark, A, III. Souter, RA. Schlaegel, BE. 1991. Stem Profile Equations for Southern Tree Species. Res. Pap. SE-282. Ashville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station. 124pp.

Clark, NA., Wynne, RH. Schmoldt, DL. 2000. A Review of Past Research on Dendrometers. Forest Science 46(4): 570-576.

Hunt, EV., Jr. 1959. A Time and Accuracy Test of some Hypsometers. Journal of Forestry 57:641-643.

McArdle, RE. 1928. Relative accuracy of calipers and diameter tape in measuring Douglas-fir trees. Journal of Forestry 26:338-342.

Moran, LA., Williams, RA. 2002. Comparison of Three Dendrometers in Measuring Diameter at Breast Height. New Zealand Journal of Applied Forestry 19(1):28-33.

Rennie, JC. 1979. Comparison of Height-Measurement Techniques in a Dense Loblolly Pine Plantation. Southern Journal of Applied Forestry 3(4):146-148.

Williams, MS., WA. Bechtold, and VJ. LaBau. 1994. Five Instruments for measuring tree height: An evaluation. Southern Journal of Applied Forestry 18(2):76-82.

Wing, MG., M. Solmie, and L. Kellogg. 2004. Comparing Digital Range Finders for Forestry Applications. Journal of Forestry 102(4): 16-20.

Van Deusen, PC. Sullivan, AD., and Matney, TG. 1981 A Prediction System for Cubic Foot Volume of Loblolly Pine Applicable Through Much of Its Range. Southern Journal of Applied Forestry. 5(4):186-189.

The Impact of Stand Identification Through An Object-Oriented Approach For Forest Management Planning*

Cliff D. Anderson[1], Donald L. Grebner[2], David L. Evans[3], Ian A. Munn[3], and Keith L. Belli[4]

*Approved for publication as Journal Article No. FO 267 of the Forest and Wildlife Research Center, Mississippi State University

[1] Graduate Research Assistant, Mississippi State University, Department of Forestry, PO Box 9681, Mississippi State, MS 39762. cda1@msstate.edu. (662)-325-8357

[2] Associate Professor of Forestry, Mississippi State University, Department of Forestry, PO Box 9681, Mississippi State, MS 39762. dgrebner@cfr.msstate.edu

[3] Professors of Forestry, Mississippi State University, Department of Forestry, PO Box 9681, Mississippi State, MS 39762. dle@rs.cfr.msstate.edu. (662) 325-2796, Imunn@cfr.msstate.edu. (662) 325-4546

[4] Professor of Forestry and Associate Dean of the College of Forest Resources, Mississippi State University, Department of Forestry, PO Box 9681, Mississippi State, MS 39762. kbelli@cfr.msstate.edu. (662) 325-2778

The Impact Of Stand Identification Through An Object-Oriented Approach For Forest Management Planning

Abstract

Stand boundary identification is an important factor in forest management planning that is dependent on the quality and resolution of the imagery available. We identified stand boundaries on an area within the John C. Stennis Space Center using two sources of multispectral imagery, IKONOS and QuickBird. Forest stands were delineated using eCognition v3.0. Segmentation was performed by initially finding an algorithm to produce objects representing forest stands larger than ten acres. Once this parameter for the algorithm was found, additional parameters (color, shape, compactness, smoothness) were iteratively changed to replicate area estimation. Preliminary results show that main differences in images exist in forest boundary locations. Also, the range of forest stand sizes within the each image type exhibit the largest differences between the images. Future work, analysis of stand boundaries in a forest planning model, will need to be completed to assess the impacts of area estimation.

Key Words: Stand boundaries, area estimation, satellite imagery

Introduction

Technological improvements in data acquisition and management have provided better decision tools for planning forest management activities. One of these tools is remote sensing. Multispectral imaging, for example, can provide quick and accurate data acquisition of managed areas. Multispectral data can be obtained through airborne or space borne sensors. The main differences in the two methods are spectral resolution and calibration. Through the recent development of very-high spatial resolution satellite sensors, such as IKONOS-2 and QuickBird, it is now possible to have image stability of space-borne data and the high spatial resolution capabilities of aerial photography. This offers imagery users the ability to obtain a valuable source of data suited for forest management planning.

Multispectral imagery can be very useful in forest management planning when determining stand boundaries, species composition, feature locations such as forest stands, trees, unique preservation areas, and the detection of stressed or dead trees. Unfortunately, planning may be impacted by how the data are processed. One of these processes is stand delineation. Stand delineation can affect the allocation of silvicultural activities on forest stands as well as the determination of total acres of stand types. The determination of acreage may increase or decrease volume estimates. As a result, the total volume estimate can change future management decisions by impacting harvest schedules. If area estimation is incorrect, the activity schedule may not be optimal for the specific management goals.

The objective of this study is to compare stand boundaries derived from IKONOS and Quick Bird satellite platforms and determine the economic impact of area estimation through the use of a forest planning model. A portion of this study, eCognition v3.0 (Definiens GmbH, Munich, Germany) was be used to estimate forest area because of it's ability to segment images into real world objects, widespread use, and because of the potential of automating forest stand delineation. This paper will focus on the development of the forest stand boundaries.

Satellite Imagery in Natural Resource Management

With the recent launch of satellites able to capture images having a resolution of less than five meters, relatively coarse spatial resolution is no longer a hindrance to the creation of local stand boundaries. Up to this point, forest managers have not had these sources of data and have relied mainly on aerial photographs and field surveys for the collection of local field data (Kayitakire et al. 2002). Satellite imagery can provide natural resource managers with an invaluable source of information as an alternative to aerial photography that may otherwise be difficult or impossible to obtain or monitor. Also, the detail is comparable to some aerial photography, is easily incorporated into a GIS, and supports multitemporal analyses of natural resources.

At spatial resolutions of about one meter, the per-pixel classification of forested lands should not be conducted without taking into account the spatial context of the information (Aplin et al. 1999). The value of an individual pixel does not provide much information since the objects of interest are often composed of many pixels. Therefore, a per-object classification is needed to correct this problem. A per-object classification should be more accurate even for lower resolution images than that of per-pixel classification (Kilpelainen and Tokola 1999).

Image Interpretation

Typically, stand delineation is accomplished by the use of heads-up digitizing, outlining on photos, or by GPS navigation of stand boundaries. The two former methods require that users can determine differences in stand attributes such as color, texture, shape, size, and context on the image. These characteristics may appear differently to different interpreters. Photo interpretation is a popular way of delineating stands on an image (Naessat 1997). Forest area has historically been interpreted from photo sampling in the USDA Forest Service Forest Inventory and Analysis Program (FIA) (Wynne et al. 2000). However, improvements in computer technology may permit delineation of stands, based on the previously mentioned attributes, without bias of person-to-person differences based on visual perception. One such package, eCognition, may be useful for applications such as stand identification from remotely sensed data through an object-oriented image segmentation approach.

The increased variability of very-high spatial resolution of images requires a stand delineation approach that is based on more than the spectral comparison of pixels. The common ways that have been presented in doing this are through segmenting images based on GIS information (property boundaries, soil types, and land use) or through segmenting from spectral or spatial attributes of the image data. The segmentation of images into unique texture regions is based on criteria such as size, shape, color, compactness, and smoothness followed by the classification of these regions based on the relative homogeneous properties and spectral patterns within each region have shown promising results (Lennartz and Congalton 2004). Aplin et al. (1999) and Kayitakire et al. (2002) noted that using this method may produce more accurate classifications compared to a per-pixel type classification. However, the accuracy of segmenting images in this manner depends on the spatial and spectral resolution of the sensor.

Study Area

The John C. Stennis Space Center (SSC), operated by the National Aeronautics and Space Administration (NASA) is being used for this study. The SSC is located in Hancock County, in southern Mississippi, and east of the Pearl River. Over half of the SSC land is used for testing facilities, laboratories, offices and other operational services. The main focus of the SSC is to conduct research on NASA's rocket propulsion systems for the Space Shuttle and future space vehicles. Research is also being conducted through federal, state, private and academic organizations for space, ocean, environmental and national defense programs. The forested areas are currently being managed by the United States Army Corps of Engineers.

Data

The IKONOS and QuickBird imagery, both taken in February of 2001, was obtained from NASA at the SSC. The imagery was received in raw tagged image format (TIF) and was subsequently stacked and mosaicked in Leica ERDA Imagine 8.6. The projection used for georeferencing was Universal Transverse Mercator (UTM), Zone 16 North WGS 1984 Datum. These images were imported into Imagine for visual inspection and data preparation. The study area of SSC to be delineated was identified and clipped from the full scene. This was done to reduce the amount of data needed to be processed and the spectral confusion of land outside of the study area.

The IKONOS satellite platform was launched in September 1999 and has a sun-synchronous orbit with an approximate three day repeat cycle. The satellite can provide panchromatic images at a resolution of one meter, and multispectral images with blue, green, red, and near infrared bands at a resolution of four meters (Dial and Grodecki 2003). Typically delivered images are 11 km square.

The QuickBird satellite platform is the highest spatial resolution commercial Earth-observation satellite available. Also, the satellite provides a swath width of 16.5 km. The satellite has 61 cm panchromatic and 2.44 m multispectral resolution and can provide four band multispectral images (blue, green, red, and near infrared) and a panchromatic image. The satellite was launched in October 2001 and has approximately a three and a half day repeat cycle (DigitalGlobe 2003).

A GIS of the study area was also obtained from SSC to populate the objects created in eCognition with forest stand types. The GIS was created in a recent inventory for SSC and was used as a reference when stand typing. The inventory was used in conjunction with tax map information for Hancock County, MS to create the GIS. When the GIS were overlain with the objects from eCongntion it was then possible to assign the proper stand type.

Methods

The primary goal of this study is to assess the impacts of area estimation using two types of imagery through a forest planning model. A portion of this study, in order to develop forest stand boundaries, used an object oriented process to identify stand boundaries. This study took the approach of iteratively changing a segmentation algorithm to simulate different area estimations and analyze these results through a forest planning model.

eCognition allows users to input five separate categories to define how objects are created. The software uses a bottom-up approach to merge objects of similar heterogeneity, which is subject to a defined scale parameter and the defined heterogeneity criteria. The scale parameter allows users to define the maximum heterogeneity allowed from the resulting objects. The heterogeneity criteria are defined by color, shape, object compactness, and object smoothness. The color and shape criteria are linked to allow users to apply weights, from 0 to 1, in order to control which criteria is more important. The color criterion is basically the standard deviation of each objects spectral values and is used along with the user defined weights to determine the acceptability of merging two objects. The shape criterion is defined by the object compactness and object smoothness. The objects smoothness and compactness allows users to define what the "ideal" object would be by using weights from 0 to 1. The more weight applied to the smoothness criteria will result in objects with smoother edges. Alternatively, objects will be more compact and have a more fractal shaped border when more weight is applied to the compactness criteria.

eCognition v3.0 was used to segment both image types. All four bands of both images (blue, green, red, and near infrared) were used in the segmentation and were weighted equally. The settings were initially defined in order to find a segmentation that would produce "forest" regions larger than 10 acres. This size limitation was determined to be the lowest acceptable forest management unit. The process to determine this "minimum mapping unit" was as follows:

1. The color, shape, compactness, and smoothness criteria remained the same as the default found in the segmentation algorithm.
2. The size parameter was iteratively adjusted from 100 to 200 in increments of 10.
3. Shapes were exported into GIS and overlaid with an existing GIS of the SSC populated with current classifications of forest cover types and use zonal majority algorithm to assign stand types to objects from eCognition.

4. The acres were queried for each object from eCognition (beginning with smallest size criteria) to determine the acres of each forest unit.
5. If any forest units were found to be less than the minimum mapping unit desired, the segmentation was rejected and steps 3 and 4 were repeated.

Results

It was determined that an initial size parameter for each image would have to be obtained because of the sensor attributes of each image type. After several iterations, a scale parameter for each image that produced forest stands greater than 10 acres was identified. An example of both the IKONOS and QuickBird images being segmented using this can be found in Figure 1. These images were segmented using the initial size parameter to produce forest stands greater than 10 acres and the color, shape, smoothness, and compactness on the default settings.

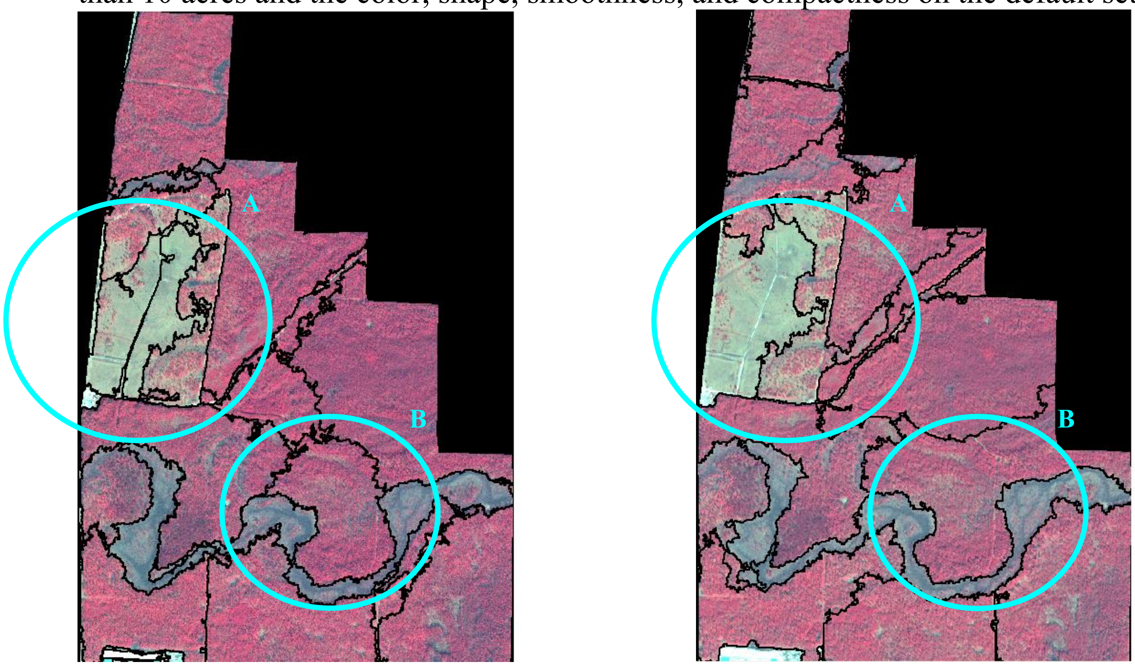


Figure 1. A multispectral QuickBird (left) and IKONOS (right) segmented image of forest stands within a portion of the John C. Stennis Space Center, Hancock Co., MS. illustrating the differences in the boundary locations of "unique" areas A and B.

One segmentation process for each image was analyzed for simple statistical exploration. The segmentation algorithm used to explore this data was consistent between each image, excluding the size parameter. The total number of stands identified was 98 and 104 for the QuickBird and IKONOS images, respectively (see Table 1). It is worth noting that the smallest (minimum) stand identified for each image was less than five acres. This is a direct result of "island" stands surrounded by roads. It was determined that since there were such a high number of stands over an operational high threshold, over 100 acres, further splitting of stands will be conducted to allow further analysis in a forest planning model. Nelson (2001) found that splitting polygons according to a multiple pass splitting routine, dependent on minimum and maximum polygon sizes, resulted in operationally acceptable areas in the development of strategic and tactical forest plans. A routine similar to the methods Nelson (2001) presented will be used in this research to spit the forest polygons appropriately to eliminate areas greater than 100 acres.

Descriptive Statistics	QuickBird	IKONOS
# of Stands	98	104
Acres Mean	68	64
Acres Range	352	213
Acres Std. Deviation	62	50
Acres Minimum	4	2
Acres Maximum	355	215
Stands greater than 100 acres	23	21

Table 1. Descriptive statistics from segmentation of the QuickBird and IKONOS images using eCognition (Definiens GmbH, Munich, Germany).

Future Work

More research is necessary to completely quantify possible differences in imagery types. Analysis of data will involve several different steps to determine the impacts of the image segmentations. To further analyze forest area estimation, the segmentation parameters (color, shape, compactness, and smoothness) will be changed iteratively. This will result in approximately 200 layers produced. This will also add several additional steps to the analysis of the images mentioned in the methods sections previously.

To quantify the possible differences between the two types of imagery, a forest planning model will be developed. Management prescriptions will also be developed for each stand. These prescriptions will include regeneration costs, site preparation costs, intermediate costs throughout the rotation, thinning revenues, and harvest revenues. Also timing of thinning, harvesting, prescribed burning, and planting will be determined using the program WINYIELD v1.11. The forest planning model will be developed with Woodstock (Remsoft) to determine the best management plan for each of the stand types. Spatial restrictions, green-up periods and adjacency constraints, will be analyzed using Stanley (Remsoft) and objective function values will be compared to determine the impacts of area estimation on forest management decisions.

Literature Cited

Aplin, P., P.M. Atkinson, and P.J. Curran. 1999. Fine spatial resolution simulated satellite sensor imagery for land cover mapping in the United Kingdom. Remote Sens. Environ. 68:206-216.

Dial, G., and J. Grodecki. 2003. Applications of IKONOS imagery. Presented at ASPRS annual conference proceedings at Anchorage, Alaska. pp. 1-13.

DigitalGlobe. (2003). QuickBird product guide. (3.9 ed) [Brochure]. Longmont, Colorado: Author.

Dubois, M.R., T.J. Straka, S.D. Crim, L.J. Robinson. 2003. Cost and cost trends for forestry practices in the South. Forest Landowners Manual, 34th Edition.

Franklin, S.E., M.A.Wulder, and G.R. Gerylo. 2001. Texture analysis of IKONOS panchromatic data for Douglas-fir forest age class separability in British Columbia. Int. J. Remote Sens. 22(13):2627-2632.

Kayitakire, F., C.F. Farcy, and P. Defourny. 2002. IKONOS-2 imagery potential for forest stands mapping. Presented at ForestSAT Symposium, Heriot Watt University, Edinburgh (Scotland), August 5th-9th, 2002.

Kilpelainen, P., and T. Tokola. 1999. Gains to be achieved from stand delineation in LANDSAT TM image-based estimates of stand volume. For. Ecol. Mgmt. 124:105-111.

Lennartz, S.P, and R.G. Congalton. 2004. Classifying and mapping forest cover types using IKONOS imagery in the northeastern United States. Proceedings of the ASPRS Annual Conference, May 2004. Denver, Colorado

Naesset, E. 1997. A spatial decision support system for long-term forest management planning by means of linear programming and a geographical information system. Scand. J. Fo. Res. 12:77-88.

Nelson, J. 2001. Assessment of harvest blocks generated from operational polygons and forest-cover polygons in tactical and strategic planning. Can. J. For. Res. 31:682-693.

Nautiyal, J.C., and P.H. Pearse. 1967. Optimizing the conversion of sustained yield-a programming solution. For. Sci. 13(2):131-139.

Wynne, R.H., R.G. Oderwald, G.A. Reams, and J.A. Scrivani. 2000. Optical remote sensing for forest area estimation. J. For. 98:31-36.

Cost Considerations of Using LiDAR for Timber Inventory[1]

Bart K. Tilley[2], Ian A. Munn[3], David L. Evans[4], Robert C. Parker[5], and Scott D. Roberts[6]

Acknowledgements:
Mississippi State University College of Forest Resources
NASA John C. Stennis Space Center
Mississippi State University Remote Sensing Technology Center
Airborne1 Corporation

Cost Considerations of Using LiDAR for Timber Inventory

Abstract

As interest in using Light Detection and Ranging (LiDAR) for forest inventory increases, the need for information comparing its cost effectiveness to conventional forest inventories is necessary. This project compared costs of a random sample ground inventory with a double sampling approach using LiDAR and fixed radius ground plots. The study examined the role of relative costs for each plot type (LiDAR and ground plots) and the similarity of plot level data (coefficient of determination) in the cost efficient mix of LiDAR and fixed radius ground plots.

Because of the high cost of acquiring LiDAR data, a double sampling approach using LiDAR technology is currently not cost effective for determining timber volumes when compared to traditional ground methods. However, LiDAR inventories can provide additional benefits such as a Digital Elevation Model (DEM), wildlife habitat characteristics, and other applications that require vertical and horizontal vegetation densities. If LiDAR data are already in place, a LiDAR inventory can be performed using a double-sample inventory to reduce cruising costs and improve the accuracy of the cruise volumes, but data must be acquired with the same time frame. Trade-offs between LiDAR and ground plots are directly related to the relative per plot costs of the two approaches and the strength of the relationship between the data derived from the two methods. In general, as LiDAR costs decrease, LiDAR plots can be substituted for ground plots to supply the same level of precision at the same total cost. As the relationship between LiDAR and ground inventory attributes increases, LiDAR plots can be substituted for a larger portion of the ground plots, while maintaining precision and total cost.

Keywords: Light Detection and Ranging, Double-sampling, Coefficient of determination

Introduction

Light Detection and Ranging (LiDAR) is a remote sensing tool that can potentially be used to conduct timber inventories. LiDAR has been used for the quantification of biomass, tree and stand height, and basal area estimation (Nelson et al. 1988, Nilsson 1996, Magnussen and Boudewyn 1998, Lefsky et al. 1999, Means et al. 1999, Means et al. 2000).

LiDAR data are collected from an aerial platform, typically an airplane but occasionally a helicopter. An airborne laser is shot to the ground below the aircraft (Dubayah and Drake 2000) and is reflected back to a sensor on the aircraft that records the time that elapsed between the shot and the reflection. Each laser shot can be reflected from more than one object allowing both tree tops and the ground to be recorded. The elevation difference between the first returns (typically the canopy) and last returns (ground) can be used to calculate tree heights. A Global Positioning Systems (GPS) and Inertial Measurement Unit (IMU) on the aircraft are used to record the exact location and time of each laser shot. Tree information obtained from the ground cruise is used to predict volume from the tree heights generated from the LiDAR data.

The only tree characteristics obtained from the LiDAR inventory are tree height and trees per acre (Dubayah and Drake 2000). Timber inventory using LiDAR requires a double-sample inventory approach because of the limited information available from a LiDAR inventory. Double sampling requires two plot types: primary plots that provide less detailed information, but typically cost less, and secondary plots that provide more information, but also cost more. Primary plots can be substituted for secondary plots to decrease cost by reducing the number of secondary plots required, if the attribute and volume information has a strong relationship with the remotely sensed data. The ground cruise provides the secondary plots and is used to collect diameter at breast height (dbh), tree height, crown class, and stem density data to determine the height-volume relationships. Tree heights from LiDAR primary plots are then used to predict timber volume.

At present, there is no consensus as to the optimal posting density for LiDAR double sampling. Parker and Evans (2004) used LiDAR data with a posting density of 0.25 postings per square meter to achieve an 11.5% sampling error at the 95% level of confidence. This study uses two posting densities to attempt to examine possible trade-off between assumed measurement accuracy (high density) verses reduced costs (low density) of LiDAR in a double sample inventory.

Objectives

The objectives of this study were to:

1) Determine if using LiDAR for timber inventory is cost effective.
2) Examine how the cost relationship changes with tract size.
3) Compare the cost and precision of two LiDAR posting densities with a conventional ground cruise.
4) Determine the breakeven point between a LiDAR double sampling cruise and a conventional timber inventory based on tract size.
5) Examine the effect of the relative cost of each plot type and the coefficient of determination between the plot types on plot allocation for double sampling.

Methods

The study area consisted of approximately 1200 acres of Louisiana State University's Lee Memorial Forest, located near Bogalusa in Washington Parish, Louisiana. The forest consisted of three stand types: mixed pine hardwood, mature pine, and pine plantations.

LiDAR data were collected in continuous strips along flight lines laid out to cover approximately 10% of the study area. LiDAR plots were then extracted from the continuous data. The double sample inventory was performed using 0.05 acre LiDAR and ground plots. The ground plot data were collected at every tenth LiDAR plot to establish height-volume relationships. There were 1,410 LiDAR plots and 141 ground plots collected from the 1,200 acres (Parker and Glass 2003).

LiDAR data were collected at two posting densities "high" and "low" to compare their accuracy for predicting timber volumes (Parker and Glass 2003). Posting density refers to the average spacing of the laser shots on the ground. The posting densities for high density and low density LiDAR data is four LiDAR shots per square meter and one LiDAR shot per square meters, respectively. Each posting density required a separate flight with high density LiDAR data requiring a lower flying altitude, thus taking longer and costing more to collect. It was hypothesized that low density LiDAR data would decrease collection costs, but result in decreased accuracy.

In order to compare the cost of a LiDAR based double-sample inventory to a random sample ground cruise, the cost of the ground cruise was obtained from actual field operations and was also used for the cost of the double-sample ground plots. The LiDAR inventory costs included the cost of obtaining the LiDAR data, the ground plots for determining the height volume relationship, and LiDAR data processing. If LiDAR data are already available, the cost of extracting the plots and processing the data for timber inventory is very low.

Regression models were constructed for both LiDAR posting densities to predict timber volumes from LiDAR derived tree heights. LiDAR tree heights were consistently underestimated compared to the ground heights of the same tree. A two stage method for correcting this problem was constructed (Parker and Mitchel 2004). First, the LiDAR counts of trees were corrected with a smoothing process before the regression model was computed. This was done by averaging the LiDAR canopy surface to reduce the number of false tree locations. Second, the LiDAR derived tree heights were considered to be negatively biased and were corrected within the regression model. The high and low density LiDAR models' predicted volumes were compared to determine which provided a more precision estimate.

The number of plots was a function of the cost of each plot type and coefficient of determination. In order to determine when a double sampling technique would be cost effective, examination of the relative costs of each plot type (ground vs. LiDAR) and the coefficient of determination was necessary. The plot allocation formulas for double sampling are:

$$n_1 = N_{rs}\left[(1-\rho^2)\sqrt{\left(\frac{c_2}{c_1}\right)\left(\frac{\rho^2}{1-\rho^2}\right)} + \rho^2\right] \qquad n_2 = N_{rs}\left[(1-\rho^2)\sqrt{\left(\frac{c_1}{c_2}\right)\left(\frac{1-\rho^2}{\rho^2}\right)}\right]$$

where:

N_{RS}= Number of random sample plots,

n_1= Number of primary (LiDAR) plots,

n_2= Number of secondary (ground) plots,

c_1= Cost of primary (LiDAR) plots,
c_2= Cost of secondary (ground) plots, and
ρ = Coefficient of determination
(Johnson 2000).

Changes in the relative cost of each plot type and coefficient of determination were examined to determine the impact on the cost effectiveness of double sampling. LiDAR plot costs were represented as a percentage of the ground plot costs to demonstrate how the number of each type of plot changed as relative costs changed. In order to determine the coefficient of determination and LiDAR plot cost that would be most cost effective, three coefficients of determination (0.5, 0.7, and 0.9) and LiDAR plot cost as a percentage of ground plot cost were examined. All calculations were based on a precision of ±10% at the 95% level of confidence. Total costs, based on the optimal plot allocation, were graphed to illustrate the break-even point between double sampling and single phase, conventional ground inventory for each coefficient of determination.

Results

The cost and sampling error for high and low posting densities were approximately \$16,200, 8.2% and approximately \$15,000, 7.6% respectively. Although the low density LiDAR data had a smaller sampling error, there was statistically no difference (α=0.05) between the sampling errors of the two posting densities. Because low density LiDAR data cost less to collect and are as accurate at predicting timber volumes as high density LiDAR data, it was the only posting density used for the break even analysis. The cost of high and low posting density LiDAR inventories exceeded the cost of a conventional ground inventory for 1,000, 10,000, and 100,000 acres, based on cost estimates obtained from the LiDAR provider (Table 1). The cost of completing the Lee Forest ground cruise was \$22/plot and was used for the per plot cost for the 1,000 acre hypothetical forest. Costs of \$31 and \$40/plot for the 10,000 and 100,000 acre hypothetical forest were used to account for additional travel time for a ±10% sampling error cruise at the 95% level of confidence.

Table 1. Total cost of two LiDAR posting density timber inventories and a conventional ground cruise providing a sampling error of ±10% @ the 95%level of confidence.

	Total Cost		
Acres	High Density	Low Density	Ground Cruise
1,000	\$15,149	\$15,049	\$4,202
10,000	\$18,424	\$17,424	\$6,107
100,000	\$40,834	\$30,834	\$7,920

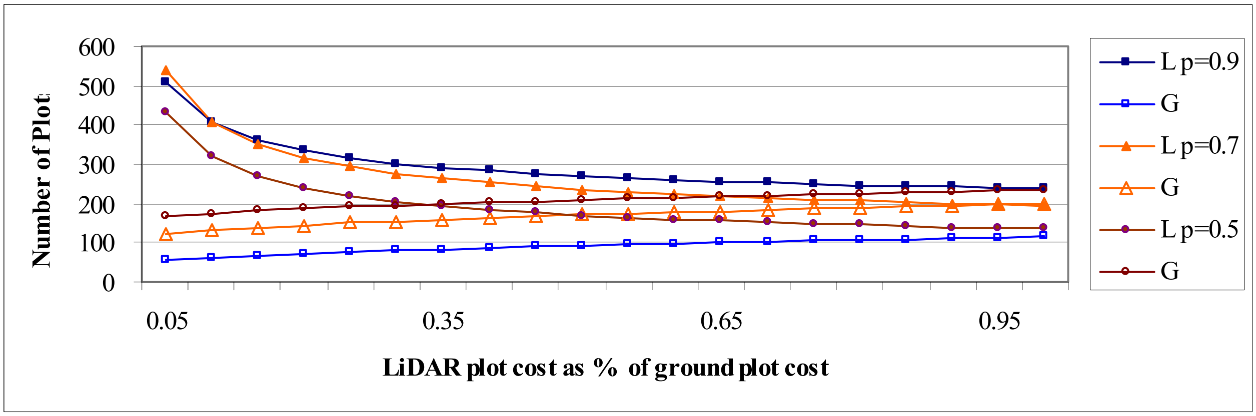
Cost Comparison

A double sampling inventory approach using low density LiDAR data and ground plots was compared to the cost of a conventional ground cruise to determine the break even point as acreage changed. Low density LiDAR inventory cost approximately \$15,000 to collect and process compared to \$4,300 for a conventional inventory for the 1,200 acre study area. This indicated that using LiDAR for timber inventory was not cost effective for small tracts of land.

For the Lee Forest, 195 random sample ground plots would be required to achieve the desired accuracy of ±10% (α=0.05), compared to the combination of 93 LiDAR and 304 ground plots for the double sampling. The plot allocation formula for double sampling required the cost of LiDAR plots be divided by the cost of ground plots and this combined with the coefficient of determination determined the percent of the initial random sample ground plots needed. Because the per plot cost of LiDAR plots was higher than the ground plot cost, the allocation formulas indicated that more ground plots were required than for a random sample ground cruise, demonstrating that double-sampling using LiDAR was not cost effective if LiDAR data were not already available. The marginal cost of extracting LiDAR data from an existing LiDAR data set is minor (Lefsky et al. 2002). Thus, double sampling using LiDAR may be cost effective.

The Lee Forest LiDAR data and ground plots had a coefficient of determination of 0.5. If this relationship, which determines the substitutability of LiDAR plots for ground plots, can be increased and/or the cost of obtaining LiDAR data decreased, LiDAR inventories may become cost effective. The combination of LiDAR and ground plots that minimizes cost for ±10% precision (α=0.05) cruise of 100,000 acres for each coefficient of determination as the percentage cost of LiDAR plots increases is shown in Figure 1.

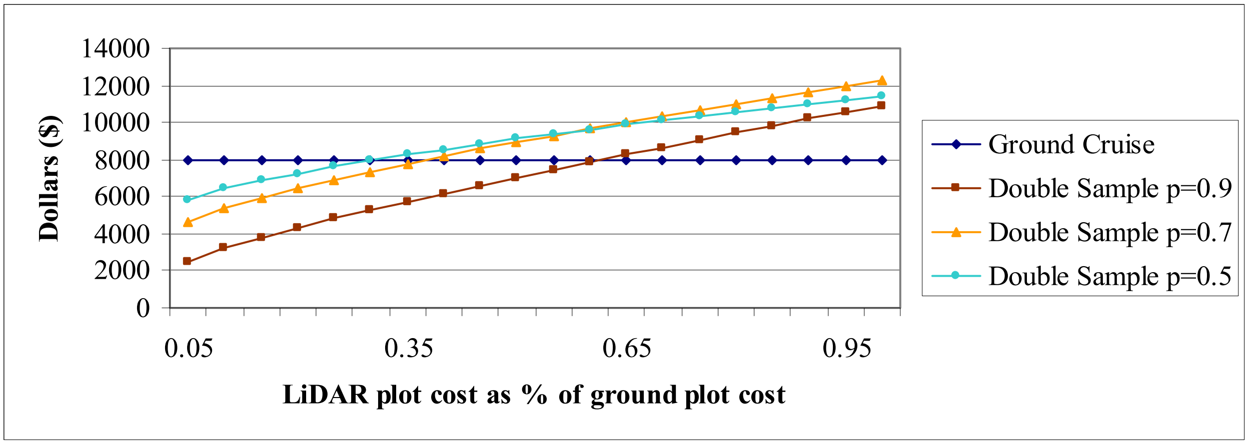
Figure 1. Allocation of LiDAR and ground plots that minimizes total inventory cost at ±10% precision at the 95% level of confidence for LiDAR (L) per plot costs expressed as a percentage of ground (G) plot costs for 100,000 acres, assuming CV%= 70 and ground plot size= 0.05 acres.



As the coefficient of determination increases, the number of ground plots required decreases and the number of LiDAR plots increases proportionately (Figure 1). As the cost of LiDAR plots approaches the cost of ground plots, the optimal number of LiDAR plots asymptotically decreases while the optimal number of ground plots increases slightly.

To illustrate the break even point for LiDAR, the total cost was graphed for three coefficients of determination levels and a range of relative costs. For a coefficient of determination equal to 0.5 (like that obtained on the Lee Forest), the break even cost of LiDAR plots was 30%. For coefficients of determination equal to 0.7 or 0.9, the breakeven cost for LiDAR was 35% and 61%, respectively, for a 100,000 acre tract.

Figure 2. Total cost of a double sampling LiDAR cruise and a fixed plot ground cruise for the three coefficients of determination and a range of relative plot costs for a 100,000 acre tract.



Discussion

Currently, timber inventory using LiDAR is not cost effective on most acreage due to the high fixed cost associated with data collection. For large, remote tracts with limited accessibility where the cost of conducting a ground cruise would be higher, LiDAR could be cost effective. As LiDAR plot costs fall below 35% of ground plot costs, double-sampling with LiDAR becomes cost effective for coefficient of determination 0.7 or greater. As the use of LiDAR for forestry and other applications increases, costs should decrease. This, combined with additional research applying LiDAR to timber inventory, may improve coefficients of determination between LiDAR and ground plots allowing LiDAR to become a cost effective inventory method. If LiDAR data are already in place or obtained for a Digital Elevation Model, wildlife habitat management, or other applications for which three-dimensional vegetation structure is required, the marginal cost of extracting plots from the data is very low (Lefsky et al. 2002). In this case, LiDAR plots can be used to increase precision or reduce total costs of a forest inventory.

References

Dubayah, R.O., and J.B. Drake. 2000. LiDAR remote sensing for forestry. J. For. 98(6):44-46.

Johnson, E.W. 2000. Forest Sampling Desk Reference. CRC Press, Boca Raton, FL. p. 985.

Lefsky, M.A., W.B. Cohen, S.A. Acker, G. Parker, T.A. Spies, and D. Harding. 1999. LiDAR remote sensing of the canopy structure and biophysical properties of Douglas-fir westen hemlock forest. Remote Sensing of Environ. 70(3):339-361.

Lefsky, M.A., W.B.Cohen, G.G. Parker, and D.J. Harding. 2002. LiDAR remote sensing for ecosystem studies. Bioscience 52(1):19-31.

Magnussen, S., and P. Boudewyn. 1998. Derivations of stand heights from airborne laser scanner data with canopy-based quartile estimators. Can. J. For. Res. 28(7):1016-1031.

Means, J.E., S.A. Acker, J.B. Fitts, M. Renslow, L. Emerson, and C.J. Hendrix. 2000. Predicting forest stand characteristics with airborne scanning LiDAR. Photo. Eng. and Remote Sensing 66(11):1367-1371.

Means, J.E., S.A. Acker, D.J. Harding, J.B. Blair, M.A. Lefsky, W.B. Cohen, M.E. Harmon, and W.A. McKee. 1999. Use of large-footprint scanning airborne LiDAR to estimate forest stand characteristics in the western cascades of Oregon. Remote Sensing of Environ. 67(3):298-308.

Nelson, R., W. Krabill, and J. Tonelli. 1988. Estimating forest biomass and volume using airborne laser data. Remote Sensing of Environ. 24(2):247-267.

Nilsson, M. 1996. Estimation of tree heights and stand volume using an airborne LiDAR system. Remote Sensing of Environ. 56(1):1-7.

Parker, R.C., and D.L. Evans. 2004. An application of LiDAR in a double-sample forest inventory. West. J. Appl. For. 19(2):95-101

Parker, R.C., and P.A. Glass. 2003. High versus low density LiDAR in double-sample forest inventory. Mississippi State University, Forest and Wildlife Research Center Paper No. 248, Mississippi State, Mississippi 39762.

Parker, R.C., and A.L. Mitchel. 2004. Smoothed versus unsmoothed LiDAR in double-sample forest inventory. Mississippi State University, Forest and Wildlife Research Center Paper No. 255, Mississippi State, Mississippi 39762.

A GIS approach to determining efficient timber transportation routes

Prabudhda Dahal[5] and Sayeed R. Mehmood[6]

Abstract

Timber transportation cost is a function of factors such as travel distance and road characteristics. In typical harvesting operation, transportation cost is estimated to account for 30 to 50 percent of the total costs. Two routes – the shortest in terms of distance traveled (L-route), and fastest in terms of time taken to travel (T-route) were compared for 30 actual timber sales that occurred in various parts of Arkansas. Both the source and destination of the timber were identified and mapped in ArcView GIS. Network Analyst in ArcView and ESRI ArcMap were used to determine travel time and distance of the routes. Travel time for L- routes was higher with an average difference of 9.69 (maximum 27.62) minutes than the travel time for T-routes for more than 60% of the cases. Gas consumption was significantly higher for L-routes with average difference of 0.82 (maximum 2.35) gallons. The study showed that the determination of appropriate timber transportation route will minimize cost and increase efficiency.

Key Words: Timber transportation, cost minimization, economic application of GIS.

[5]Graduate Research Assistant, School of Forest Resources, University of Arkansas at Monticello, P.O. Box 3468, Monticello, AR, 71656. prabdahal@yahoo.com. (870) 460-9976.

[6]Assistant Professor, School of Forest Resources, University of Arkansas at Monticello, P.O. Box 3468, Monticello, AR 71656. mehmood@uamont.edu. (870) 460-1894

A GIS approach to determining efficient timber transportation routes

Introduction

Costs are direct contributors to the price of a product. In addition, various other market attributes and their interactions determine product prices. These market forces are often beyond the control of an industry. Especially to a forest land owner, with an extended time lag between his investment decision and returns from the investment, it is difficult, if not impossible, to predict market conditions with precision.

Increased operation cost increases product price, *ceteris paribus*. One of the significant price contributors in forest industry is the transportation cost. For a typical harvesting operation, transportation cost is estimated to account for 30 to 50 percent of harvesting cost (Miyata and others 1986). Timber extracted from a tract is transported to varying distances and under varying road conditions. Some forest tracts are close to roads and therefore the hauling time, and consequently the hauling cost is low. Timber from other tracts requires hauling to longer distances making transportation more costly. In addition to the distance, roads also vary in surface characteristics and attributes such as speed limit. This results in variation in travel time. Travel time also depends on elevation and slope of roads. Presumably, more energy and cost is required to travel per unit distance on a road with uneven surface than on one which is even. Transportation cost is a function of factors such as distance of travel, type and specification of the truck used, road type, terrain characteristics, logging condition (wet or dry), and driving techniques (Grooves and others 1987; Nader 1991; Fuel economy 2003). However, time is one of the most important factors affecting hauling cost per unit distance because it directly affects fuel consumed, maintenance cost, and wages and rents of operator and equipment.

Timber transportation has a far reaching cost implication. It is likely to cause variation in the price paid by different mills or buyers for the same tract. Given two mills, one physically closer to a tract than the other, the mill farther away may not be able to pay as much as the mill that is physically closer because of the additional cost of transportation. Timber harvest operation includes assignment of roads, skid trails and landing zone locations. Traditionally, the assignment of landing zones and haulage routes in industry-owned lands in the southern United States is placed by operators who find the best way to take the timber out of the tract and to transport it (Kluender and others 2000). This is a subjective approach and the assignment of path may not be optimal. Determination of the optimal path for skidding and transporting timber from tract to mill will increase the efficiency by reducing the cost involved.

Efficient transportation route allocation requires tools for determining the best among the alternative routes. Geographical Information System (GIS) has been widely used to solve complex problems on various spatial scales and can be an effective tool to determine the most efficient transportation route. Determination of such route will reduce transportation cost, thus increasing efficiency. This study attempts to determine efficient routes for transporting timber from a number of tracts to different mills by using GIS.

Analysis model

A principal theme of economic studies is to attempt to maximize efficiency. When resources are scarce, efficient allocation is key in the list of priorities. Decision making as an activity in an optimization problem seeks objective such as cost minimization while satisfying various types of resource allocation problems (Miyata and others 1986). The basic premise of this study is to determine transportation routes based on cost minimization objective. For the purpose of this study, it is assumed that the cost will be minimized if the time taken to transport timber from a tract to a mill is minimized. Put another way, time is being used as a proxy for cost. This approach is appropriate for two prominent reasons. First, earlier studies have shown that cost of operation decreases with the increasing speed of log truck used for transporting timber (Grooves and others 1987; Fuel economy 2003). This implies that the less time it takes to travel a unit distance, the lower the cost. Second, most of the wage and rent payments are based on time of operation. Therefore lesser the time taken, the cheaper is the operation.

The data

Thirty sawtimber sales that occurred in various parts of Arkansas were randomly selected from a list of about 400 timber sale data. Only sawtimber sales were chosen to make the tracking of destination (mill) easy. The data set contained information including timber characteristics, tract characteristics, tract location, buyers, bid prices etc. Sale area and location was mentioned in all timber sales with township, range and section specification. Tracts for sale were identified and digitized using point theme in ArcView 3.3. A new shapefile with all the 30 tracts was created. Destination mills were identified from the sale information and located using Arkansas wood industries directory. The mills were then mapped as point themes in ArcView 3.3. All the shapefiles were created in North American Datum (NAD) of 1927 datum and Universal Transverse Mercator (UTM) coordinate system Zone 15 North.

Road classification

A shapefile containing the road network of Arkansas was obtained from the GeoStor website (GeoStor 2003). The TIGER/Line map of the U.S. Census Bureau was used because of its database containing length for every road segment and a convenient road classification system. The road classification is called Census Feature Class Codes (CFCC), which is a three-character code. The first character is a letter describing the feature class, the second character is a number describing the major category; and the third character is a number describing the minor category. Feature class "A" is reserved for roads with numbers from "1" to "7" following the letter for various road types. Within each of these seven major categories, there are three to eight minor categories. Each major category corresponds to specific road classes such as limited access highways (usually interstates), primary roads (usually state highways with some access), secondary highways, streets etc. This information was used in the study to determine speed limits for each road class which was then used to calculate travel time for a section of each road that the log truck traveled. For the purpose of this study, only the major categories (one to seven) were used and speed limits were assigned (Table 1). These speed limits were obtained from a number of different sources including the Insurance Institute for Highway Safety (2003),

Table 1: Speed limit assigned to various road classes.

Road Classification	Road Description	Speed Limit (mph)
A1	Limited access highways, usually Interstates	65
A2	Primary road, usually State Highways with some access	55
A3	Secondary highways	50
A4	Streets	30
A5	Trails	20
A6	Special roads, commonly on/off ramps	10
A7	Other roads, including private roads like those in big condo complexes , etc	15

American Trucking Association (2003) websites, and personal observation of posted speed limits. Travel time for every section of road was determined using these speed limits. Two new fields were created in the attribute table of road network. The first field contained speed limits of each road section and the second contained travel time of each road section for the given speed limit.

Data analysis

The first step in comparing different routes for transporting timber is the identification of alternative routes. One of the approaches is to find the shortest route with the least accumulated distance in a road network. Another approach is to find the route that requires the least time to traverse. This study first identified routes based on each of the two approaches mentioned above. The analysis produced 60 routes, two for each of the 30 timber sales. These routes were then compared to determine which one was more efficient in fuel consumption and travel time. Route assignment was done by using Network Analyst program in ArcView 3.3. Shortest routes (L-route) were first determined using length of the road as the analysis parameter. This was followed by the determination of the fastest route (T-route) using travel time as the analysis parameter. For most of the sales, these routes were different (visually) and followed different segments of the road network (Figure 1). However, since these two routes used two different parameters (time and distance), direct comparison of the routes was not feasible. Therefore, time that would be required to travel the L-route was calculated in ArcMap by first identifying the road segment corresponding to the L-route, and then adding up the time to traverse each segment. Thus, there were two routes for each sale with two travel times, the time to travel L-route (LT) and the time to travel T-route (TT). Similarly, the total length of each of the T-routes was also calculated in ArcMap producing two road distances, the distance of L- route (LL) and the distance of T-route (TL). Per unit gas consumption was determined for both the routes.

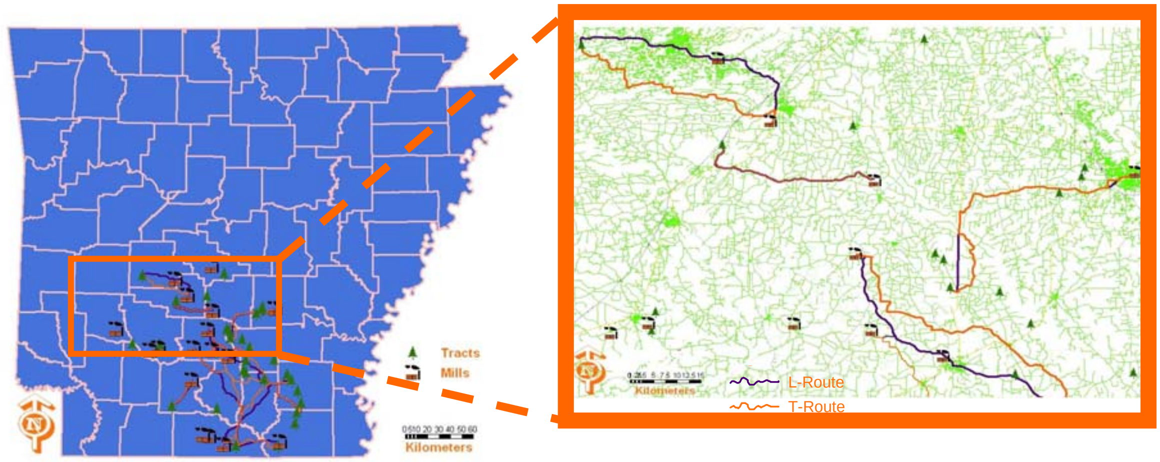


Figure 1: Timber tracts, mills and the L-route and T-routes for sawtimber sales in AR.

Gas consumption per mile for length of the road was determined using average gas mileage reported by Sloan 1984 and Nader 1991. Gas consumption for the time taken to travel was determined for a 400 brake horse power (bhp[7]) log truck using Sloan (1984) conversion factor. Length, time and gas consumption for both the routes were compared using pooled t-tests. Microsoft Excel was used for data recording and SAS system for windows V8 was used for statistical analysis.

Theory behind Network Analyst in ArcView

By definition, a network is a set of interconnected linear features through which people, goods, resources, or information can flow. A network data model in the GIS consists of such elements as links (arcs), nodes, stops, centers, and turns (Chang 2002). A link refers a segment separated by two nodes in a road network. Network nodes are the endpoints of line segments of the network and may represent intersections and interchanges of a road network. A turn is a transitional node from one arc (street) to another arc in a network. Stops are locations visited in a path. In this study, for example, the tract locations and the mill locations are stops. Network Analyst uses algorithms such as Djikstra algorithm to determine the least cost path with minimum cumulative impedance between nodes on a network (Chang 2002). The impedance could be time, length, or actual cost determined by adding various costs for traversing a segment.

[7] Log trucks may have slightly higher or lower BHP but the number used here is for ease of calculation and a normal variation in actual BHP is assumed. The formula is Gal/hr=BHP Truck * 0.0255

Results and discussion

Average distance of the L-route was 38.47 miles whereas the average distance of T-route was 40.65 miles. Average travel time of L-route was 26.17 minutes while the average travel time of T-route was 21.33 minutes. For all timber sales, average, maximum and minimum travel time for transporting timber through L-route was higher compared to the travel time for T-route (Table 2). The average difference in travel time for the two routes was 9.69 minutes with a maximum difference of 27.62 minutes. Gas consumption analysis produced similar result with higher average gas consumption for L-routes as compared to T-routes. Average difference in gas consumption for the two routes was 0.82 gallons with the highest difference of 2.35 gallons.

Table 2: Summary statistics of the distance and travel time of timber transportation routes.

	Observation	Average	Std Dev	Maximum	Minimum
L-route distance (LL in miles)	30	38.47	21.07	85.99	7.21
T-route distance (TL in miles)	30	40.65	22.33	91.16	7.51
L-route time (LT in minutes)	30	26.17	14.77	58.26	3.98
T-route time (TT in minutes)	30	21.33	11.75	44.45	3.68
Time difference (LT-TT in minutes)	30	9.69	8.91	27.62	0.00
LL fuel consumption (GLL in gallons)	30	4.45	2.51	9.90	0.68
TT gas consumption (GTT in gallons)	30	3.62	2.00	7.56	0.63
Gas consumption diff (GLL-GTT gallons)	30	0.82	0.76	2.35	0

T-test was conducted to test if the distance in L-route (LL) was statistically greater than or equal to the distance in the T-route (TL). P-value for this test was 0.6503. The result indicated that mean TL was not less than mean LL.

The hypothesis of constant variance of the two times gave a p-value of 0.2224 and failed to reject at α =.05. Therefore, a pooled t-test was performed to test if the mean time taken to transport timber through L-route was higher than the mean time taken to transport through T-route. Result of the t-test indicated that transporting timber through T-route was significantly faster than L-route at 90 percent level of significance. Gas consumption in the T-route was also significantly higher than in the L-route with a p-value 0.0002 (Table 3). Results indicated that the gas consumption was significantly higher for traveling through L-routes than traveling through T-routes.

Table 3: Results of t-tests of distance, time and gas consumption for the two routes

Test/ Hypothesis	T-statistic	Df	Pr > t
Test of Mean Distance: LL vs. LT H_0: Mean LL - Mean TL ≤ 0 H_a: Mean LL - Mean TL > 0	-0.388	58	0.6503
Test of Mean Time: LT vs. TT H_0: Mean LT - Mean TT ≤ 0 H_a: Mean LT - Mean TT > 0	1.406	58	0.0825
Test of Mean Gas Consumption: GLL vs. GTT H_0: Mean GLL - Mean GTT ≤ 0 H_a: Mean GLL - Mean GTT > 0	3.778	45.98	0.0002

Distance in the L-route was not significantly less than the distance in T-route. Yet, the travel time for transporting timber through L-route was greater than the time required for transporting through the T-route. Gas consumption was also significantly higher in the L-routes as compared to the T-routes. The analysis of alternative routes for transporting timber in a comparatively smaller spatial scale revealed that time of travel and gas consumption was significantly higher in the routes that are physically shortest. Transporting timber through shorter distances did not necessarily take less time as is evident in the results. This study confirms that there could be alternative routes that are more efficient and cost effective than physically shortest routes.

Increased time incurred in an operation increases consumption of gas. This is revealed by the comparison of gas consumption for two routes. Time is also the factor based on which the wages of operators, rents of equipments, and depreciation are determined. Increased time increases the cost of all these factors. For example, with the current average diesel price $1.70 per gallon, as much as $ 8 could be saved in gas alone, while transporting timber through a T-route instead of L-route. Given that log-trucks usually make a number of trips from a particular tract to the mill, total cost saved by assigning the least-cost route can thus be significantly higher.

Transportation time is dependent on such factors as driver performance, truck engine, road and tract conditions, weather, etc. For all the routes, and for all timber sales, these factors were held constant throughout the analysis. There were, however, some limitations of the study. The time calculated in this study ignored the time spent at stop lights, stop signs, and time lost when turning from one road section to another. When making turns, a truck is likely to slow down below the speed limit. A significant time is also lost in stop lights and signs when the route is through a congested road network such as cities. Therefore the time calculated here is somewhat underestimated. However, the time lost for both the routes should be more or less equal as both the routes use speed limit as the determining factor for time. Furthermore, the distance that would be traveled in these routes were not statistically different. This also provided a reason to believe that the time lost in stops would not be significantly different between these routes. As such, it was assumed that the total time lost in stops and turns is equal for both routes. Hence the difference in travel time is likely to remain the same even when this loss is ignored.

This study can be easily applied to include the quantity of timber transported and bid price paid for determining the net gain from log transportation and potential additional bid price the tract would entertain. The analysis can also be expanded to compare transportation costs for the closest mill from a tract versus the mill to which the timber was transported and examine the spatial price determination and potential bidding differential.

Literature Cited

American Trucking Association. 2003. Available online from http://www.truckline.com/safetynet/reference/speed_limit.html. Accessed on 2003 September 25.

Chang K. 2002. Introduction to geographic information systems. McGraw Hill: New York, NY. 348 p.

Fuel Economy. 2003. When it comes to fuel economy where's the beef. Available online from http://www.trucktires.com/library/publications/periodicals/RealAnswers/97V2Issue3/7v2i3fuel.htm. Accessed on 2003 October 27.

Grooves KW, Pearn GJ and Cunningham RB. 1987. Predicting logging truck travel times and estimating costs of log haulage using models. Australian Forestry 50(1): p54-61

GeoStor. 2003. Available online from http://www.cast.uark.edu/cast/geostor/ . Accessed online 2003 September 27.

Insurance Institute for Highway Safety. 2003. Available online from http://www.hwysafety.org/safety_facts/state_laws/speed_limit_laws.htm. Accessed 2003 September 27.

Kluender R, Weih R, Corrigan M and Pickett J. 2000. The use of geographic information system in harvest landing location for ground based skidding operations. Forest Product Journal 50 (3): 87-92.

Miyata ES, Zabinsky ZB, Rideout DB and Mann CN. 1986. Least-cost analysis of log transportation. Proceeding of the 1986 winter meeting of American Society of Agricultural Engineers, 1986 Dec 16-19, Chicago, IL. American Society of Agricultural Engineers, St. Joseph , MI. 28p.

Nader J. 1991. Measurement of the impact of driving technique on fuel consumption: preliminary results. Roads and Transportation, Technical Report; Forest Engineering Research Institute of Canada, Pointe Claire, Quebec. 6p.

Sloan H. 1984. The effect of truck design on road standards, road construction and timber hauling costs in southwest Virginia. In Petes PA and Luchok J, editors. Mountain Logging Symposium Proceedings, 1984 June 5-7, West Virginia University. p161-90.

Regional Changes in the Timber Resources of and Lumber Production in Pennsylvania

William G. Luppold [1]
USDA Forest Service

Matthew S. Bumgardner [2]
USDA Forest Service

[1] The authors are, respectively, Project Leader, USDA Forest Service, Northeastern Research Station, 241 Mercer Springs Road, Princeton, WV 24740. email wluppold@fs.fed.us 304.431.2770 (v): 304.431.2772 (fax)

[2] Forest Products Technologist, USDA Forest Service, Northeastern Research Station, 241 Mercer Springs Road, Princeton, WV 24740. email mbumgardner@fs.fed.us 304.431.2707 (v): 304.431.2772 (fax)

Regional Changes in the Timber Resources of and Lumber Production in Pennsylvania

Abstract

In this study we examine regional differences in the hardwood timber resources of Pennsylvania and explain how the combined changes in this resource and in lumber prices have influenced regional lumber production. Isolation of these relationships is important because shifts in lumber production affect harvesting levels and harvesting activity influences long-term forest composition and structure. We define three hardwood regions in Pennsylvania based on forest composition and present a chronology of regional changes in sawtimber volumes, sawtimber composition, and lumber production. Regional changes in hardwood lumber production are related to fluctuation in the inflation-adjusted price of lumber from 1970 to1999. We found that regional changes in lumber production are influenced by a combination of variations in interspecies price and regional changes in species composition.

Key Words – Hardwood, sawmill, sawtimber

Introduction

In 2002, Pennsylvania contained nearly 78 billion board feet of hardwood sawtimber (McWilliams et al. 2003) or approximately 7 percent of the estimated eastern U.S. inventory (Smith et al. 2001). More than 30 percent of this timber consists of three species with high current market values: black cherry, hard maple, and northern red oak. Pennsylvania's forests also contain large quantities of other commercially important species such as white oak, black oak, ash, red maple, and yellow-poplar. Still, the composition of this forest varies considerably when the state is examined from east to west and north to south (Alerich 1993).

Pennsylvania's timber resource has been dynamic with respect to volume and composition. Sawtimber volume has tripled since 1965, but the rate of growth has been greatest in the northern and western portions of the state (Table 1). The composition of Pennsylvania's forest also has been changing as selective cutting over the last 70 years has contributed to increased relative volumes of shade tolerant species such as red and sugar maple (Table 2).

Table 1 – Changes in sawtimber inventory (hardwood and softwood) in Pennsylvania by survey unit, 1965 to 200

Survey Unit	1965[a]	1978[b]	1989[b]	2002[c]	Percent Change[d]
	-----million board feet (International log scale)------				
Western	3,378	6,770	10,024	11,583	243
Southwestern	2,627	4,401	5,358	7,152	172
North-central	4,503	8,362	11,093	15,307	240
Allegheny	6,700	12,123	18,247	24,753	269
Northeastern	1,397	3,304	5,121	5,817	316
South-central	3,345	5,377	6,175	8,608	157
Pocono	2,193	3,273	5,164	6,362	190

Southeastern	2,126	4,476	5,536	6,651	213
Total[e]	26,269	48,087	66,718	86,235	228

[a] Developed from Ferguson (1968)
[b] Developed from Alerich (1993)
[c] Developed using USDA Forest Service (2004)
[d] For years 1965 to 2002
[e] May not be the sum of units due to of rounding error.

With its large volume of quality timber, the Keystone State has consistently been the nation's largest producer of hardwood lumber with production in excess of 1.1 billion board feet (U.S. Census Bur. 2001). Lumber production also has more than doubled between 1970 and 1999 (U.S. Census Bur. 1971, 2001). Luppold (1996) and Smith et al. (2003) reported that census data has consistently underestimated lumber production, though these alternative estimates and census indicate a similar rate of growth over the last 3 decades.

While hardwood lumber production has increased, the variation in value and growth of timber resources within Pennsylvania leads one to question whether changes in lumber production have been uniform across the state. Further, regional differences in species composition and the changing relative value of different hardwood species (interspecies pricing) over the last 30 to 50 years (Luppold and Prestemon 2003) may have influenced the amount of lumber produced in a given area or region. Understanding the interaction between the hardwood lumber market, the timber resource, and the timing and magnitude of harvesting is important since the latter can influence long-term forest composition and structure in a particular region.

Table 2 – Percent composition of Pennsylvania's sawtimber inventory by region, 1965 and 2002.[a]

Species	Northern[b]		Western[c]		Eastern[d]	
	1965[e]	2002[f]	1965	2002	1965	2002
Oaks						
Northern red oak	14.5	9.3	21.2	13.3	13.2	13.9
Other red oaks[g]	2.2	1.5	9.3	4.5	14.1	11.7
White oak	5.0	2.1	10.0	7.1	9.9	8.1
Chestnut oak	1.9	1.2	7.9	5.5	16.1	14.3
All oaks	**23.6**	**14.1**	**48.5**	**30.4**	**53.3**	**48.0**

Northern hardwoods						
Sugar maple	9.9	11.9	4.7	5.7	0.7	1.6
Red maple	14.1	23.8	8.6	15.6	5.4	7.8
Cherry	19.6	18.6	8.3	12.9	0.6	2.4
Birch	0.7	3.1	0.6	2.4	nr[h]	3.6
Beech	7.2	4.6	2.8	3.1	0.9	1.0
Basswood	2.7	2.0	0.6	2.0	nr	0.7
All northern hardwoods	**54.2**	**64.0**	**25.6**	**41.7**	**7.6**[i]	**17.1**
Other species						
Ash	5.9	7.1	2.1	3.0	3.0	5.9
Yellow-poplar	nr	2.0	3.3	6.0	8.9	10.7
Hickory	0.3	0.9	2.7	2.2	4.0	3.8
Softwoods	14.7	9.9	9.9	10.2	17.1	10.1

[a] Not all species are reported (i.e. percentages do not add to 100).
[b] Includes the Allegheny and northeastern FIA survey-units.
[c] Includes the western, southwestern, and north-central FIA survey-units.
[d] Includes the Pocono, south-central, and southeastern FIA survey-units.
[e] Developed from Ferguson (1968).
[f] Developed from USDA For. Serv. (2004).
[g] Includes black, scarlet, pin, and shingle oaks.
[h] Estimate not reported.
[i] Underestimates northern hardwood because many of these species were not reported in detail for survey-units in this region in 1965.

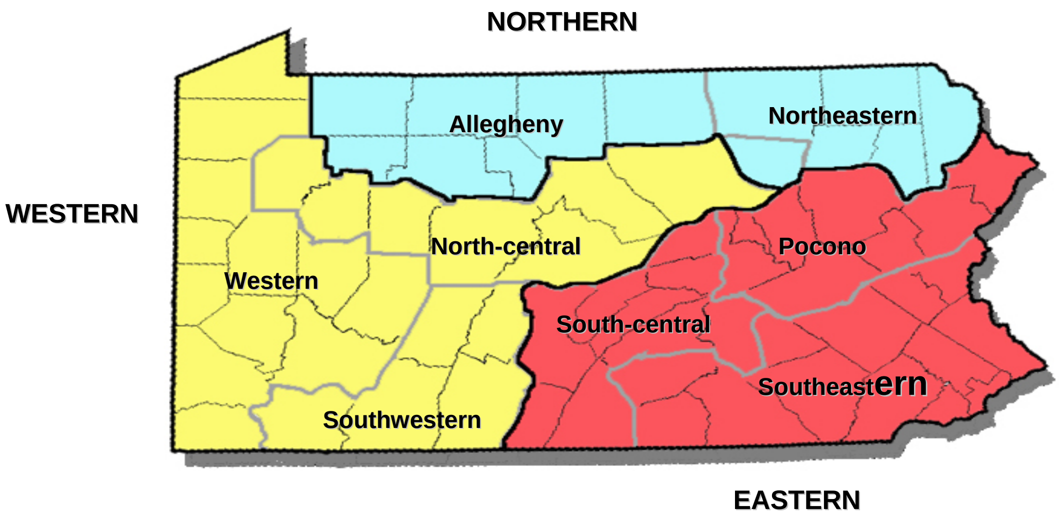
In this study we compare regional changes in Pennsylvania's timber resources to regional changes in lumber production and examine the influence of changing interspecies price, weighted for changing composition, on lumber production. Specifically, we group USDA Forest Service, Forest Inventory and Analysis (FIA) survey units into larger and more manageable regions, examine changes in lumber production between regions, and relate relative changes in lumber production to changes in regional price indexes weighted for changes in forest composition.

Defining Hardwood Regions for Pennsylvania

Pennsylvania contains eight FIA survey units. These units originally were defined in terms of physiographic features and county boundaries, but neighboring units often contain sawtimber resources with similar composition. The relatively large number but small size of many of these units made it impractical to examine the long-term relationship between the resource and the hardwood lumber industry at the survey unit level, so we combined them for this study using cluster analysis. This analysis was based on three variables: proportional sawtimber volumes of black cherry, all maples (red and sugar maple combined), and all oaks (chestnut, northern red, select white, and other oaks combined) for each survey unit in 1989

(Alerich 1993). Three readily identifiable clusters (northern, western, and eastern) emerged based on the average linkage method (Fig. 1). Other methods yielded identical clusters.

Figure 1. -- Regions of Pennsylvania analyzed and the Forest Service survey units aggregated to form these regions.



Regional Changes in Pennsylvania's Lumber Production

The earliest available estimates of hardwood lumber production for Pennsylvania were derived from a 1970 survey of the state's sawmill industry (Pennsylvania Dep. of Environ. Resour. 1971). Subsequent surveys of Pennsylvania's sawmilling industry were conducted in 1975, 1982, and 1986. The most recent production estimates were developed from a sawmill database developed by Smith et al. (2003). However, between 1970 and 1999 there have been two major swings in interspecies pricing associated with changing market preferences. In the 1970s and 1980s, the price of red and white oak surged while the price of maple declined. This corresponds to a period of increasing popularity of oak in furniture styles (Frye 1996). In the late 1980s, the price of red oak remained high while that of white oak began to decline relative to red oak. At the same time, the price of maple and cherry began to increase as styles incorporating closed-grain species increased in popularity. As a result, we decided to examine changes in Pennsylvania's lumber production for two periods: 1970 to 1986 (the red and white oak period) and 1986 to 1999 (the cherry, maple, and red oak period).

Table 3 presents a modified shift-share analysis for lumber production in the three regions of Pennsylvania for the two periods being examined. This analysis contrasts actual changes against expected changes assuming a consistent rate of growth in lumber production across all regions. A negative percentage difference indicates less than expected growth while a positive percentage indicates a greater than expected growth. The formulas are:

$$EC_{i,\,t,t+n} = (V_{t+n} - V_t) * P_{it}$$

and

$PD_{i,t,t+n} = (AC_{i,t,t+n} - EC_{i,t,t+n}) / AC_{i,t,t+n}$

Where:

$EC_{i,t,t+n}$ = Expected change in lumber production in region i between periods t and t+n

V_{t+n} = Lumber production in all regions in period t+n

V_t = Lumber production in all regions in period t

P_{it} = Proportion production volume in region i in period t

$PD_{i,t,t+n}$ = Percentage difference between actual and expected change in region i between periods t and t+n

$AC_{i,t,t+n}$ = Actual change in lumber production in region i between periods t and t+n

Table 3 – Shift-share analysis of regional lumber production (mmbf) in Pennsylvania 1970 to 1986 and 1986 to 1999.

Region	Northern	Western	Eastern	All regions
		1970 to 1986		
Production 1970[a]	143	329	134	606
Production 1986[b]	232	479	290	1001
Expected change	93	214	87	
Actual change	89	150	156	
Percentage difference	-4.3	-29.9	79.3	
		1986 to 1999		
Production 1986	232	479	290	1001
Production 1999[c]	375	618	318	1311
Expected change	72	148	90	
Actual change	143	139	28	
Percentage difference	98.6	-6.1	-68.9	

[a] Pennsylvania Department of Environmental Resources (1971); procedures developed by Luppold (1996).

[b] Pennsylvania Department of Environmental Resources (1986); procedures developed by Luppold (1996).

[c] Smith, et al. (2003).

In 1970, more than 54 percent of the lumber was produced in the western region, while the northern and eastern regions contained 24 percent and 22 percent of production, respectively (Table 3). Between 1970 and 1986, production increased by nearly 400 million board feet. However, the relative production in the western region decreased to 48 percent with most of the increased proportion shift accruing in the eastern region. In percentage difference, production in the northern region grew slightly less than expected, production in the western region was 30 percent less than expected, and production in the eastern region was 79 percent more than expected.

Between 1986 and 1999 lumber production increased by an additional 300 million board feet, mostly in the northern and western regions. In percentage difference, production in the western region grew slightly less than expected, production in the eastern region was 69 percent less than expected, and production in the northern region was 99 percent more than expected (Table 3).

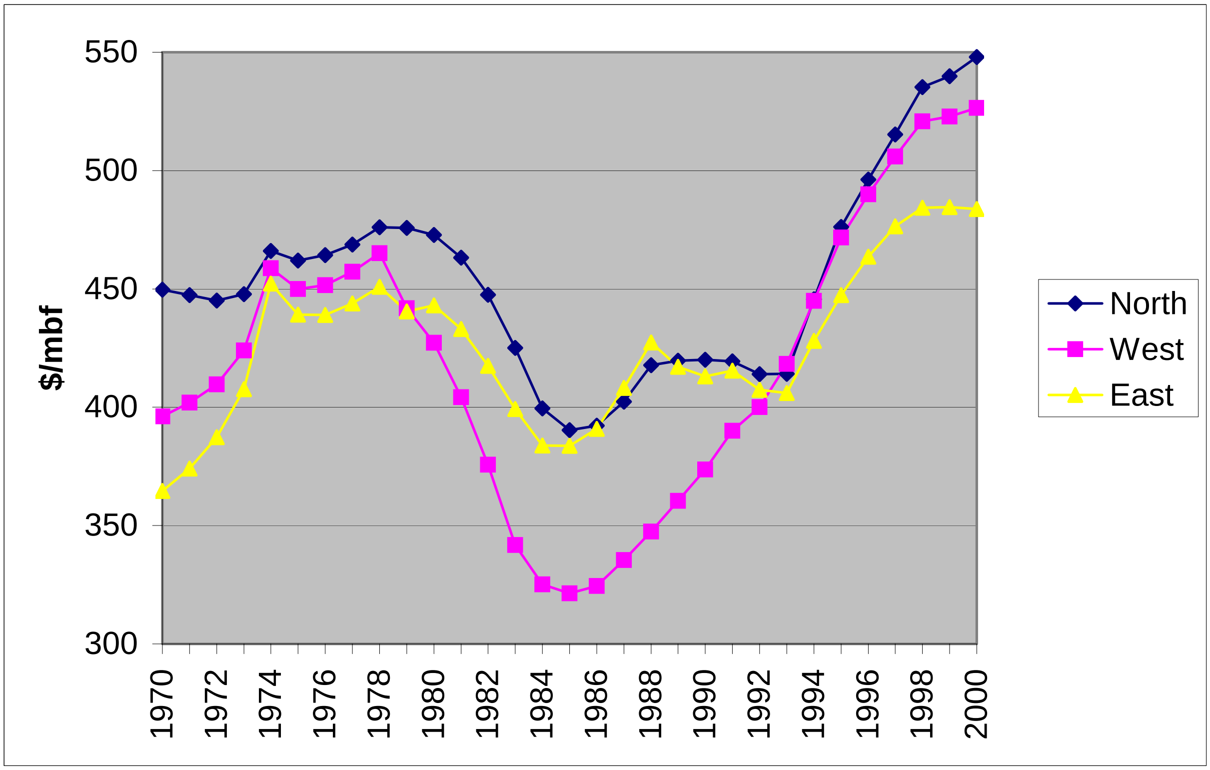
Influence of Lumber Prices on Regional Lumber Production

When examining the hardwood resource for the three timber regions of Pennsylvania, it was noted that the eastern region had the lowest rate of growth in sawtimber but the highest relative rate of growth in lumber production between 1970 and 1986. These two trends seem inconsistent given that the eastern region also contained the lowest percentage of select species as defined by Araman (1987). However, changes in relative lumber production also are influenced by changes in the relative interspecies price.

Figure 2 presents a 5-year moving average of deflated regional price series based on the composite prices of No. 1 Common (1C) lumber for the species in each region. A 5-year moving average was selected to reduce cyclical variation in lumber prices that could confound the analysis and because changes in lumber production are the result of both current and past prices (Luppold 1984). The price of 1C lumber was obtained for the Appalachian region for the first week in January from 1966 to 2000 (Hardwood Mar. Rep.1966 to 2000). Prices were deflated using the Producer's Price Index for all industrial commodities (U.S. Dep. of Labor 2003). Because regional forest composition has changed over time (Table 2), the price series for each region reflects changes in lumber prices for relative volumes of species in the regions and changes in relative composition of these species over time. These variable weights were developed yearly by extrapolating the proportional volumes of the hardwood species reported in Ferguson (1968), Alerich (1993), and USDA Forest Service (2004) for the inventory years 1965, 1978, 1989, and 2002, respectively.

Figure 2 reveals that lumber prices faced by sawmills in each region followed distinctly different trends. The northern region consistently had the highest or near highest price for the 30-year period. By contrast, prices in the western region began between those in the other regions, declined in the mid-1980s, and then increased steadily. Prices in the eastern region increased in the 1970s, and remained relatively high until the early 1990s, but have since lagged behind those in the other regions.

Figure 2. Five year moving average of deflated 1Common hardwood lumber price in the northern, western, and eastern regions of Pennsylvania weighted for changing sawtimber composition.



Changes in relative prices between 1970 and 1986 are reflected in the actual versus expected changes in the shift-share values in Table 3. During this period, the price of species increased in the eastern region, decreased in the western region, and showed the least variability in the northern region (Fig. 2). The large increase in relative prices in the eastern region resulted from an increase in the price of red and white oak (the most common species in this region). The large drop in relative price in the western region reflected declining prices for hard and soft maple and increased proportions of these species (Table 2). Compared to the western region, relative prices in the northern region remained high during this period due to continued high price for black cherry, a smaller decrease in relative oak volumes, and a smaller increase in relative maple volume. The smaller changes in composition in the northern region resulted in virtually no change in relative production.

In the late 1980s the price of red oak remained high, the price of white oak began to decline relative to red oak, and the price of maple and cherry began to increase. This caused relative production in the northern region to increase, virtually no change in relative production in the western region, and a decrease in relative production in the eastern region.

SUMMARY AND CONCLUSIONS

The hardwood sawtimber inventory in Pennsylvania more than tripled in volume between 1965 and 2002. Coincident with this increase has been a change in forest composition as proportional volumes of maples have increased. However, changes in sawtimber volume and forest composition have not been uniform across the state. The northern region has had the greatest increase in sawtimber volume and the largest proportional change from oaks to maples. By contrast, the eastern region has had the smallest increase in inventory and the smallest shift in forest composition.

Pennsylvania's sawmilling industry also has grown over the last 35 years as timber inventories have increased and prices for most species of hardwood lumber have cycled upward. However, the rate of growth in regional lumber production has not strictly coincided with increases in inventories, nor has it coincided with expectations with respect to timber quality. Between 1970 and 1986, lumber production more than doubled in the eastern region, even though this region had the least relative increase in sawtimber inventory and the lowest proportion of select species. However, after 1986, production in the northern and western regions grew while production in the eastern region remained nearly constant. The reason for this is that lumber production is influenced not only by changes in interspecies pricing but also by changes in forest composition.

Literature Cited

Alerich, C.L. 1993. Forest statistics for Pennsylvania--1978 and 1989. USDA For. Serv. Res. Bull. NE-126. 244 p.

Araman, P.A. 1987. Eastern United States hardwood sawtimber resources and export potential. P. 127-134 in Proc. Southern Forest Economics Workers and Mid-West Forest Economists Symp.

Ferguson, R. H. 1968. The timber resources of Pennsylvania. USDA For. Serv. Res. Bull. NE-8. 147p.

Frye, L.R. 1996. The most popular furniture woods: the historical perspective. Wood and Wood Products Centennial 1896-1996. 100(14): 304-307.

Hardwood Market Report. 1966 to 2000. A. Lemsky (ed., 1966-1987), H. Jones (ed., 1987-2000). Memphis, TN.

Luppold, W.G. 1984. An econometric study of the U.S. hardwood lumber market. Forest Sci. 30(4): 1027-1038.

Luppold, W.G. 1996. Structural changes in the central Appalachian hardwood sawmilling industry. Wood and Fiber Sci. 28(3): 346-355.

Luppold, W.G. and J.P. Prestemon. 2003. Tests for long-run relationships in hardwood lumber prices. For. Sci. 49(6): 918-927.

McWilliams, W.H, C.A. Alerich, D.A. Devlin, A.J. Lister, T.W. Lister, S.L. Sterner, and J.A. Westfall 2003. Annual inventory report for Pennsylvania's results from the first three years. USDA For. Serv. Res. Bull. NE-159. 95 p.

Pennsylvania Department of Environmental Resources. 1971. Sawmill directory. PA. Dep. of Environ. Res., Harrisburg. 22 p.

Pennsylvania Department of Environmental Resources. 1986. Sawmill directory. PA. Dep. of Environ. Res., Harrisburg. Unnumb.

Smith, P.M**.,** W. Luppold, and S. Dasmohapatra. 2003. Estimating the size of the hardwood sawmill industry in Pennsylvania. Forest Prod. J. 53(6): 19-22.

Smith, W.B., J.S. Vissage, D.R. Darr, and R.M. Sheffield. 2001. Forest resources of the United States, 1997. USDA For. Serv. Gen. Tech. Rep. NC-219. 190 p.

USDA Forest Service. 2004. Forest inventory mapmaker Version 1.0 USDA Forest Service,. http://ncrs2.fs.fed.us/4801/fiadb/index.htm

USDC Census Bur. 1971. Lumber production and mill stocks 1970. U S Dept of Comm. Bur. of Census. MA24T(70). Washington, D.C.

USDC Census Bur. 2001. Lumber production and mill stocks 2000. U S Dept of Comm. Bur. of Census. MA321(00)-1. Washington, D.C.

U.S. Department of Labor. 2003. Producer price index internet address http://data.bls.gov/cgi-bin/surveymost?wp.

Forest2Market's On-line Timber Pricing Service

Presented at the
Southern Forest Economics Workshop
St. Augustine, Florida
March 15, 2004

Peter J. Stewart
President/CEO

Note about author: **PETER J. STEWART - President/CEO and Founder**
Pete is a 15-year veteran of the forest products industry. As President/CEO and founder of Forest2Market, Inc., he continues to take the lead in developing new products for the forest products industry. Prior to founding Forest2Market and developing the industry's first ever real time pricing service, he led the development of the industry's first web based forest inventory management and mapping system with his previous employer.

Prior to these leadership roles in technology, Pete was responsible for forest planning and harvest scheduling for $350 million of institutional forestland. He also was actively involved in many of the major southern timberland transactions between 1994 and 1999. Pete has a B.S. in Forestry from Texas A&M and a M.S. in Forest Economics from the University of Georgia.

Forest2Market (F2M) is an on-line timber transaction database for the US South. Formed in 2000, Forest2Market provides real time, transaction level stumpage data in 11 southern states. F2M has progressively added raw material pricing capabilities over the past four years. After launching its online stumpage pricing service in July 2000, F2M added delivered pricing capabilities by June 2001, a suite of publications by January 2002, culminating with its first chip pricing publication by April 2004.

The exponential data and customer growth has made F2M's pricing service the industry standard. Figure 1 describes growth in both market penetration and individual product prices over the first four years.

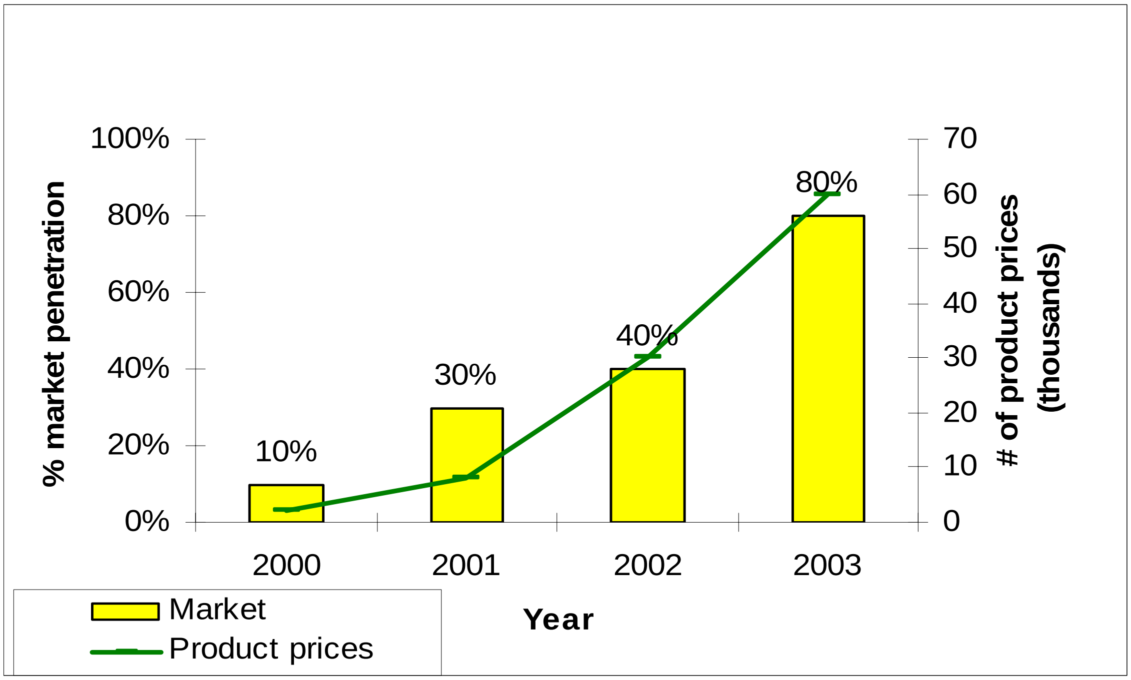


Figure 1 depicts market penetration and data growth from 2000 to 2003.

One of Forest2Market's base business premises is that the southern wood supply system is inherently inefficient. This inefficiency costs both buyers and sellers in real financial terms. Large trends driving industry changes are underway:

- Increasing demands by Wall Street on the forest products industry. The industry's chronically low returns have pushed forest products companies to consolidate and spin off low yielding timberland assets
- Quick and prominent rise in timberland as a financial vehicle
- Continued fragmentation of the individual private landowner base

These larger trends have focused the industry on new ways to understand the timber market in real and meaningful ways. Forest2Market is able to take advantage of these trends by:

- Catering to forest investment groups by providing clearer and more documented timber sales and market data
- Provide individual timberland owners high quality and timely timber price information
- Provide forest products companies reliable benchmarks, transfer price and supply agreement pricing data

One advantage that the US South has over many other world markets is that it is, from a market perspective, relatively stable and very large. There are approximately 67,000 annual, individual timber sales contracts in the US South, amounting to around 230 million tons of wood, with a value of about $6.2 billion.

The vast number of transactions and the poor price discovery (among other things) have led to dramatic price volatility. It is common for unit pricing on pulpwood to vary 200% in any one market, year over year. With little price discovery or mechanisms to better understand the mechanics of timber pricing, this volatility has been engrained and accepted in the industry for the last 30 years.

Additionally, the forest industry's wood supply chain has the classical characteristics of a manufacturing supply chain. It is very long, has large in-process inventories, many suppliers, many middle men, is capital intensive, has a large unknown supply base and poor price discovery.

A graphic depicting the supply chain and common returns on capital for the various participants along the chain demonstrates its length and complexity.

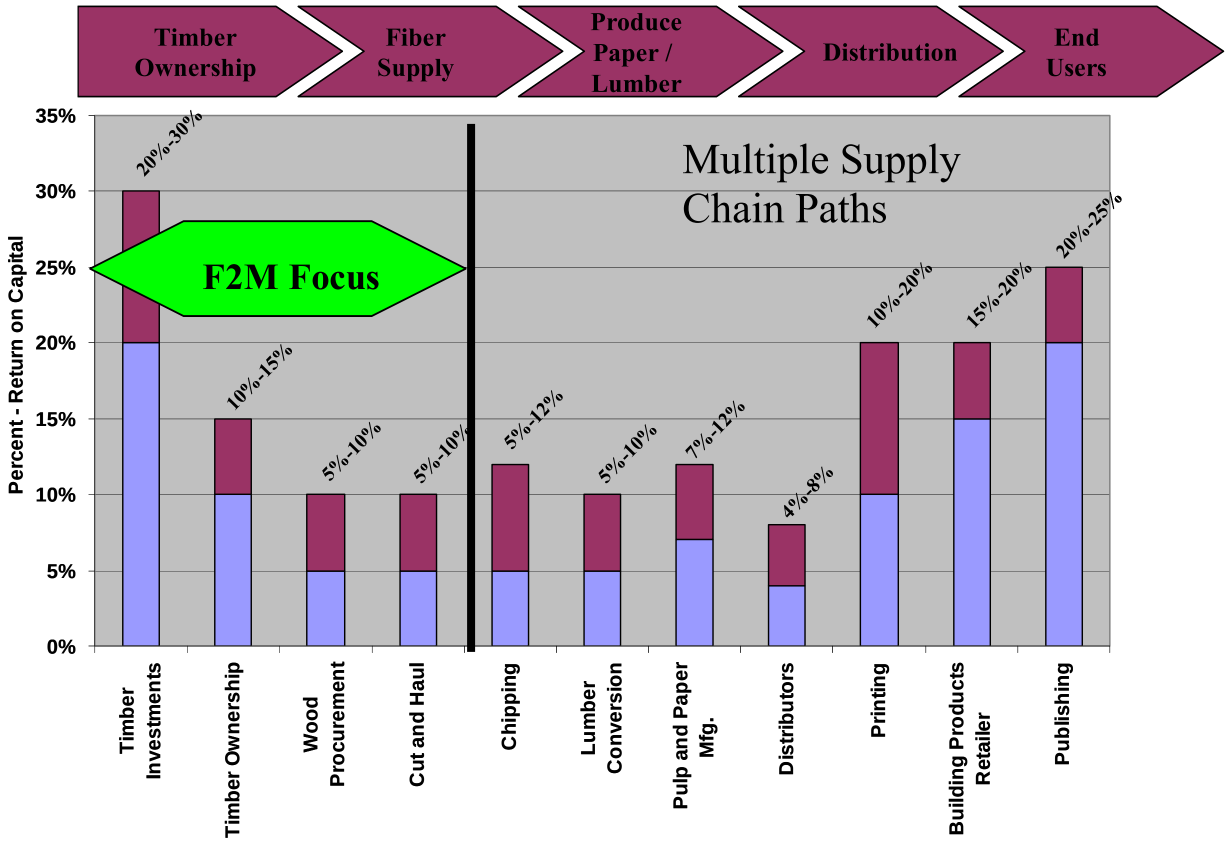


Figure 2 depicts the long and cumbersome forest products supply chain.

<u>Codification is Key to F2M Data</u>

One key to Forest2Market's success is the development of a codified transaction data collection system. Forest2Market collects 17 separate variables attendant to each timber sale. Each variable or attribute has a discrete set of choices (lists from a drop down menu). Each choice has a clear definition. For example, the "Access" attribute has five choices – one choice being "Tract access abuts a paved road," the second being, "Tract access abuts a dirt county road" and so on.

Typical data includes:

- Average diameter at breast height (DBH) by sawtimber product
- Accessibility
- Loggabliliy
- Quality
- Buyer type
- Seller type
- Price by product
- Volume by product
- Stand type
- Type of harvest

- Type of sale
- Location
- Rainfall and weather patterns

Forest2Market also verifies all data in five ways:

- Each customer (or data contributor) is pre-qualified by Forest2Market
- Each unit price goes through a variance test
- Duplicates are eliminated by a de-dup routine
- Sales are reviewed by a forester with 15 years of buying and selling experience
- Call backs and audits are performed

Another very important aspect of Forest2Market's data set is its shear breadth of data. Since October 2000, Forest2Market has collected over 18,000 individual timber sales equating to 60,000 individual product prices. The annual run rate is between 5,000 and 6,000 individual sales.

A snap shot of F2M's web site displays the breadth of timber sales data and the detail associated with each sale.


F2M Forest2Market
Solutions for the Forest and Wood Products Industries
September 24, 2003

Registered
Logout
Timber Sales Input
Timber Sales Query
Timber Sales Admin
Land Valuation
Contribution Reward Sheet
Indexes
Expert Commentary
Change Profile
Free
Find A Market
Find A Service Provider
Company Profiles
Pay On-Demand
Query Timber Prices

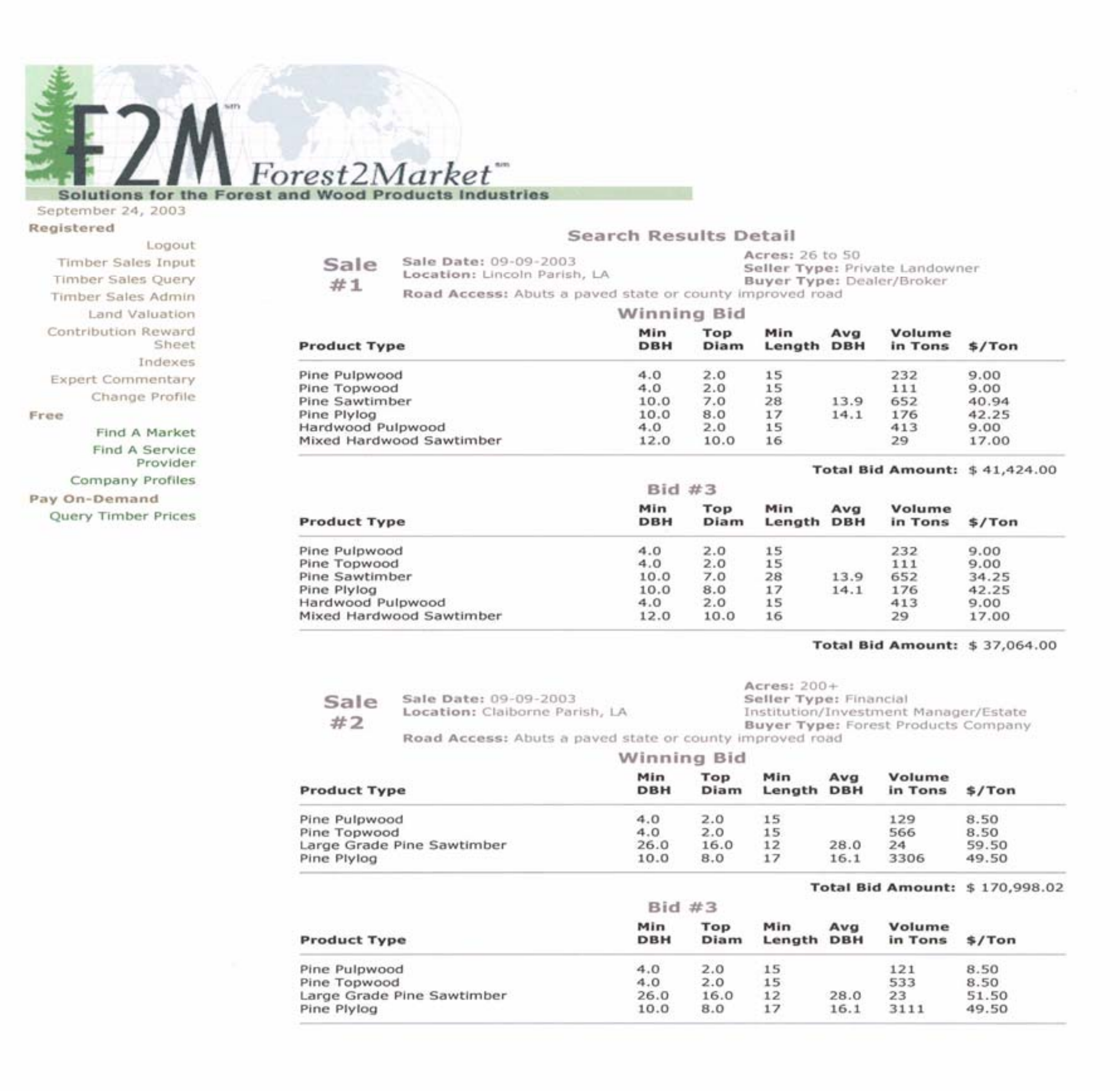
Search Results - Summary
Searching in ALL counties in the state of Louisiana
Date Range: 01/1/2003 - 09/24/2003

Product	W.Avg Price/Ton	W.Avg DBH	Sales	Volume (Tons)	Graph
Pine Pulpwood	$6.85	---	209	145696	View Graph
Pine Topwood	$7.90	---	194	91048	View Graph
Pine Chip n Saw	$18.61	9.5	9	4379	View Graph
Pine Sawtimber	$43.41	15.5	207	550808	View Graph
Large Grade Pine Sawtimber	$56.19	23.1	41	5575	View Graph
Large Pine Pole	$66.36	15.8	5	5050	View Graph
Small Pine Pole	$54.44	11.6	3	905	View Graph
Pine Plylog	$43.34	15.9	74	118402	View Graph
Pine Post	$6.66	---	2	4605	View Graph
Hardwood Pulpwood	$6.98	---	159	103323	View Graph
Hardwood Scragg / Cleatwood	$11.34	---	18	1899	View Graph
Mixed Hardwood Sawtimber	$19.06	---	100	41291	View Graph
Hard Hardwood Sawtimber	$30.87	---	15	7292	View Graph
Select Hardwood Sawtimber	$35.90	---	6	4729	View Graph

Search Again | View Details | Download Details

Home | Sitemap | Help | Contact Us | Privacy Statement | Legal
Copyright 2003 Forest2Market℠

Figure 3 is a summary table that depicts the breadth of data available on F2M's website.



F2M Forest2Market
Solutions for the Forest and Wood Products Industries
September 24, 2003

Registered
Logout
Timber Sales Input
Timber Sales Query
Timber Sales Admin
Land Valuation
Contribution Reward Sheet
Indexes
Expert Commentary
Change Profile

Free
Find A Market
Find A Service Provider
Company Profiles

Pay On-Demand
Query Timber Prices

Search Results Detail

Sale #1

Sale Date: 09-09-2003
Location: Lincoln Parish, LA
Road Access: Abuts a paved state or county improved road
Acres: 26 to 50
Seller Type: Private Landowner
Buyer Type: Dealer/Broker

Winning Bid

Product Type	Min DBH	Top Diam	Min Length	Avg DBH	Volume in Tons	$/Ton
Pine Pulpwood	4.0	2.0	15		232	9.00
Pine Topwood	4.0	2.0	15		111	9.00
Pine Sawtimber	10.0	7.0	28	13.9	652	40.94
Pine Plylog	10.0	8.0	17	14.1	176	42.25
Hardwood Pulpwood	4.0	2.0	15		413	9.00
Mixed Hardwood Sawtimber	12.0	10.0	16		29	17.00

Total Bid Amount: $ 41,424.00

Bid #3

Product Type	Min DBH	Top Diam	Min Length	Avg DBH	Volume in Tons	$/Ton
Pine Pulpwood	4.0	2.0	15		232	9.00
Pine Topwood	4.0	2.0	15		111	9.00
Pine Sawtimber	10.0	7.0	28	13.9	652	34.25
Pine Plylog	10.0	8.0	17	14.1	176	42.25
Hardwood Pulpwood	4.0	2.0	15		413	9.00
Mixed Hardwood Sawtimber	12.0	10.0	16		29	17.00

Total Bid Amount: $ 37,064.00

Sale #2

Sale Date: 09-09-2003
Location: Claiborne Parish, LA
Road Access: Abuts a paved state or county improved road
Acres: 200+
Seller Type: Financial Institution/Investment Manager/Estate
Buyer Type: Forest Products Company

Winning Bid

Product Type	Min DBH	Top Diam	Min Length	Avg DBH	Volume in Tons	$/Ton
Pine Pulpwood	4.0	2.0	15		129	8.50
Pine Topwood	4.0	2.0	15		566	8.50
Large Grade Pine Sawtimber	26.0	16.0	12	28.0	24	59.50
Pine Plylog	10.0	8.0	17	16.1	3306	49.50

Total Bid Amount: $ 170,998.02

Bid #3

Product Type	Min DBH	Top Diam	Min Length	Avg DBH	Volume in Tons	$/Ton
Pine Pulpwood	4.0	2.0	15		121	8.50
Pine Topwood	4.0	2.0	15		533	8.50
Large Grade Pine Sawtimber	26.0	16.0	12	28.0	23	51.50
Pine Plylog	10.0	8.0	17	16.1	3111	49.50

Figure 4 shows detailed comparable timber sales available on the F2M website.

<u>F2M Data Describes the Market in New Ways</u>

Forest2Market's detailed and rigid collection methodology allows for a deeper understanding of the market, particularly the sawtimber market.

A simple example demonstrates how better data brings clarity to the market structure. Forest2Market collects average DBH on each sawtimber product. A simple scatter diagram comparing average DBH to price per ton shows a very strong correlation. This is a relationship that is well known in the industry, but often very difficult to quantify.

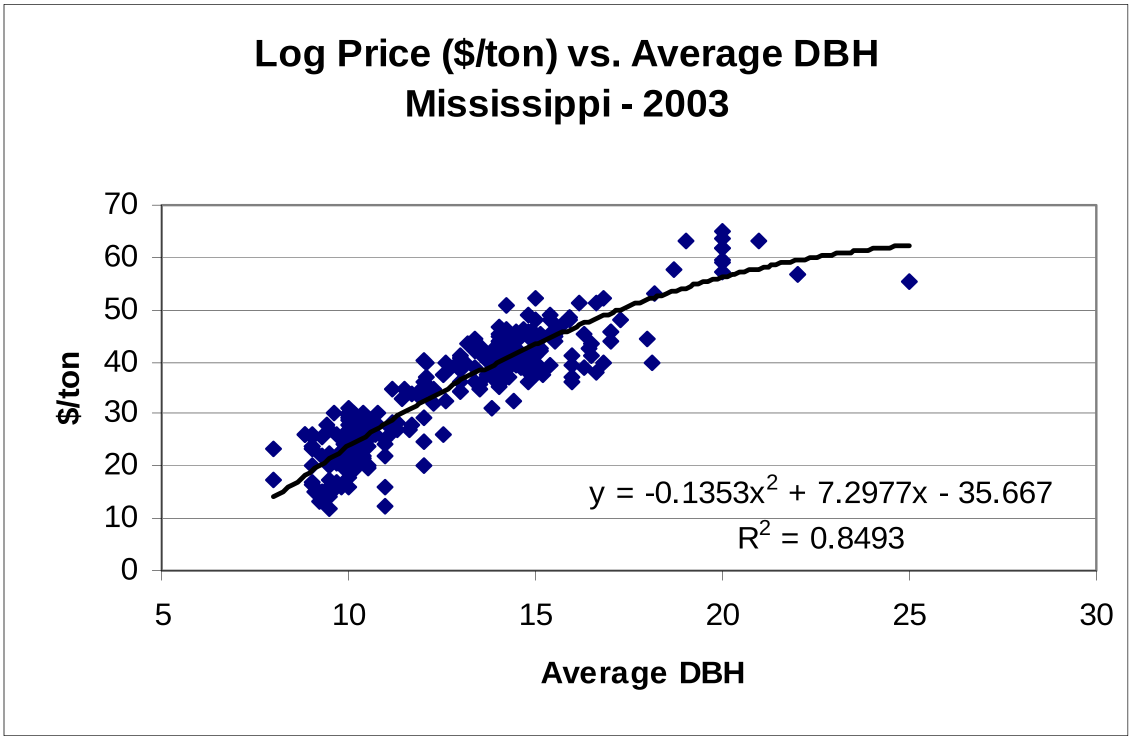


Figure 5 depicts the relationship between tree size and price per ton. It is clear that this relationship is strong.

Even though this relationship speaks to the influence that tree size has on price, a deeper look reveals the true market structure for pine sawtimber.

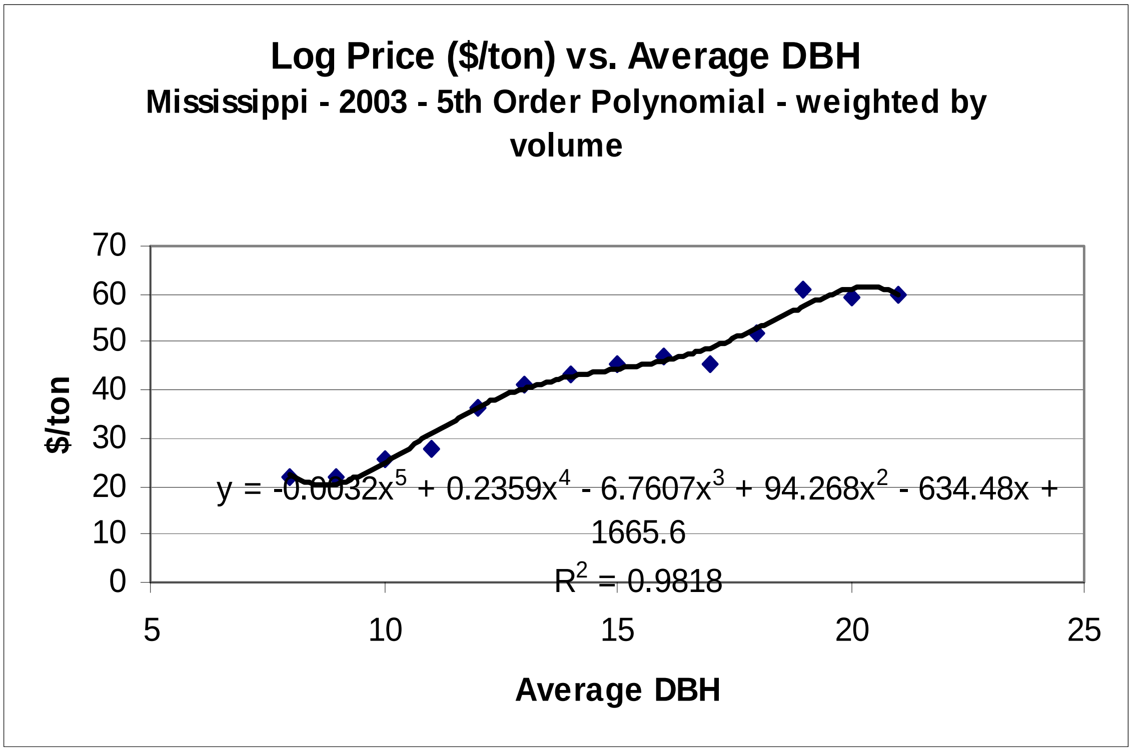


Figure 6 shows that by weighting prices by DBH and applying a higher order polynomial, the true structure of the southern pine market is revealed.

By taking a simple weighted average of price by DBH, a true understanding of the market structure and how each product is priced according to size is revealed. Notice that small chip n saw pricing is almost flat between 7.5-inches and 9.5-inches DBH. Logs in this size range are composed of marginal chip n saw from pine thinnings. It is clear that the market does not differentiate price between these size ranges. Chip n saw only starts picking up value when it reaches 10-inches DBH. Notice also how prices flatten through the true sawtimber product class (13" to 16"), after which prices elevate and eventually flatten.

This is the typical market structure for pine sawtimber in the US South.

Practical Industry Applications of F2M Data

F2M data is being used in many practical industry situations. These include:

- Deeper and meaningful price discovery
- Comparative Sales Analysis
  - Appraisals
  - Timber bids
- Comparative/Competitive Analysis
- Supply agreement pricing
- Transfer pricing
- Benchmarking

One of the most straightforward and practical applications of Forest2Market's data is price benchmarking. Since F2M can demonstrate that for every inch change in DBH, there is a corresponding \$2-3/ton change in unit price (see Figures 5 & 6) and that average DBH in any market can swing 2-4 inches from summer to winter, any benchmark that does not incorporate size changes is flawed. In many cases, changes in tree size from period to period clouds the true market trends. It is F2M's firm belief that the validity of historically commonly accepted industry trend data can be called into question because the sawtimber size issue was not addressed.

As such, F2M has developed the concept of a 14-inch DBH benchmark for pine sawtimber and a 10-inch DBH benchmark for pine chip n saw. F2M chose 14-inch DBH for pine sawtimber because the weighted average DBH of pine sawtimber in the US South is 14.1 inches. While the weighted average DBH of pine chip n saw in the US South is 10.2 inches – thus the 10-inch chip n saw benchmark.

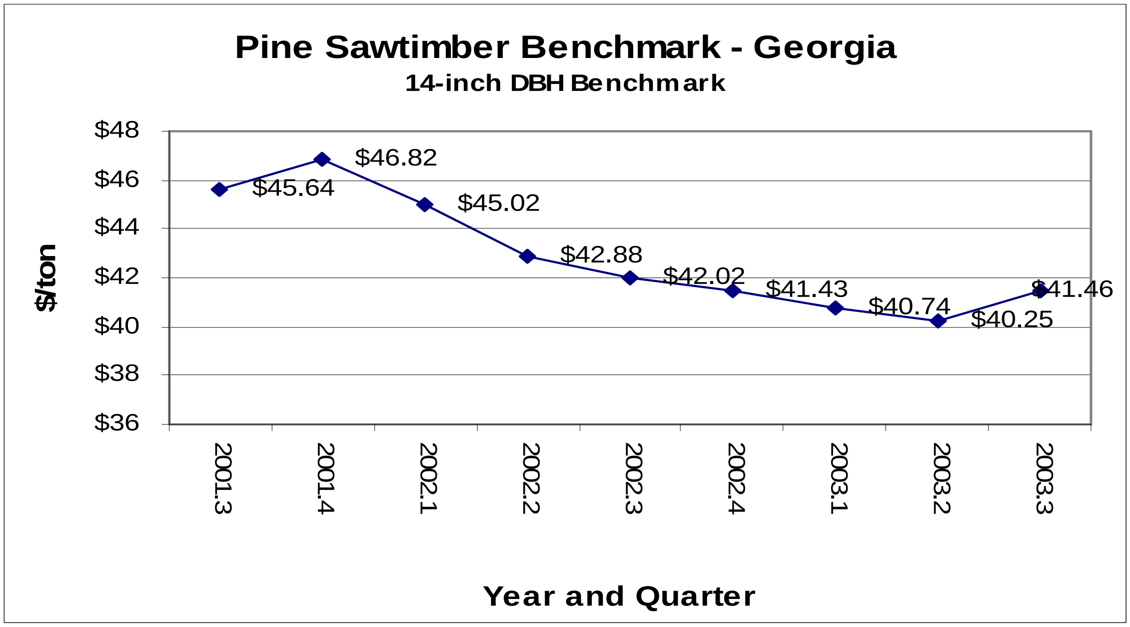


Figure 7 depicts Forest2Market's 14-inch DBH sawtimber benchmark for Georgia.

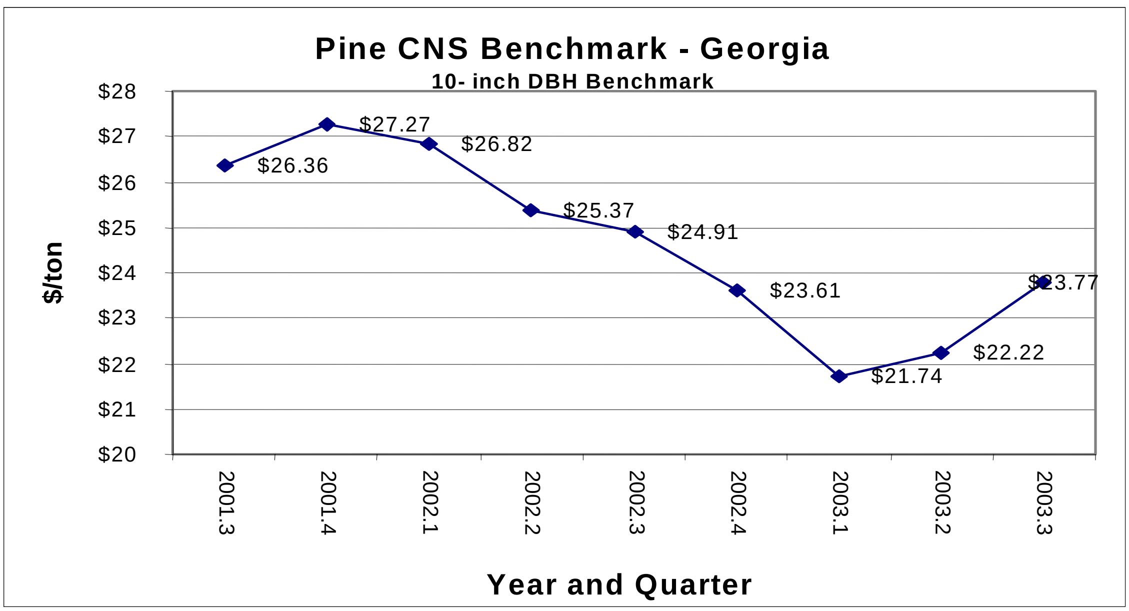


Figure 8 depicts Forest2Market's 10" DBH chip n saw benchmark for Georgia.

Practical Research Applications

For the academic community, Forest2Market's data has some very practical research applications. The first is better economic modeling through:

- Statistically sound and high quality data
- Data that is geographically appropriate (down to a county level)

- Consistent trend data (benchmarks)
- Expert and professional staff
- Data that is delivered in an MS-Excel format for easy data handling

The second application of Forest2Market's data is better market segmentation. This allows researchers to:

- Segment data to the county level
- Match timber price data with mill drain data
- Compare and contrast costs across market basins
- Compare pricing patterns and trends to consumption patterns
- Compare pricing to timber supply patterns

The third research aspect - where F2M's data is perfectly positioned - is to provide base data for research into new financial products for the industry, including modern risk management tools such as Options and Futures. Since Forest2Market's data is transaction based, price risk can be assigned to discrete markets over discrete time periods. This allows researchers the ability to assign risk to option pricing models (e.g. Black-Scholes).

Conclusions

Forest2Market's timber data service provides on-line access to comparable timber sales data in the US South. This data can be accessed down to the county level. Forest2Market has developed a series of checks and balances to assure data quality and provides a breadth of sales never available before.

The practical and research implications of this data are numerous. Already embraced as a standard in the industry, Forest2Market's data provides the deepest level of market understanding available.

Forest2Market provides academic discounts and a free college student program to southern forestry schools.

VALUING PERFECT KNOWLEDGE IN TIMBER MANAGEMENT

Matthew H. Pelkki[8]
Associate Professor, University of Arkansas-Monticello

ABSTRACT

Timber stumpage prices exhibit considerable volatility, which has a tremendous effect on the long-term returns associated with growing timber. Predicting trends in the market occupies a great deal of effort in forest economics research and practice. But what are the possible gains from having the ability to predict the future of timber stumpage markets? On the stand-level, forward-recursive dynamic programming can be used to estimate the value of perfect knowledge of future timber stumpage prices when those prices are simulated with a stochastic price function. Through repeated simulations, estimations of the value of market knowledge or market possibility knowledge can be made. This methodology can be used to explore the value of predicting future timber prices under situations where mean temporal price increase and variance parameters in a stochastic price function are modeled to represent differing long-term projections about U.S. stumpage markets. It can also be used to assess landowner risk to levels of return that are unacceptable.

Key words: dynamic programming, stochastic prices, risk

[8] Associate Professor, University of Arkansas-Monticello, School of Forest Resources, P.O. Box 3468, Monticello, AR 71656. pelkki@uamont.edu. (870) 460-1949 (v); (870) 460-1092 (fax).

VALUING PERFECT KNOWLEDGE IN TIMBER MANAGEMENT

INTRODUCTION

Solutions to the optimal rotation length and stand density problem are important for non-industrial landowners because a single stand may represent their entire forest; it is also important in a forest-wide setting as optimal solutions for various rotation ages provide economically efficient alternatives for forestwide optimization techniques. Dynamic programming is one method that has been used to solve rotation length and density problems (Schreuder 1971, Brodie and Kao 1979, Arthaud and Klemperer 1988, Pelkki 1998).

Complicating any harvest decision is the uncertainty regarding future timber prices. Timber prices are generally acknowledged as the single most important factor affecting the return to capital in a timber investment (Vardaman 1989), but timber prices are also the most difficult to predict. Although timber prices are temporally correlated (Haight and Holmes 1991, Yin and Newman 1995), accurately predicting long-term timber prices is difficult task because timber price changes are tied to economic growth, seasonal weather patterns, environmental management, and human behavior (Yoshimoto and Shoji 2002). In fact, historical data shows that pine sawtimber stumpage prices in the Southeast United States can fluctuate by as much as 60% in one year (LDA&F 2003).

Applying deterministic solutions in a stochastic environment will lead to suboptimal solutions, and Yoshimoto and Shoji (2002) stress the importance of correctly specifying the stochastic price functions as a perquisite to obtaining useful results. Use of dynamic programming with stochastic prices has been successful in theory (Brazee and Bulte 2000), and the results found that expected thinning ages decrease while harvest (rotation) age increases. Teeter and Caulfield (1991) determined thinning regimes in even-aged loblolly pine stands; however, rotation length was fixed.

This study will examine results from repeated forward-recursive dynamic programming simulations under a stochastic price functions. In effect, the management regimes resulting from such a simulation have perfect knowledge of all timber price changes. Thinning strategies and rotation lengths will be analyzed and "good" rotation strategies based on the results will be simulated under the same stochastic price functions to determine the difference between returns under perfect knowledge, knowledge of the market parameters (market knowledge), and knowledge of only possible future market conditions (market possibility knowledge).

METHODS

Forward-recursive dynamic programming was employed to generate the optimal rotation schedule for each simulation in this study. The objective function can be defined mathematically in equation 1:

$$f_N(Y_N) = \sum_{n=0}^{N} r_n(T_n) \tag{1}$$

Where the variables and functions can be defined as:

T_n – a management action with resulting physical outputs at stage n

r_n -- is the net present value of the action T_n

Y_N – is the ending state for the problem, in this case, the final harvest is a clearfelling operation.

The objective function (1) is subject to several constraints. Equation 2 links state Y_n to a state in a future stage (Y_{n+1}) through the growth function (G_{n+1}) and the management action (T_n).

$$Y_n + G_{n+1}(Y_n) - T_{n+1} = Y_{n+1} \qquad \text{for n = 0, 1, 2, 3, …. N-1} \qquad (2)$$

Equations three and four define a state in a stage prior to any management activity (X_n) and also define that the final action (T_N) is a clearfelling harvest.

$$X_n - T_n = Y_n \qquad (3)$$

$$X_N - T_N = Y_N = 0 \qquad (4)$$

Finally, a recursive equation links management policies sequentially to form an optimal policy or set of management actions over an entire rotation:

$$f_n(Y_n) = \max_{(Y_{n-1}, T_n)} \left[r(X_n, T_n) + f_{n-1}(Y_{n-1}) \right] \qquad (5)$$

Implementation of forward-recursive dynamic programming requires several elements. Stand age is the most straightforward choice for the stage variable. In this study, the stage (growth) interval was set at two years. State variables or descriptors for density included number of trees per acre (TPA) and cubic foot volume per acre (ft.^{3}/ac). The neighborhoods or intervals for these variables were set at $\pm$ 10 TPA and $\pm$ 10 ft.^{3}/ac. A third state descriptor, number of thinnings (NTh) was added to the formulation to allow the total number of thinnings in an optimal strategy to be constrained (three or less) as well as preventing the comparison of two states with different numbers of thinnings.

The initial stage and state condition was a 10-year old shortleaf pine plantation tree list taken from Smalley and Bailey (1974) for a plantation of 500 trees per acre with a site index of 82 feet at 50 years. While multiple starting conditions could have been considered, the purpose of this research was to study the impacts of stochastic price functions on dynamic programming results, and previous research (Pelkki 1997) had indicated that this planting density was optimal. Stand establishment costs were \$131 per acre and based on South-wide average costs for planting and site preparation (Dubois et al. 2003).

An individual-tree growth model (Miner et al. 1987) was used to project stand states forward in time, representing the function $G_{n+1}()$ from equation 2. The model used a parameter set fit for the Central United States.

Thinning strategies that could be part of any overall policy included thinning from below (TfB), thinning from above (TfA), thinning from above and below (TaB), and mechanical row thinning (TM). These four thinning strategies could be applied at levels removing between 10% and 50% of the initial state's (X_n) basal area, in 10% increments. Finally, management actions of clearcutting (CC) and "do nothing" (DN) could also applied to each state (T_n).

The return function, $r_n()$ was a net present value equation applied to the physical outputs from each action T_n. Volume equations (Miner et al. 1987) converted the individual trees projected by the growth model into sawtimber and pulpwood volumes, to which stumpage prices were applied and then a present value was calculated as shown in equation 6.

$$r_n(T_n) = \frac{P_n \times V(T_n) - F - PCT}{(1+i)^{nw}} \qquad (6)$$

The variable w represents the width of the stage interval (2 years), and the variable i represents the discount rate, which for all simulations was set at 10%. The variable *F* represents a fixed entry cost of $40 per acre on all harvests, and *PCT* represents the cost of removing premerchantable stems. Furthermore, the value P_n is reduced by 15% in all thinning operations to reflect the reduced efficiency and higher costs of partial removals.

The values P_n were derived from a stochastic price function. Historic two-year stumpage price changes were determined from timber prices reported by State of Louisiana (LDA&F, 2003). The frequency distribution for 2-year sawtimber and pulpwood price changes observed in Louisiana from 1955 to 2002 strongly resembles a triangular distribution (Figures 1 and 2). Using this price distribution, parameters for a future timber market that is "optimistic" are presented in table 1. In order to study the impact the stochastic price function parameters have on the dynamic programming results, two variations were hypothesized, one with the same mean price change but less variance (low variance market) and another with a smaller mean price growth and equal likelihood of price increases or decreases (pessimistic market). The triangular function parameters for these three market scenarios are given in Table 1.

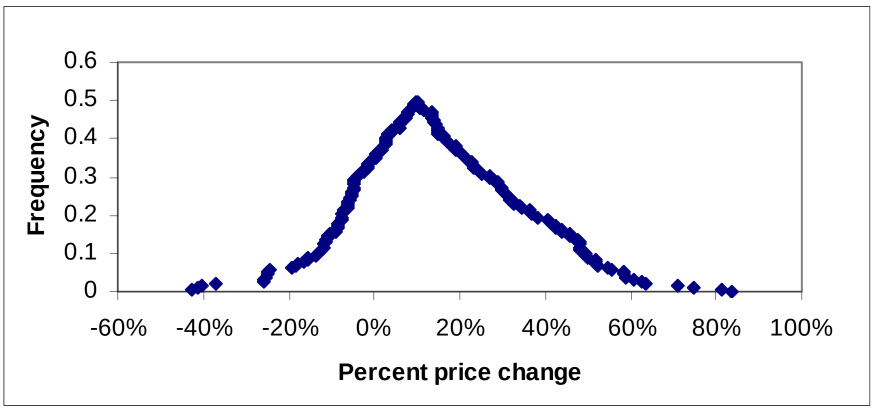


Figure 1. Frequency distribution of historic percent pine sawtimber stumpage price changes in Louisiana (1955-2002)

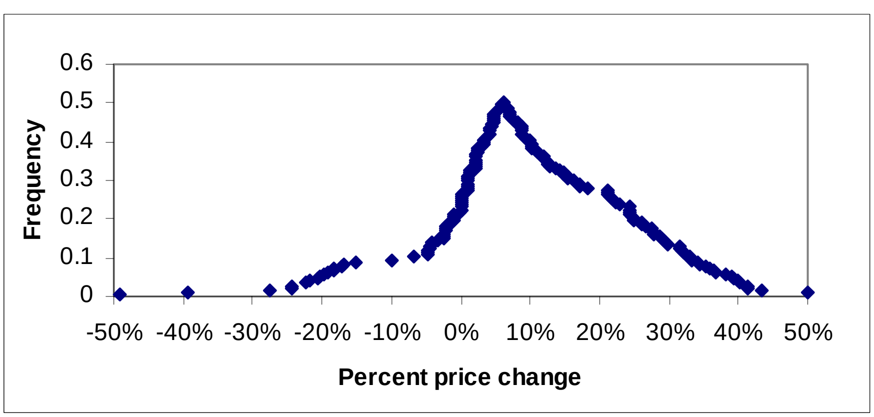


Figure 2. Frequency distribution of historic percent pine pulpwood stumpage price changes in Louisiana (1955-2002)

Table 1. Triangular distribution parameters for two-year stumpage price changes for three market scenarios used in dynamic programming simulations.

Optimistic Market (Historic)			
	Mean	Min	Max
Sawtimber	+14%	-43%	+84%
Pulpwood	+9%	-49%	+51%
Low Variance Market			
	Mean	Min	Max
Sawtimber	+14%	-20%	+40%
Pulpwood	+9%	-25%	+25%
Pessimistic Market			
	Mean	Min	Max
Sawtimber	+4%	-60%	+60%
Pulpwood	+2%	-50%	+50%

Under each market scenario, 30 simulations were completed. The simulations where limited to a maximum of three thinning operations during a single rotation. The actual results of the dynamic programming simulations would represent knowledge of the exact price changes in the future. Typical regimes were developed within each market scenario, using the timing, strategy, and intensity that was most frequently observed. This regime would represent knowledge of general market behavior in the future, but not the exact price changes (market knowledge). Finally, a most typical regime for all simulations was established, which would represent only knowledge of the three possible market conditions over the future (market possibility knowledge).

RESULTS AND DISCUSSION

The rotation length and soil expectation value under a situation of perfect knowledge of the market and all future prices is presented in table 2. Lower variance leads to longer rotations and higher economic returns even when the "average" price increase is the same. When the market is poor, rotations are shorter and have a much lower SEV.

Table 2. Average observed rotation length and SEV under three stochastic markets.

Future Market	Average SEV ($/acre)	Average Rotation Age
Optimistic	$517	60 years
Low Variance	$772	76 years
Pessimistic	$65	40 years

The observed thinnings and their frequency under each market are presented in table 3. Thinning from above (TfA) is clearly the preferred strategy for shortleaf pine in all scenarios and in all thinnings (first, second, or third). In a pessimistic market, thinning from above and below (TaB) is included 37% of the time. Thinning from above and below has a lesser impact on increasing rotation length than thinning from above, which is probably why it is a better choice in a market with slow stumpage price increases. The dominance of the thinning from above strategy is similar to that found under a deterministic setting for shortleaf pine (Pelkki, 1997).

Table 3. Observed thinnings under three market scenarios.

Market Condition	Thinning order	Thinning strategy	Observations	Average age	Average intensity
Optimistic	First	TfA	29	26	20%
		TaB	1		
	Second	TfA	29	32	30%
		TaB	1		
	Third	TfA	26	40	50%
		TaB	1		
		TfB	1		
Low variance	First	TfA	26	26	30%
	Second	TfA	29	36	40%
		TfB	1		
	Third	TfA	30	46	50%
Pessimistic	First	TfA	17	20	30%
		TaB	11		
		TfB	1		
	Second	TfA	21	26	40%
		TaB	5		
	Third	TfA	17	32	50%
		TaB	4		

Thinning intensity increases with age and order in the rotation scheme. First thinnings remove 20–30 % of the stand basal area, second thinnings remove 30-40%, and late thinnings remove 50%. It appears that less variance or fluctuation in stumpage prices favors later thinnings even when the mean price change is the same. Clearly, poor stumpage markets lead to earlier thinnings as well as rotation length. Poorer markets also tend to utilize fewer thinnings, only 70% of the observed simulations in a pessimistic market condition used a third thinning.

Based on the most frequently observed management actions in table 3, four rotation schemes were developed, one for each of the markets, representing market knowledge, and an overall average scheme representing knowledge only of the set of possible future market conditions. Table 4 presents the four rotation schemes. These schemes were then simulated under each of the stochastic price schedules from which they were developed. Table 5 presents statistics related to soil expectation value under conditions of perfect price knowledge, exact market knowledge, and market possibility knowledge.

Table 4. Most frequently observed market rotation scheme and overall average rotation scheme.

Knowledge level	Rotation Age	First Thinning	Second Thinning	Third Thinning
Optimistic market	60	TfA 30% 26 yrs	TfA 30% 32 yrs	TfA 50% 40 yrs
Low variance market	76	TfA 30% 26 yrs	TfA 40% 36 yrs	TfA 50% 46 yrs
Pessimistic market	40	TfA 30% 20 yrs	TfA 40% 26 yrs	TfA 50% 32 yrs
Market possibilities	58	TfA 30% 24 yrs	TfA 40% 32 yrs	TfA 50% 40 yrs

Table 5. Soil expectation value ($/acre) for each market condition and the amount of knowledge available to the decision maker.

Market Condition	Statistics	Perfect Knowledge	Market Knowledge	Market Possibility Knowledge
Optimistic	Average	$517	$373	$333
	Min	$20	-$16	-$16
	Max	$2579	$2095	$2011
	SE	$92	$75	$70
Low Variance	Average	$772	$562	$487
	Min	$234	$203	$138
	Max	$2055	$1526	$1664
	SE	$82	$59	$59
Pessimistic	Average	$65	$24	$16
	Min	- $19	- $57	- $48
	Max	$253	$160	$155
	SE	$14	$11	$11

As expected, only knowing the three possible market conditions correctly provides the lowest soil expectation value, as foresters must rely on the overall average timing for thinnings and rotation determination. If the correct market condition can be predicted, then per acre land values can be increased by an average of $40 in an optimistic market, $75 in a low variance market, and $8 in a pessimistic market. Going a step further, if foresters could actually predict all future price changes in a market (perfect knowledge), then per acre values would be increased by and average of $144 per acre in an optimistic market, $210 in a low variance market, and $41 in a pessimistic market.

The data generated can also be used to evaluate risk. Table 6 shows the percent likelihood of achieving a rotation of equal or greater value with market knowledge or market possibility knowledge. There is an 80% chance, if a manager has correct knowledge of the type of market, that SEV values for shortleaf pine will be $110 or more in an optimistic market, $280 in a low variance market, and -$28 in a pessimistic market. Similarly, if the land manager bases his management on only the knowledge of what future possible markets will exist, then there is only a 30% chance of per acre SEV values equaling or exceeding $333 in an optimistic market, $534 in a low variance market, or $67 in a pessimistic market.

Table 6. Likelihood of attaining land values in shortleaf pine stands with varying levels of knowledge about future market conditions.

Likelihood	Market Knowledge			Market Possibility Knowledge		
	Optimistic	Low Variance	Pessimistic	Optimistic	Low Variance	Pessimistic
80%	$110	$280	- $28	$111	$226	- $38
50%	$238	$433	$1	$219	$396	$2
30%	$371	$660	$55	$333	$534	$67

10%	$625	$925	$110	$575	$875	$93

CONCLUSIONS

Thinning from above is a very robust strategy for managing shortleaf pine. While thinning from above lengthens rotation age here as in previous, deterministic price studies (Pelkki 1997), even under pessimistic market conditions it is selected far more than other forms of thinning. To reduce the risk in poorer markets, an early thinning from above and below, which is neutral to rotation length, can be used to generate early income without increasing rotation length and risk of potential losses due to price decreases.

Reducing the variance in timber stumpage markets appears to increase the likelihood of higher returns from timber investments, even though the long-term mean stumpage price increase value remains the same.

If forest economists can predict the correct market behavior by estimating the correct parameters for stumpage prices over a rotation, then rotation schemes can be developed that achieve returns that average 72% of perfect knowledge. If the set of likely future market conditions can be predicted, then knowing the market possibilities will achieve returns that are, on average, 63% of perfect knowledge.

From the point of view of added value, economic research into predicting the behavior of future timber markets can increase returns from timber management 40-60%.

Future research will study other forest types, particularly hardwoods and loblolly pine, and expand the number of stochastic market parameters included in this type of analysis.

LITERATURE CITED

Arthaud, G.J., and W.D. Klemperer. 1988. Optimizing high and low thinnings in loblolly pine with dynamic programming. Can. J. For. Res. 18:1118-1122.

Brazee, R.J. and E. Bulte. 2000. Optimal Harvesting and Thinning with Stochastic Prices. For. Sci. 46(1):23-31.

Brodie, J. D., and C. Kao. 1979. Optimizing thinning in Douglas- fir with three descriptor dynamic programming to account for accelerated diameter growth. For. Sci. 25:665-672.

Dubois, M.R., T.J. Straka, S.D. Crim, and L.J. Robinson. 2003. Cost and Cost Trends for Forestry Practices in the South. Forest Landowner 62(2):3-9.

Haight, R.G., and T.P. Holmes. 1991. Harvesting loblolly pine plantations with hardwood competition and stochastic prices. For. Sci. 37:1266-1282.

LDA&F. 2003. Louisiana Quarterly Report of Forest Products. Louisiana Department of Agriculture and Forestry. Data for 1955 to 2001 accessed on web page
www.ldaf.state.la.us/divisions/forestry/reports/quarterreport/original-report.asp
on August 20, 2003.

Miner, C. L., N. R. Walters, M. L. Belli. 1988. A guide to the TWIGS program for the North Central United States. USDA For. Serv. Gen. Tech. Rep. NC-125. 105 p.

Pelkki, M. H. 1997. Optimal shortleaf pine management in the Central United States. Northern Journal of Applied Forestry 14(2)67-71.

Pelkki, M. H. 1998. Impacts of thinning strategies on financial returns from yellow-poplarstands, Southern Journal of Applied Forestry Vol. 23(2):69-77.

Schreuder, G. F. 1971. the simultaneous determination of optimal thinning schedule and rotation for an even-aged forest. For. Sci. 17:333-338.

Smalley, G.W. and R.L. Bailey. 1974. Yield tables and stand structure for shortleaf pine plantations in Tennessee, Alabama, and Georgia highlands. USDA For. Serv. Res. Pap. SO-97.

Teeter, L.D. and J.P. Caulfield. 1991. Stand density management strategies under risk: Effects of stochastic prices. Can. J. For. Res. 21:1373-1379.

Vardaman, J.M. 1989. How to make money growing trees. John Wiley & Sons, New York, NY. 296 p.

Yin, R.S. and D.H. Newman. 1995. A note on the tree-cutting problem in a stochastic environment. J. For. Econ. 1:181-190.

Yoshimoto, A. and I. Shoji. 2002. Comparative analysis of stochastic models for financial uncertainty in forest management. For. Sci. 48(4):755-766.

Explaining Timberland Values in the United States

Mary Ellen Aronow[9], Clark S. Binkley[10], and Courtland L. Washburn[11]

Abstract

The financial fortunes of timberland investors ultimately depend on conditions in markets for timberland properties. The behavior of timberland markets, however, is not well understood. In this paper, we use data from the NCREIF Timberland Property Index to develop historical series of timberland property values in the U.S. South and U.S. Pacific Northwest. We then use these historical series to examine the influence of operating revenues and interest rates on timberland values in each region. The former is influential, while the later, surprisingly, is not.

[9] Senior Forest Economist, Hancock Timber Resource Group, 99 High Street, 26th Floor, Boston, MA 02110. maronow@hnrg.com. (617)747-1566.
[10] Managing Director and Chief Investment Officer, Hancock Timber Resource Group, 99 High Street, 26th Floor, Boston, MA 02110, cbinkley@hnrg.com. (617)747-1583.
[11] Director of Economic Research and Investment Strategy, Hancock Timber Resource Group, 99 High Street, 26th Floor, Boston, MA 02110. cwashburn@hrg.com. (617)747-1584.

EXPLAINING TIMBERLAND VALUES IN THE UNITED STATES

Returns from investments in timberland properties are comprised of two elements. The first is an 'income' return, or cash dividend, reflecting the current net operating revenues associated with timber harvesting and the sale of a myriad of non-timber products from forests. The second is an 'appreciation' return reflecting the change in the value of the underlying timberland asset. The former is readily and widely understood to depend mainly on timber prices, and a comparatively large body of work, starting in the 1950s, has been devoted to understanding and forecasting supply, demand and prices for timber (e.g., Haynes 2003; Newman and Wear 1990). Changes in timberland values are less well understood.

This information gap is problematic. Historically about two thirds of the total returns from timberland have been in the form of appreciation, and the appreciation returns have been, by far, the more volatile component. As result, understanding the factors that create this volatility in timberland values is critical to effective timberland investment management.

The study of timberland markets has been hampered by the lack of a consistent time series of historical data on timberland values. One potential source of such information is the National Council of Real Estate Investment Fiduciaries (NCREIF). NCREIF maintains quarterly data on timberland properties in the United States owned by institutional investors (see Hancock Timber Resource Group, 2000, for a description of the NCREIF organization and its Timberland Property Index). The NCREIF timberland database, which begins in 1987, now contains 264 properties, covering 5.5 million acres, and valued in total at $7.0 billion (as of 31 March 2004). In their raw form, the NCREIF:

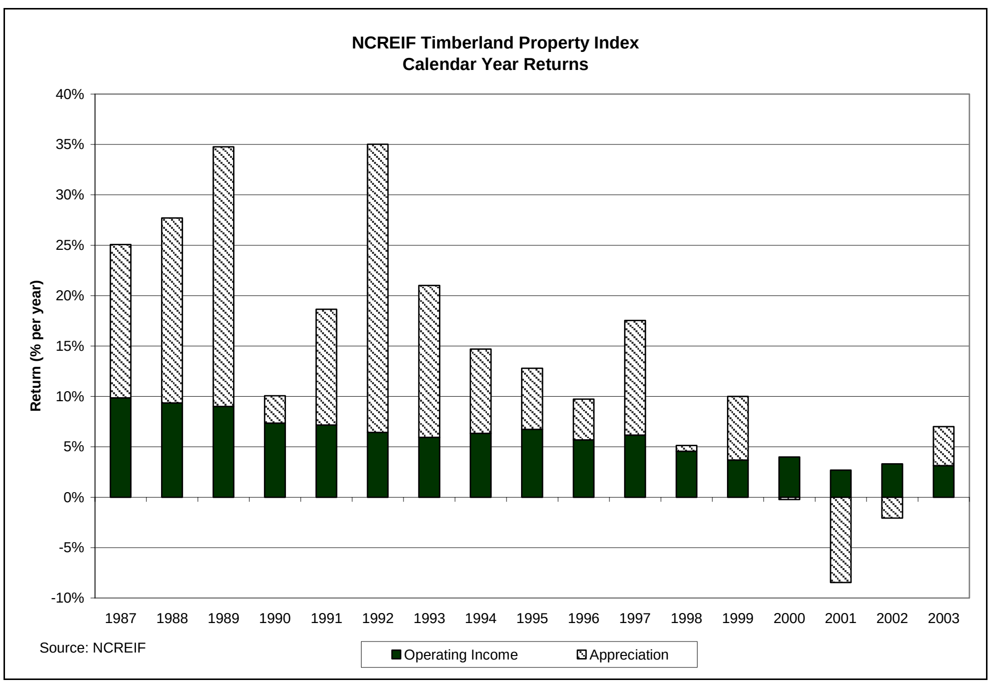


Figure 1. NCREIF Timberland Property Index returns

values are not directly suitable for the analysis contemplated in this paper. As a consequence, the first section, below, deals with some of these problems with the data. The second section uses the adjusted time series to investigate the determinants of timberland values. As one might expect, timberland values are strongly influenced by net operating revenues, which in turn depend on timber prices. Conditions in overall capital markets, however, appear to have little effect on the value of timberland properties.

1. Historical Estimates of Timberland Values in the United States

The NCREIF Timberland Property Index records data on the investment performance--including market values--of timberland properties managed for institutional investors by member organizations. Figure 2 shows the raw value data, stated on a per-acre basis, for the full time series in the South and Pacific Northwest. (Values are also available for the Northeast. The sample of Northeast properties is less homogenous, however, and we therefore focus on the South and Pacific Northwest.)

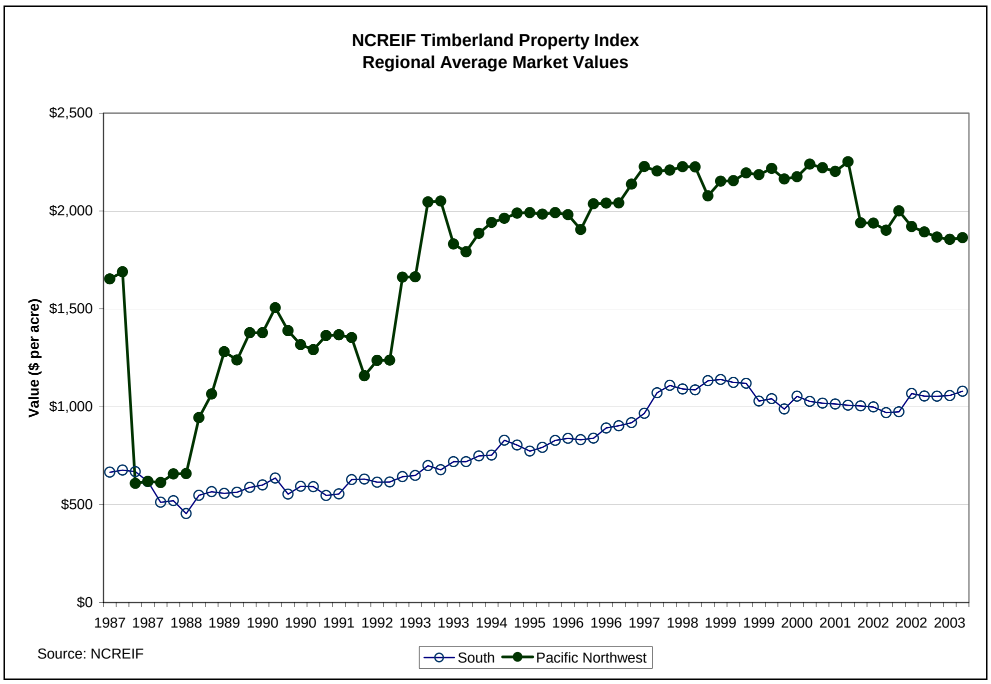


Figure 2. Average reported per-acre value of timberland in the NCREIF Timberland Property Index

At least four issues complicate the direct use of these data as time series of timberland property values:

- The values are based largely on appraisals rather than actual market transactions,
- All properties are not revalued each quarter,
- The sample of properties changes from quarter to quarter, and
- The timber inventory on each property changes over time due to growth and harvest.

It is well known that appraisals are lagging indicators of value (owing to their reliance on past comparable transactions), and tend to be less volatile than actual value changes. Similar issues arise in commercial real estate investment research, and methods have been devised in that context to deal with the appraisal-smoothing problem (e.g., Geltner 1993; Giliberto 2003). We, however, leave that work to another day.

We are able in this analysis to address the other difficulties in the data. Because the large majority of properties in the Index are revalued at the end of the fourth quarter, we stick to annual analyses based on calendar-year changes in values. This is a simple way to mitigate the stale-appraisal problem.

We handle the problems associated with the changing sample of properties and the changing timber inventory by using rates of return for the NCREIF Timberland Property Index to estimate an adjusted series of per-acre market values for a prototypical 'fully regulated', or in foresters' terms, 'normal', forest (although there is nothing normal about such a hypothetical forest!). A normal forest has, by definition, a stable inventory of timber, and produces a steady flow of harvested timber from year to year.

Our procedure for estimating historical values for normal forests has two parts. First, we estimate historical per-acre net operating revenues for the prototypical forest. Then, we compute the timberland values that, in combination with the estimated net operating revenues, produce the same rates of return as reported by the NCREIF Timberland Property Index. Said another way, we take as given the NCREIF returns. We determine what the operating-income return would be for a normal property, and we attribute the remainder of the NCREIF return to appreciation of our standardized forest.

A. Determining Historical Net Operating Revenues for a Normal Forest

We estimated per-acre levels of annual operating activity—timber harvests by species and product, production of non-timber products, and management activities—for a representative timberland property under management by the Hancock Timber Resource Group in the South and Pacific Northwest, under an assumption that the timber inventory on this sample of properties was in a normal condition.

We assumed that operating costs and prices for non-timber forest products were constant in real terms, and applied 2003 levels to earlier years. We applied historical regional-average timber prices calculated from Timber Mart-South (for the South) and Log Lines (for the Pacific Northwest) to the annual timber-harvest levels to obtain historical estimates of timber-sales proceeds. Figure 3 shows the normal-forest operating revenues in comparison with the actual NCREIF-reported data.

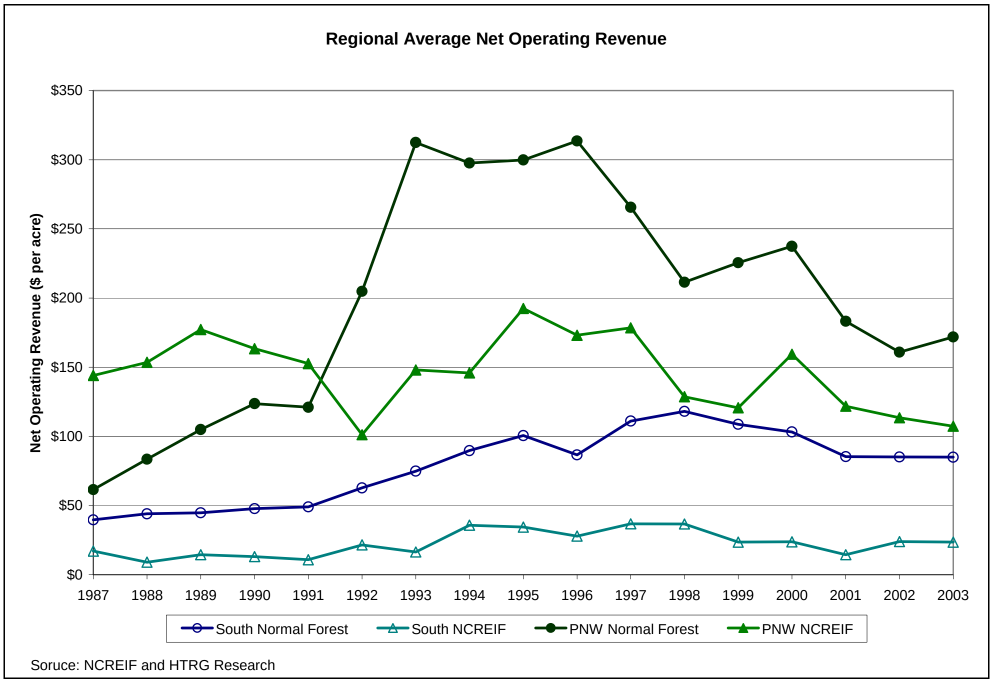


Figure 3. Estimates of annual net operating revenues from normal forests compared with revenues reported for properties in the NCREIF Timberland Property Index

In the South, the normal-forest income levels are far higher than those reported in the NCREIF database. This suggests that institutional investors tend to hold properties with forests younger than the normal-forest assumption, and the harvest levels are therefore lower. Anecdotal evidence is consistent with this conclusion, where southern timberland sellers often offer relatively immature properties for sale (keeping those with higher levels of cash flow for themselves). Some timberland investment managers craft investment strategies out of this market-place necessity.

The results of our analysis in the Pacific Northwest are a bit more complex and interesting. NCREIF-reported incomes have been flat but volatile, where the normal-forest revenues track timber prices upward during the late 1980s and early 1990s, and downward thereafter. The NCREIF-reported revenue through 1991 was higher than that of a normal forest. This suggests that Pacific Northwest properties in the NCREIF Index during its early years contained disproportionately large inventories of harvestable timber. Landowners evidently harvested this timber heavily during this time of relatively high prices caused by a sharp reduction in the availability of public timber. The year-to-year volatility in the NCREIF results may be due to a changing property sample, harvest-timing decisions, or a combination of the two factors.

B. Calculating Historical Normal Forest Values

With the normalized revenue estimates in hand, one can infer the timberland values for a normal forest that are necessary to produce the NCREIF returns. We need a starting point to peg our series of timberland values, however, and selected year-end 2003. To obtain year-end 2003 values, we formulated a simple model of the value of a normal forest:

$$\text{Value}_t = \text{Net Annual Operating Revenue}_t/\text{Real Discount Rate}_t,$$

where Value_t is the value of a normal forest at the end of year t, Net Annual Operating Revenue_t is the operating income produced by the forest during the calendar year t, and Real Discount Rate_t is the real discount rate used by timberland market participants to value timberland properties at the end of year t. This model effectively assumes that net operating revenues are expected to keep pace with general inflation.

We estimated real discount rates for timberland properties at year-end 2003 as the average real IRR that properties under HTRG management are expected to produce in each region assuming that future timber prices and management costs hold steady in real terms at 2003 levels. These rates were 7.2 percent in the South and 8.1 percent in the Pacific Northwest.

We then divided our estimates of 2003 income levels by these rates to obtain estimates of year-end 2003 values for a normal forest in each region. It is then a simple matter to calculate the year-end timberland values back to 1987 that, in combination with our historical operating revenue estimates, generate the historical NCREIF rates of return.

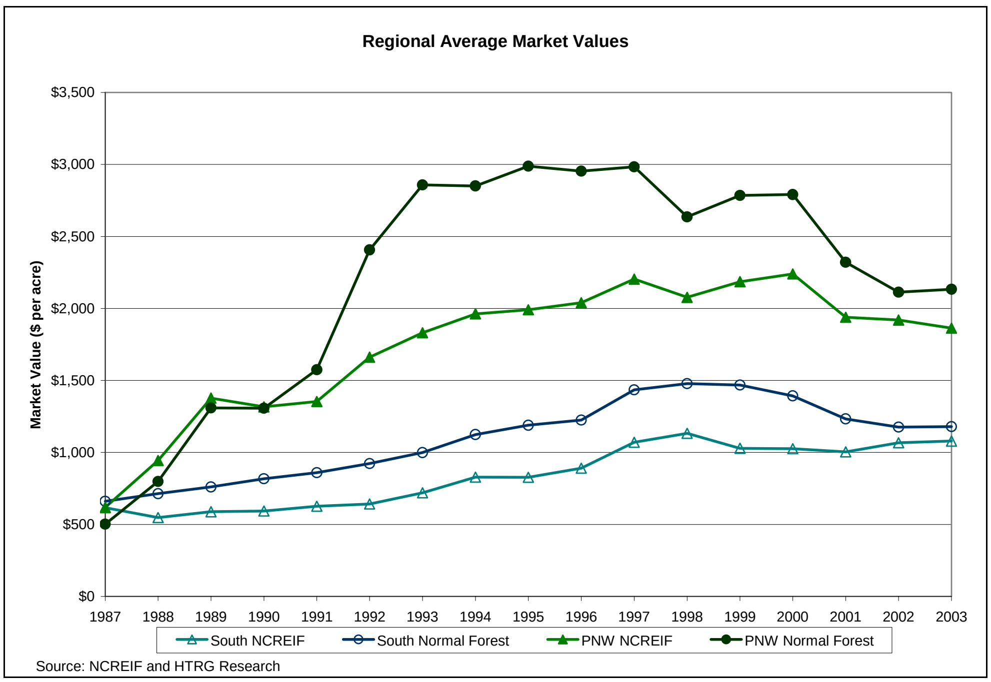


Figure 4. Estimates of year-end market values for normal forests compared with values reported for properties in the NCREIF Timberland Property Index

The results of this calculation are shown in Figure 4. For the South, the estimates of normal forest value have been above the raw NCREIF data. This supports our earlier conclusion that the sample of southern properties in the NCREIF database tends to be 'young', without the aggregate timber inventory and value one would expect from a normal forest.

Our southern value estimates follow the NCREIF data quite closely through the 1990s. Since 1999, however, our estimates of the per-acre value of a normal southern forest have declined by 20 percent, where the per-acre value of the sample of NCREIF properties has increased by 5 percent. We speculate that this is due largely to the addition to the NCREIF database of a substantial number of properties managed by new member organizations that are carried at relatively high per-acre values.

Our estimates of normal-forest values for the Pacific Northwest are also generally higher than those in the NCREIF database, but not always. The lower values in the early years supports our earlier conclusion that managers were depleting inventory on relatively 'mature' properties in the late 1980s. The 'Spotted Owl Effect' on timberland values in the Pacific Northwest, which is dampened in the NCREIF-reported values, is better reflected in our normal-forest series of property values.

2. Determinants of Timberland Values

While the normal-forest property-value estimates are of interest in their own right, they are more compelling as the basis for an analysis of the determinants of timberland values.

The simple model of timberland value that we outlined earlier suggests that changes in the per-acre price of timberland properties should be a function of changes in per-acre operating income levels and changes in the real timberland discount rate. To test the model, we regressed the rate of change in our adjusted year-end timberland values on the rate of change in our estimates of annual-average income levels and the rate of change in real yields for 10-year government bonds, a proxy for the timberland discount rate:

$$\ln(\text{Value}_t/\ \text{Value}_{t-1}) = \alpha + \beta_1 \ln(\text{Revenue}_t/\ \text{Revenue}_{t-1}) \\ + \beta_2 \ln(\text{Real Bond Yield}_t/\text{Real Bond Yield}_{t-1}) + \text{error}_t,$$

where Real Bond Yield$_t$ is the nominal yield on a 10-year US bond at the end of year t less surveyed expectations of long-term inflation (Wilshire Associates 2003).

The results of the regressions are (t-statistics in parenthesis):

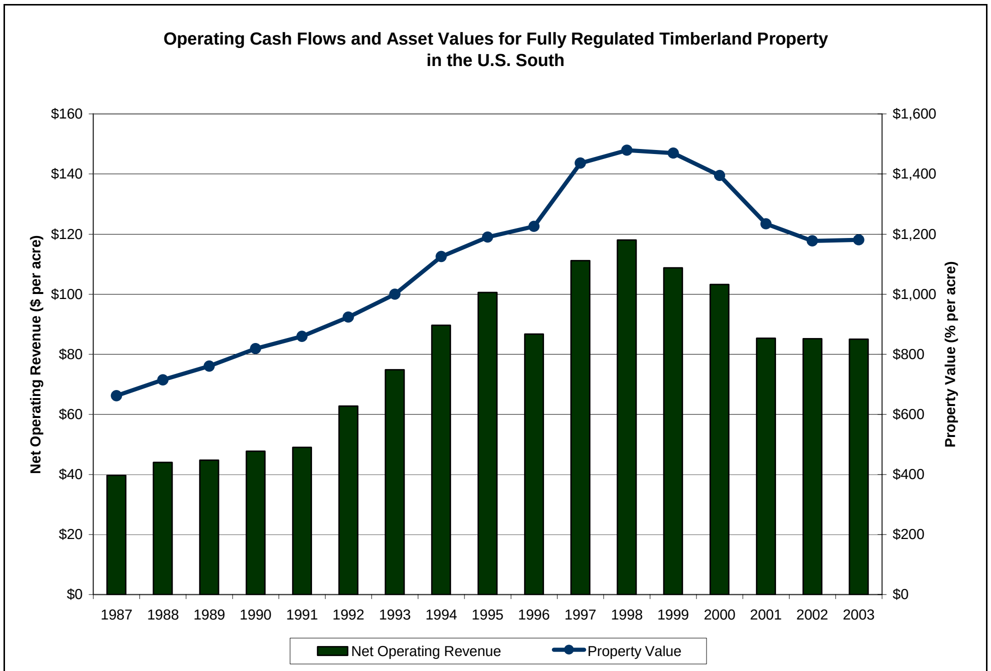
South

Timberland Value = 0.016 + 0.45*Revenue + 1.3*Real Yield $\quad R^2 = 0.73$
(5.79) (1.59)

Pacific Northwest

Timberland Value = 0.040 + 0.74*Revenue – 2.0*Real Yield $\quad R^2 = 0.64$
(4.80) (-0.71)

For both regions, the combination of changes in operating income and real bond yields explains about two-thirds of the variability in timberland value changes. There is a strong relationship between rates of change in timberland property prices and rates of change in net income levels in both regions. This relationship is demonstrated in Figure 5a and 5b, which shows that timberland values have tended to move with operating revenues.



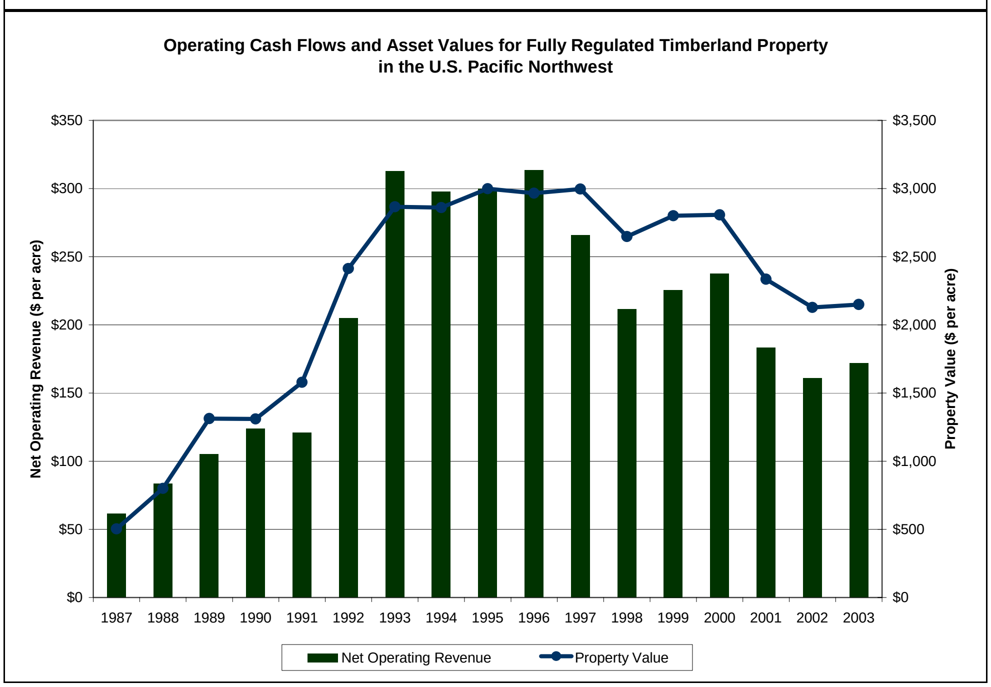


Figure 5a and 5b. Estimates of normal-forest operating revenues and market values

The elasticity of timberland values with respect to operating revenues in the Pacific Northwest is 64% higher than in the South (0.74 vs 0.45). While the reasons are not altogether clear, two factors appear to be at work. First, timber supply is much less elastic in the Pacific Northwest, so changes in lumber prices are more rapidly translated into changes in timber prices. The stickiness of supply response in the South is due to the structure of timberland ownership, comprised in that region of a myriad of nonindustrial private landowners. We hypothesize that these landowners probably respond less rapidly to changes in timberland markets just as they respond less rapidly to changes in timber markets. Second, bare land values in the South are a higher proportion of timberland value than in the Pacific Northwest, and bare-land values (at least as reported by appraisers) are less responsive to timber-price movements than are the values of the standing timber inventory.

The results also suggest that discount rates used by participants in timberland markets are largely independent of interest rates in the broader bond markets. This is illustrated in Figure 6, which plots our historical estimates of the real yield on a 10-year US bond against estimates of historical discount rates for a timberland property portfolio (with an assumed weighting of two-thirds in the South and one-third in the Pacific Northwest.) The two series do not move together, as evidenced by the variability of the premium for timberland discount rates over bond yields.

3. Conclusions

Understanding the determinants of timberland values is critical to understanding the returns from timberland investments. Little previous research has focused on this

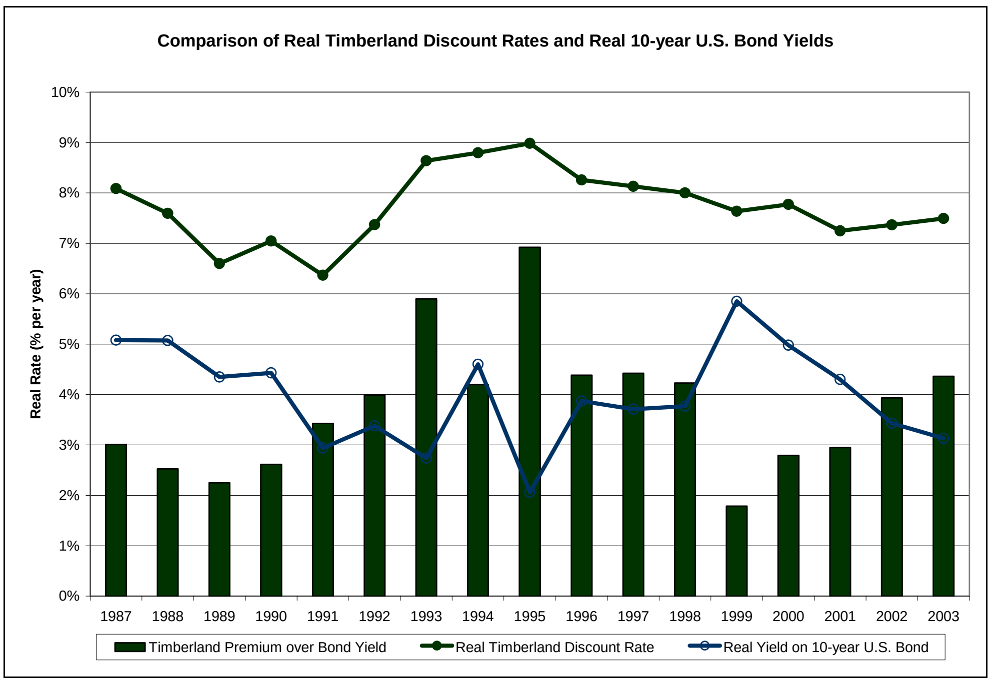


Figure 6. Comparison of real timberland discount rates and real 10-year US bond yields

problem largely, we believe, as a result of an absence of a reasonable time series of data describing timberland values. The emergence of the NCREIF Timberland Property Index has greatly helped to resolve this problem but does not go the full way. Of particular importance is the fact that the NCREIF database simply reflects the sample of properties that timberland investment advisors happen to contribute in a given quarter. These properties my be young or old, and may contain only immature plantations or old-growth timber. As a result, before any meaningful analysis can be conducted, it is necessary to standardize the age distribution of the forests. We have outlined one means to do so, and have used the resultant data to investigate the factors that explain movements in timberland values. Timber prices—through their influence on operating revenues—appear to have a strong effect; interest rates do not. A key remaining issue is to take account of the appraisal-based reductions of return volatility, and some promising paths exist to do so.

Literature Cited

Geltner, D. 1993. Estimating Market Values from Appraised Values Without Assuming an Efficient Market. *Journal of Real Estate Research* 8(3):325-346.

Giliberto, M. 2003. Assessing Real Estate Volatility. *The Journal of Portfolio Management* Special Real Estate Issue, September 2003:122-128.

Hancock Timber Resource Group. 2000. Measuring Timberland Performance. *Hancock Timberland Investor* Third Quarter 2000.

Haynes, R.W. 2003. *An Analysis of the Timber Situation in the United States: 1952-2050*. USDA Forest Service General Technical Report PNW-GTR-560.

Newman, D.H. and D.N. Wear. 1990. *Research Directions in the Study of Timber Markets and Forest Policies*. USDA Forest Service General Technical Report SE-62.

Wilshire Associates. 2003. *2003 Asset Allocation Return and Risk Assumptions*.

Relative Prices and Competitiveness in Sawmills and Wood Preservation Industry in the United States and Canada: Preliminary Results

Rao V. Nagubadi[12] and Daowei Zhang[13]

Abstract

This paper examines relative prices and relative productivity levels in sawmills and wood preservation industry between the United States and Canada using purchasing power parities. Translog price function is used to estimate the rates of productivity growth and differences in productivity for the industry between the two countries over the period 1958 to 2001. A major finding is that the relative U.S. productivity level in the industry was lower than that of the Canadian industry till 1996, but improved over the Canadian industry over the period 1997-2001. The competitiveness of the industry's products was facilitated mainly by the deteriorating exchange rate of Canadian dollar.

Key Words: Relative productivity levels, rates of technical change, gap in technology.

[12] Post-doctoral Fellow, School of Forestry & Wildlife Sciences, Auburn University, AL 36849. nagubve@auburn.edu. (334) 844-1052 (v); (334) 844-1084 (fax).

[13] Professor, School of Forestry & Wildlife Sciences, Auburn University, AL 36849. zhangd1@auburn.edu. (334) 844-1067 (v); (334) 844-1084 (fax).

INTRODUCTION

This paper addresses relative prices and competitiveness in sawmills and wood preservation industry in the U.S. and Canada. Earlier research suggested that total factor productivity growth was lagging behind in Canadian sawmills industry. Abt et al. (1994) estimated that total factor productivity (TFP) grew at an average annual rate of 1.6 and 1.3% in the sawmilling industry for the U.S. West and the U.S. South regions over the period 1965-88. They also estimated that the TFP grew by -0.1% in Canada's B.C. Coast, and between 1.2 and 1.3% in other regions of Canada over the same period. However, there is little information on the issue of competitiveness of products in sawmills and wood preservation industry between the U.S. and Canada.

The Presidential Commission on Industrial Competitiveness (1985) defines competitiveness, "the degree to which a country can, under free and fair market conditions, produce goods and services that meet the test of international markets while simultaneously maintaining and expanding the real incomes of its citizens." Competitiveness of an industry in a country is determined by the efficiency with which its inputs and resources are employed in the production of goods and services relative to its counterpart in other countries. In the long run, productivity growth plays an important role in the competitiveness of an industry.

The purpose of the study is to estimate relative prices using purchasing power parities for the outputs and inputs of sawmills and wood preservation industry in the United States and Canada for the period 1958-2001. It also estimates relative levels of productivity and annual rates of technical change for the industry in both countries.

METHODOLOGY

Purchasing Power Parities and Relative Prices

Purchasing power parity (PPP) is a theory of exchange rates whereby a unit of any given currency should be able to buy the same quantity of goods and services in all countries. PPP is a way of comparing average costs of goods and services between countries. Jorgenson and Kuroda's (1990) methodology for estimating PPP is based on linking time-series data sets on prices in Canada and the United States. Suppose, *q*(Canada,0) and *q*(US,0), are prices in Canada and the United States in the base period evaluated in terms of their local currencies, Canadian dollars and US dollars, respectively. We can define PPP for the output of an industry in the base period, say PPP(0), as

$$(1) \qquad PPP(0) = \frac{q(Canada,0)}{q(US,0)}.$$

The PPP(0) gives the number of Canadian dollars required in Canada to purchase an amount of the output of the industry costing one dollar in the U.S. in the base period.

To estimate PPP for all outputs in Canada and the U.S., we first construct a time series of prices for all outputs in both countries in domestic currency. To obtain price indexes for industry outputs in the U.S., we normalize the price index for each industry, say *q*(US,T), at unity in the base period. We normalize the corresponding price index for Canada, say *q*(Canada,T), at the PPP in the base period. We obtain estimates of PPP for all years, say PPP(T), from these price indexes and PPP(0) for the base period from the equation,

$$(2) \qquad PPP(T) = PPP(0)\frac{q(Canada,T)}{q(Canada,0)}\ \frac{q(US,0)}{q(US,T)},$$

where PPP(0) is the PPP in the base period and q (Canada,0), q(US,0) are the price of the output in an industry in Canada and the U.S. in the base period.

The relative price of the output of an industry in Canada and the U.S. in US\$, say p(Canada, US), is the ratio of the PPP for that output to the Canadian\$-to-US\$ exchange rate, E,

(3) $$p(\text{Canada,US}) = \frac{PPP(T)}{E}.$$

The relative price of output in Canada and the U.S. is the ratio of number of US\$ required in Canada to purchase an amount of the output costing one US\$ in the United States. This index is the measure of international competitiveness between Canadian industry and its U.S. counterpart. This relative price was used as an indicator of competitiveness to assess international competitiveness by Jorgenson and Kuroda (1990) between Japan and the United States, and Lee and Tang (2002) between Canada and the United States. We construct relative prices for six outputs, softwood lumber, hardwood lumber, woodchips, wood preservation products, woodties-shingles-shakes (WTSS), other products, and weighted output and four inputs, labor, capital, energy, and materials, for the industry for the United States and Canada.

Relative Productivity Levels

Jorgenson and Nishimizu (1978) provided theoretical framework for productivity comparisons between countries based on a bilateral translog production function. This framework was used extensively by several other researchers, including Jorgenson, Kuroda and Nishimizu (1987), Jorgenson and Kuroda (1990), Kuroda and Nomura (1999), and Lee and Tang 2002). According to these researchers, relative total factor productivity levels can be assumed to reflect differences in technology levels. The dual translog price function developed by Jorgenson and Kuroda (1990) enables us to express the output price in each country as a function of input prices and the level of productivity in that country. Relative prices of output between Canada and the U.S. can be accounted by allowing input prices and levels of productivity to differ between countries. Following Jorgenson and Kuroda (1990), we assess the relative productivity levels in the industry for the U.S. and Canada based on dual translog price function for the two countries,

(4) $$\ln q = \alpha_O + \textstyle\sum_i \alpha_i \ln p_i + \alpha_T T + \alpha_D D + \tfrac{1}{2} \sum_i\sum_j \beta_{ij} \ln p_i \ln p_j + \sum_i \beta_{iT} \ln p_i T + \sum_i \beta_{iD} \ln p_i D + \tfrac{1}{2} \beta_{TT} T^2 + \beta_{TD} TD + \tfrac{1}{2} \beta_{DD} D^2$$

where q is output price, p_i are input prices, i = L (labor), K (capital), E (energy), and M (materials), is a dummy variable (equal to one for the United States, and 0 for Canada), and T is index of time as indicator of technology. The above translog price function is characterized by constant returns to scale.

The value (compensation) shares of inputs, v_i, in the industry are equal to the logarithmic derivatives of the price function with respect to logarithms of input prices:

(5) $$v_i = \frac{\partial \ln q}{\partial \ln p_i} = \alpha_i + \textstyle\sum_j \beta_{ij} \ln p_j + \beta_{iT} T + \beta_{iD} D.$$

The rate of productivity growth, v_T, defined as negative of rate of growth of output price, is the logarithmic derivative of the price function with respect to time, holding input prices constant:

(6) $$v_T = -\frac{\partial \ln Q}{\partial T} = -(\alpha_T + \textstyle\sum_i \beta_{iT} \ln p_i + \beta_{DT} D + \beta_{TT} T).$$

The difference in technology in the industry between Canada and the United States, v_D, is defined as the negative of the rates of growth of output price. The difference in technology between two countries is obtained by taking the logarithmic derivative of the price function with respect to the dummy variable, holding the input prices constant:

(7) $v_D = -\dfrac{\partial \ln Q}{\partial D} = -(\alpha_D + \sum_i \beta_{iD} \ln p_i + \beta_{DT}\, T + \beta_{DD}\, D).$

Based on the above price function (4), Jorgenson and Kuroda (1990) show that the average productivity growth, $\bar{v}_T$, between two points of time T and T-1, can be expressed as the negative of the translog index of the difference between a weighted average of growth rates of input prices and the growth rate of output price for an industry:

(8) $\bar{v}_T = -\{\ln q(T) - \ln q(T\text{-}1) - \sum_i \bar{v}_i\, [\ln p_i(T) - \ln p_i(T\text{-}1)]\}$ $(i = L, K, E, M)$,

where the weights, $\bar{v}_i$, are average value (compensation) shares in the years *T* and *T-1*, given by

$$\bar{v}_i = ½\, [v_i(T) + v_i(T\text{-}1)].$$

Equation (8) is referred to as translog price index of the rates of technical change or rates of productivity growth.[14]

Similarly, the average of the differences in the logarithms of the productivity levels between two countries, $\hat{v}_D$, can be expressed as the negative of the translog index of the difference between logarithms of output prices, minus a weighted average of differences between logarithms of input prices:

(9) $\hat{v}_D = -\{\ln q(Canada) - \ln q(US) - \sum_i \hat{v}_i\, [\ln p_i(Canada) - \ln p_i(US)]\}$ $(i = L, K, E, M)$,

where the weights, $\hat{v}_i$, are average value shares for Canada and the U.S., given by

$$\hat{v}_i = ½\, [v_i(Canada) + v_i(US)].$$

Equation (9) is referred to as translog price index of differences in technology or differences in productivity.

DATA CONSTRUCTION

The industries included in this study for the U.S. are NAICS (North American Industry Classification System) codes 321113 (sawmills) and 321114 (wood preservation) from 1997 to 2001 in the U.S. Prior to 1997, these industries were under SIC (Standard Industrial Classification) codes 2421 (sawmills and planning mills), SIC 2429 (special products sawmills), and SIC 2491 (wood preserving).[15] The main sources of data for the U.S. are Annual Survey of Manufactures (ASM), and Census of Manufacturing (CM).

The corresponding industries for Canada are listed as NAICS 321111 (sawmills- except shingle and shake mills), 321112 (shingle and shake mills), and 321114 (wood preservation) from1997 to 2001.[16] Prior to 1997, there were listed under SIC 2512/2513 (sawmills and planing mill products), SIC 2511 (shingle and shake mills) and SIC 2591 (wood preservation).[17] The main sources of data for Canada are Annual Census of Manufactures (ACM) and Statistics Canada publications Catalogues # 35-204, 35-250, and CANSIM-II.

---

[14] According to Diewert (1976) the translog index numbers are exact for the translog production or price function developed by Christensen, Jorgenson, and Lau (1971, 1973).

[15] The series before 1997 are merged using ratios of 84% of SIC 2421, 21% of SIC 2429, and 100% of SIC 2491 for the industry in the United States.

[16] There is a slight difference in the NAICS codes for the industry, Canada preferred to have two codes separately for sawmills & planing mills (321111) and shingle & shake mills (321112), while in the U.S. this industry is represented as one group (321113).

[17] The series before 1997 are merged using 98.2% of SIC 2511 and 2512/2513, and 100% of SIC 2591 for the Canadian industry.

The quantities for six outputs, softwood lumber, hardwood lumber, wood chips, wood preservation products, wood ties-shingles-shakes, and other products are imputed from the value of shipments using the prices constructed from the available quantities and dollar values. Since wood chips are in bone dry tons, and WTSS are in squares, suitable conversion factors are applied to convert them into uniform thousand board feet equivalents.[18]

Our unit for labor input is the hours worked. The capital stock input is in real 2001 dollars in their respective currencies, while fuels energy and electric energy are imputed quantities in British thermal units (Btu), and material inputs are in thousand board feet (MBF). Material inputs include non-wood materials and contract work but are represented as wood-equivalent material quantities. Wherever data are unavailable, suitable interpolations and imputations are made to fill in the gaps. The average value or compensation shares for labor, energy, and material inputs are estimated as the shares of respective input expenditures in the total revenue. The compensation for capital is derived by subtracting the compensation for labor, energy, and materials from the total revenue. The service price of capital is estimated by dividing the compensation for capital by the total capital stock.

We use real capital stock data in 1987 dollars, available separately for machinery and equipment (M&E), and plants and structures (P&S) by SIC codes for years 1958-96 from the manufacturing industry database developed by National Bureau of Economic Research (NBER) and U.S. Census Bureau's Center for Economic Studies (CES) for the U.S. (Bartelsman et al. 2000). For 1997-01, capital stock data are constructed by perpetual inventory method using 8.33% depreciation for M&E, and 5% depreciation for P&S on previous year's capital stock and adding current year new capital expenditure. For Canada, capital stock data in 1997 constant Canadian dollars, computed using straight line method of depreciation, are taken from Statistics Canada. The Capital stock data for both countries are converted to 2001 constant dollars using their respective GDP deflators.

The nominal value of shipments for the industry increased to nearly ten-fold from US$2.67 to US$25.92 billion in the U.S., while the value of shipments rose to about 33-fold in Canada from CAN$0.53 to CAN$17.6 billion in shipments between 1958 and 2001. The revenue shares in value of shipments for softwood lumber declined from 60 to 45% and hardwood lumber from 25 to 22% in the U.S. In Canada, the share of softwood lumber declined from 76 to 70% and hardwood lumber from 6 to 2%. The share of wood chips increased from 1 to 10% in the U.S. and 4 to 12% in Canada. The share of wood preservation products increased from 6 to 15% in the U.S. and from 3 to 4% in Canada The significance of wood ties-shingles-shakes products declined and share of other products comprising mainly contract work increased marginally in both countries.

The value or compensation share of labor in the total revenue declined from 25 to 16% in both countries over the period. The value share of capital declined from 25 to 17% in the U.S. but slightly increased from 20 to 21% in Canada. The value share of energy (fuels and electric power) was constant at 2% in the U.S., but increased from 2 to 3% in Canada. The value share of materials rose from 49 to 66% in the U.S. and from 52 to 59% in Canada.

RESULTS

Relative Output and Input Prices

[18] The approximate conversion factors are: wood chips- one Bone Dry Ton = 1.15 MBF and wood ties-shingles-shakes- one Square = 0.1212 MBF (David Briggs- personal communication).

Table 1 presents the relative prices for Canada (US=1) for all outputs for the industry along with exchange rate (CAN$/US$) over the period 1958-2001. The relative prices for softwood lumber, wood preservation products, and weighted output were lower in Canada than in the U.S. and declined consistently, except for brief periods, in accordance with the depreciation of Canadian dollar in relation to US dollar. Softwood lumber price started at almost on equal footing in 1958, but declined to 79% of the U.S. softwood lumber price in 2001. The dominating influence of exchange rate is evident on relative prices for softwood lumber and weighted output of Canadian industry. Till 1971, the exchange rates and relative prices were flat, and from 1973 onwards as exchange rate in Canadian dollars per US dollar increased, the relative prices for softwood lumber and weighted output declined dramatically up to the year 1987. During the period from 1987 to 1991, relative prices increased as the exchange rates declined. Again with the increase in the exchange rate, the relative prices experienced steep decline after 1992.

Prices of hardwood lumber, wood chips, and WTSS, increased from 84, 76, and 134% of the U.S. price in 1958 to 99, 90, and 176% of the U.S. price in 2001. Wood preservation products prices, which were 75% of the 1958 U.S. price, declined to 63% in 2001. Overall, the relative price of total output was between 64 to 84% of the U.S. price for the industry over the entire period with fluctuations in between in accordance with movements in exchange rates.

Table 2 shows relative prices for inputs in the Canadian industry. The relative prices for labor in Canada were 84% of the U.S. labor price in 1958, but gradually increased till 1977. Thereafter up to 1986, Canadian labor prices remained more or less on par with the U.S. labor prices, but increased between 1987 and 1993 before finally declining to 78% in 2001 under the impact of increasing exchange rate. The relative prices for capital declined from 112% in 1958 declined to 32% by 1985, however again increased to 141% in 2001. The relative prices for energy were higher in Canada than in the U.S. till 1976, but declined 80% of the U.S. prices, by the year 2001. The material prices in the Canadian industry were higher than those in the U.S. between 1958 and 1991, then declined to 56% of the U.S. price in 2001.

Table 1. Relative prices of outputs for sawmills and wood preservation industry (NAICS 3211) in Canada (US=1), 1958-2001. ([@]Wood preservation products; [#]Woodties-shingles-shakes)

Year	Softwood Lumber	Hardwood Lumber	Wood Chips	WPP[@]	WTSS[#]	Other	Weighted Output	Exchange Rate (CAN$/US$)
1958	0.95	0.84	0.76	0.75	1.34	1.09	0.80	0.9710
1959	0.89	0.84	0.82	0.78	1.35	1.09	0.78	0.9590
1960	0.92	0.84	0.85	0.75	1.20	1.08	0.77	0.9700
1961	0.92	0.93	0.96	0.73	1.33	1.06	0.78	1.0130
1962	0.90	0.92	0.77	0.72	1.29	1.03	0.74	1.0690
1963	0.89	0.88	0.79	0.74	1.34	1.02	0.75	1.0785
1964	0.92	0.91	0.87	0.76	1.41	1.03	0.77	1.0786
1965	0.94	0.92	0.79	0.76	1.35	1.04	0.74	1.0780
1966	0.92	0.90	0.81	0.72	1.31	1.01	0.73	1.0773
1967	0.95	0.95	0.69	0.74	1.47	1.04	0.74	1.0787
1968	0.93	0.97	0.70	0.76	1.11	1.04	0.77	1.0775
1969	0.87	0.88	0.71	0.72	1.17	0.98	0.71	1.0768
1970	0.93	0.90	0.76	0.68	1.26	0.97	0.74	1.0440
1971	0.86	1.02	0.46	0.70	1.24	0.97	0.66	1.0098
1972	0.94	1.15	0.69	0.80	1.10	1.07	0.84	0.9905
1973	0.93	1.03	0.69	0.81	1.18	1.05	0.82	1.0006
1974	0.93	0.89	0.60	0.77	1.18	0.97	0.72	0.9780
1975	0.89	1.04	0.68	0.78	1.22	1.00	0.76	1.0173
1976	0.82	0.97	0.74	0.71	1.05	0.93	0.76	1.0140
1977	0.78	0.88	0.72	0.65	1.25	0.87	0.72	1.0634
1978	0.76	0.77	0.67	0.64	1.09	0.85	0.72	1.1402
1979	0.80	0.81	0.58	0.69	1.08	0.88	0.70	1.1715
1980	0.82	0.95	0.67	0.67	1.36	0.86	0.76	1.1692
1981	0.78	0.96	0.66	0.63	1.05	0.79	0.70	1.1989
1982	0.79	0.92	0.68	0.65	1.12	0.79	0.68	1.2337
1983	0.78	0.85	0.64	0.58	1.27	0.79	0.69	1.2324
1984	0.77	0.80	0.67	0.56	1.22	0.73	0.64	1.2951
1985	0.77	0.86	0.68	0.60	1.42	0.72	0.66	1.3655
1986	0.81	0.89	0.67	0.60	1.55	0.76	0.67	1.3895
1987	0.76	0.84	0.72	0.62	1.25	0.76	0.63	1.3260
1988	0.85	1.14	0.78	0.65	1.22	0.81	0.68	1.2307
1989	0.84	1.23	0.84	0.68	1.50	0.84	0.72	1.1840
1990	0.85	1.16	1.03	0.75	1.57	0.85	0.78	1.1668
1991	0.85	1.25	0.95	0.80	1.62	0.84	0.84	1.1457
1992	0.79	1.07	0.83	0.62	1.67	0.77	0.78	1.2087
1993	0.72	0.90	0.70	0.47	1.65	0.76	0.69	1.2901
1994	0.80	0.94	0.76	0.50	1.36	0.79	0.75	1.3656
1995	0.84	1.04	1.07	0.62	1.54	0.80	0.83	1.3724
1996	0.91	1.15	1.09	0.56	1.92	0.84	0.99	1.3635
1997	0.86	0.90	0.91	0.51	1.37	0.78	0.75	1.3846
1998	0.82	0.77	0.78	0.55	1.33	0.72	0.67	1.4835
1999	0.85	0.99	0.86	0.54	1.77	0.75	0.82	1.4857
2000	0.78	1.02	0.98	0.64	1.91	0.70	0.76	1.4851
2001	0.79	0.99	0.90	0.63	1.76	0.69	0.75	1.5488

Table 2. Relative prices of inputs for NAICS 3211 in Canada (US = 1), 1958-2001.

Year	Labor	Capital	Energy	Materials	Exch. Rate (CAN$/US$)
1958	0.84	1.12	2.40	1.51	0.9710
1959	0.83	0.93	2.71	1.49	0.9590
1960	0.89	1.18	2.76	1.60	0.9700
1961	0.87	0.55	2.82	1.53	1.0130
1962	0.81	0.65	2.57	1.59	1.0690
1963	0.80	0.75	2.82	1.72	1.0785
1964	0.73	0.77	2.52	1.86	1.0786
1965	0.80	0.80	2.34	1.81	1.0780
1966	0.83	0.85	1.92	1.55	1.0773
1967	0.81	0.52	2.32	1.53	1.0787
1968	0.81	0.88	2.26	1.46	1.0775
1969	0.81	0.68	2.11	1.31	1.0768
1970	0.88	0.37	1.71	1.35	1.0440
1971	0.92	0.44	1.46	1.26	1.0098
1972	0.90	0.65	1.43	1.22	0.9905
1973	0.91	0.72	1.40	1.15	1.0006
1974	1.07	0.46	1.26	1.17	0.9780
1975	1.06	0.46	1.17	1.21	1.0173
1976	1.10	0.68	1.17	1.22	1.0140
1977	1.07	0.75	0.99	1.14	1.0634
1978	0.94	0.78	0.93	1.06	1.1402
1979	0.96	0.84	0.80	0.79	1.1715
1980	1.01	0.81	0.69	0.88	1.1692
1981	1.03	0.57	0.71	0.85	1.1989
1982	1.02	0.36	0.80	1.18	1.2337
1983	1.03	0.58	0.85	1.01	1.2324
1984	0.97	0.38	0.79	1.04	1.2951
1985	0.91	0.32	0.75	1.31	1.3655
1986	0.93	0.44	0.80	1.32	1.3895
1987	1.03	0.57	0.77	1.07	1.3260
1988	1.05	0.45	0.88	1.04	1.2307
1989	1.11	0.48	0.85	1.03	1.1840
1990	1.13	0.44	0.87	1.14	1.1668
1991	1.14	0.57	0.95	1.14	1.1457
1992	1.10	0.77	0.89	0.97	1.2087
1993	1.04	0.79	0.88	0.86	1.2901
1994	1.00	0.88	0.88	0.81	1.3656
1995	0.98	0.76	0.87	0.78	1.3724
1996	0.98	1.01	0.81	0.89	1.3635
1997	0.87	0.99	0.80	0.64	1.3846
1998	0.80	0.80	0.82	0.51	1.4835
1999	0.81	1.48	0.83	0.57	1.4857
2000	0.80	1.01	0.78	0.61	1.4851
2001	0.78	1.41	0.80	0.56	1.5488

Table 3. Difference in technology and annual rates of technical change for NAICS 3211 in the U.S. and Canada, 1958-2001.

Year	Diff. in technology, v_D between U.S.and Canada	Annual rate of technical change, v_T		Difference in annual rates of change
		U.S.	Canada	
1958	0.2835	-	-	-
1959	0.2697	0.0412	0.0164	0.0248
1960	0.3722	-0.0863	0.0226	-0.1090
1961	0.2059	0.0310	-0.1220	0.1530
1962	0.2474	0.0372	0.0658	-0.0286
1963	0.3057	0.0111	0.0505	-0.0394
1964	0.2819	0.0564	0.0396	0.0168
1965	0.2881	0.0200	0.0271	-0.0071
1966	0.2345	0.0800	0.0316	0.0484
1967	0.0901	0.0784	-0.0458	0.1242
1968	0.2058	-0.0408	0.0119	-0.0527
1969	0.1500	-0.0059	-0.0371	0.0312
1970	0.0663	-0.0176	-0.0334	0.0158
1971	0.1042	0.0333	0.0389	-0.0056
1972	0.0384	0.0524	-0.0365	0.0889
1973	0.0271	0.0047	-0.0217	0.0264
1974	0.0559	-0.1096	-0.0340	-0.0756
1975	0.1104	-0.0711	-0.0100	-0.0611
1976	0.2428	0.0355	0.1391	-0.1036
1977	0.2556	0.0559	0.0579	-0.0020
1978	0.2307	0.0739	0.0474	0.0266
1979	0.0841	0.0367	-0.1041	0.1408
1980	0.1079	-0.0655	-0.0116	-0.0539
1981	0.1051	-0.0666	-0.0300	-0.0366
1982	0.1822	0.0132	0.1273	-0.1141
1983	0.1796	0.0686	0.0064	0.0622
1984	0.0997	0.0792	0.0291	0.0501
1985	0.1976	-0.1247	-0.0430	-0.0817
1986	0.1979	0.0195	-0.0229	0.0425
1987	0.1614	0.1448	0.0797	0.0651
1988	0.0140	0.0421	-0.0679	0.1100
1989	0.0168	-0.0015	-0.0053	0.0038
1990	0.0499	0.0054	0.0552	-0.0498
1991	0.1193	-0.0129	0.0489	-0.0618
1992	0.1551	0.0568	0.0560	0.0007
1993	0.1920	-0.0585	-0.0528	-0.0056
1994	0.1017	0.0929	-0.0078	0.1008
1995	-0.0500	0.1105	-0.0012	0.1117
1996	0.0252	-0.0822	-0.0368	-0.0454
1997	-0.0901	0.1459	0.0036	0.1423
1998	-0.2252	-0.0107	-0.1013	0.0906
1999	-0.0371	-0.0377	0.1191	-0.1568
2000	-0.1245	-0.0069	-0.0129	0.0060
2001	-0.1038	-0.0276	-0.0130	-0.0146

Relative Productivity levels

Table 3 presents the difference or proportional gap in relative productivity levels and the annual rates of technical change for the industry for the U.S. and Canada. Till 1994, the productivity or technology level in the U.S. industry was inferior to that of the Canadian industry. In 1958, the difference or the gap between the U.S. and Canadian industry productivity or technology levels was nearly 28%. This means that the productivity level of the U.S. industry was 72% that of Canadian industry in that year. The gap in technology in the industry between Canada and the U.S. increased to 37% in 1960, and thereafter the technology gap and declined to nearly 3% by 1973. However, the gap in technology increased again to 26% by 1977. From 1977 onwards, the technology gap fluctuated and finally closed the gap by 1997. Between 1997 and 2001, productivity level of the U.S. industry exceeded that of Canadian industry and reached about 110% of the productivity level of Canadian industry in 2001.

The average rates of technical change for the industry in both countries reveal that the U.S. industry experienced positive technical change in 26 years out of 43 years, as against 20 years of positive technical change for the Canadian industry. Particularly after 1987, large differences in annual rates of technical change in the U.S. industry over the Canadian industry led to the widening of gap in the industry's productivity growth between the two countries after 1987 (Figure 1).

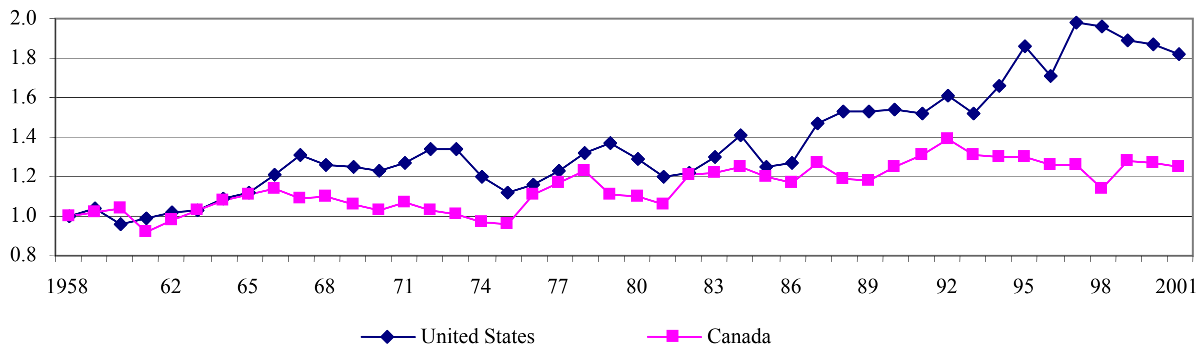


Figure 1. Total factor productivity growth (Törnqvist-Theil) indexes for sawmills and wood preservation industry (NAICS 3211) in the United States and Canada.

An examination of output per unit of inputs reveals that output per labor and capital are higher in Canada over the U.S. over the analysis period. Output per unit of energy input is higher in Canadian industry than in the U.S. industry till 1979. But from 1980, the trend is reversed. Output per unit of energy is higher in the U.S. industry between 1980 and 2001. The output per unit of material input, the most important input in the industry, is also higher in the Canadian industry till 1993. But from 1994 onwards, the U.S. industry's material productivity exceeds that of Canadian industry.

CONCLUSION

This paper examines the relative prices and relative productivity levels in sawmills and wood preservation industry (NAICS 3211) between the United States and Canada using purchasing power parities and translog price indexes of rates of productivity growth. Preliminary results indicate that the competitiveness of the Canadian industry over its counterpart in the United States is due to the overwhelming impact of the variations in the exchange rates. Relative prices for the industry's outputs, except hardwood lumber and woodties-shingles-shakes, are lower in Canada relative to the U.S. throughout the period of analysis.

Competitiveness of the Canadian industry may have been facilitated by decreases in relative prices of materials, capital service, and energy inputs under the impact of changing exchanging rates. However, relative prices of capital have been on the rise in Canada during the final three years of this analysis. There appears to be no particular advantage for Canada in respect of material costs till 1991 since relative prices for materials were higher in Canada compared to the U.S. between 1958 and 1991.

Till 1996, relative productivity levels were higher in Canadian industry than its counterpart in the U.S. However, technology gap between the two countries closes by 1997 and thereafter U.S. industry's relative productivity level exceeds that of Canadian industry. Output per unit of labor and capital inputs were lower in the U.S. than in Canada throughout the period of analysis. However, output per unit of energy input since 1980 and output per unit of materials input since 1995 have been higher in the U.S. industry, and this may have led to higher relative productivity levels in the U.S. industry compared to Canadian industry since 1997

REFERENCES CITED

Abt, R.C., J. Brunet, B.C. Murray, and D.C. Roberts. 1994. Productivity growth and price trends in the North American sawmilling industries: an inter-regional comparison. *Can. J. For. Res.*, 24: 139-148.

Bartelsman, E.J., R.A. Becker, and W. Gray. 2000. The NBER-CES manufacturing industry database (Internet address: *http://www.nber.org/nberces/nbprod96.htm*). June 2000.

Briggs, D. 2004. Personal communication. College of Forest Resources, University of Washington, Seattle, WA.

Christensen, L.R., D.W. Jorgenson, and L.J. Lau. 1971. Conjugate duality and the transcendental logarithmic production function. *Econometrica*, 39(4):255-256.

Christensen, L.R., D.W. Jorgenson, and L.J. Lau. 1973. Transcendental logarithmic production frontiers. *Rev. Econ. Stat.*, 55(1):28-45.

Diewert, W.E. 1976. Exact and Superlative Index Numbers. *J. Econometrics*, 4 (4):115-46.

Jorgenson, D.W., and M. Kuroda. 1990. Productivity and international competitiveness in Japan and the United States, 1960-1985. In Hulten, C.R. (ed.), *Productivity Growth in Japan and the United States*, Studies in Income and Wealth, Vol.53, University of Chicago Press, pp.29-55.

Jorgenson, D.W., and M. Nishimizu. (Dec., 1978). U.S. and Japanese economic growth, 1952-1974: An international comparison. *Economic J.*, 88(352):707-726.

Kuroda, M., and K. Nomura. 1999. Productivity comparisons and international competitiveness. *Journal of Applied and Input-Output Analysis*, 5:1-36.

Lee, F.C., and J. Tang. 2002. Productivity levels and international competitiveness between Canadian and United States. Chapter 3 (pp. 93-115), in Someshwara Rao and Jianmin Tang (eds.), *Productivity Issues in Canada*, University of Calgary Press, Alberta, Canada.

President's Commission on Industrial Competitiveness. 1985. *Global Competition: The New Reality*, Volume I-II. Washington.

Influence of Markets on the Composition of Central Appalachian Forests

William G. Luppold[1]   Gary W. Miller[2]

USDA Forest Service   USDA Forest Service

[1]Project Leader, USDA Forest Service, Northeastern Research Station, 241 Mercer Springs Road, Princeton, WV 24740, email wluppold@fs.fed.us; (304) 431-2770

[2]Research Forester, USDA Forest Service, Northeastern Research Station, 180 Canfield street, Morgantown, WV 26505, email gwmiller@fs.fed.us (304) 285-1521

.

Influence of Markets on the Composition of Central Appalachian Forests

Abstract

Timber harvesting has been disturbing Central Appalachian hardwood forests since colonial times, but its most profound influence on forest composition has occurred during the last 130 years. Between the end of the Civil War and the Great Depression, the lumber industry went from state to state harvesting relatively large portions of the timber resource. This disturbance and the slash fires that occurred after harvesting frequently resulted in even-aged timber stands and an increase in northern red oak. During the Depression, harvesting decreased and marginal farm lands were abandoned. Mill size declined because of a scarcity of timber, and selective cutting based on diameter and species became common. While shade intolerant and mid tolerant species regenerated on abandoned farmlands, the implementation of selective cutting after 1929 generally favored the regeneration of shade-tolerant species. In 1973, the adoption of floating exchange rates ushered in an era of international trade. During this period, timber that regenerated during and after the era of heavy cutting grew into commercial size, and consumption by baby boomers resulted in an increase in demand for hardwood products. The markets that resulted further emphasized selective cutting based on timber quality and species. Today, the composition of hardwood forests reflects the history of harvesting disturbances and the changing market structures that promoted them.

Key words: Forest composition, hardwoods, hardwood markets

Introduction

During the last 130 years, timber harvesting has had a continual and profound influence on the composition of hardwood forests. Nowhere is this more apparent than in the Central Appalachian region of the eastern United States.[3] In this paper we analyze how harvesting and the market mechanisms that drive harvesting have affected and continue to affect forest composition in this region.

In this analysis, it is assumed that firms operating within forest-product markets attempt to maximize profits. We also assume at any given time there are established manufacturing and marketing procedures that set operational boundaries for harvesting practices. These practices continue until economic events force industry to reevaluate the market/resource situation and adopt new production technologies, harvesting procedures, and marketing practices. It also is assumed that these economic adjustments occur primarily during or after periods of declining profits in which firms are forced to reevaluate their competitive position within the market. When economic events are relatively mild and short lived, small changes in production and marketing that occur are best examined as cycles (Luppold et al. 1998). More dramatic economic events force industry to make even greater changes and are best examined as eras. Embodied in these assumptions is that economic events influence harvest patterns, but these patterns are predicated on the composition, quantity, and quality of timber available at the onset of an era.

It is further assumed that markets influence forests through harvesting by determining which trees are cut. Harvests affect forest composition directly through the removal of some or all standing trees. They affect the long-term process of regeneration indirectly by perturbing the distribution of biological resources. Research has shown that harvest patterns determine the long-term success of hardwood regeneration (Trimble 1973). While time and location-specific economic incentives (i.e., product prices and production costs) determine what portion of the canopy is removed at a harvesting site, the overall market determines long-term harvesting activities on a landscape level during a market era. However, because an extensive period is needed for hardwood timber to regenerate and mature, harvesting during a given era has the greatest impact on forest composition and related production and marketing practices in future eras.

Over the past 130 years three distinct eras were initiated by economic events and characterized by resource availability and harvesting practices (Fig. 1, Table 1). The dates in Table 1 are approximate because hardwood-processors need time to make the transition from one era to the next. Also, cycles continued to occur within each era, but these changes followed the harvesting pattern that was initiated at the beginning of an era. Finally, we reemphasize that the characteristics of the timber resource at the beginning of each era influence the predominant harvesting pattern.

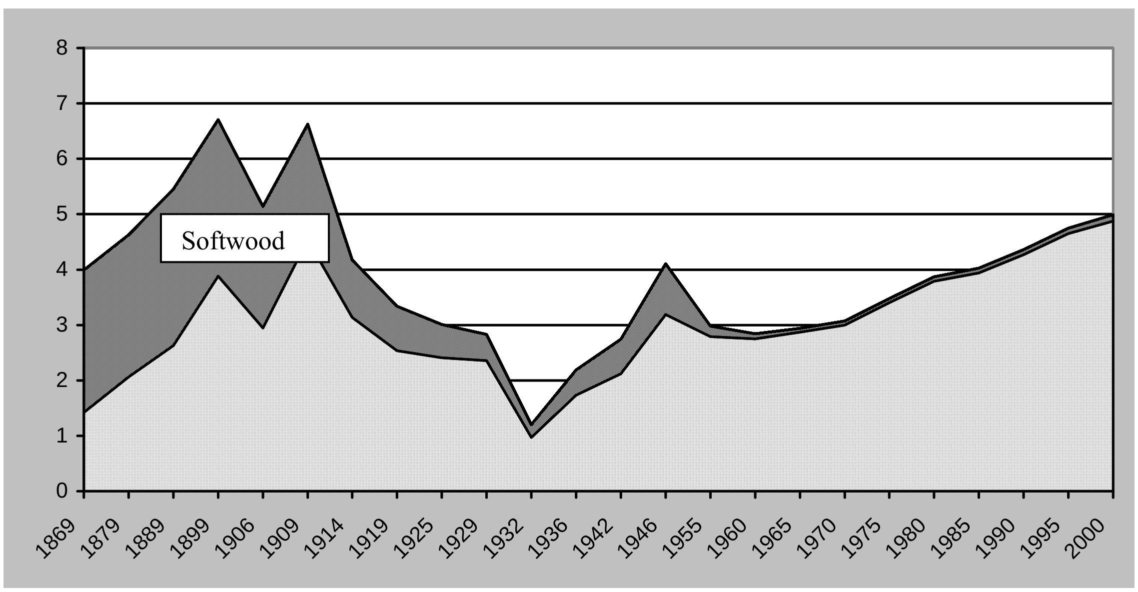
---

[3]The Central Appalachian Region includes Tennessee, Kentucky, Ohio, West Virginia, Pennsylvania, and New York.

Era of Heavy Cutting

Heavy cutting in the Central Appalachian region began with the onset of the Civil War and continued until 1929. East wide, lumber production increased by nearly 550 percent, peaking in 1909 (Steer 1948) as demand for lumber surged due to increased industrialization, urbanization, and immigration. Harvesting and production technology that existed during peak production years (steam donkeys, locomotives, and large band mills) allowed sawmills to grow to a size such that an area could be "logged out" in less than a decade (Clarkson 1964). In some areas, initial harvesting focused on specific high-value species such as spruce or white pine. Subsequent harvests were less discriminating as numerous species were removed (Carvell 1986). As a result, the era of heavy cutting often was characterized by partial harvests followed by more complete harvests decades later. The relatively large quantity of softwood produced in the Central Appalachian region in the 19th century reflects a much different forest than exists today.

Figure 1. Hardwood and softwood lumber production in the Central Appalachian region, 1869 to 2000. The x-axis is spaced unevenly due to limited data prior to 1906, the desire to show the magnitude of production decline resulting from the Depression, and the unavailability of state-level data from 1946 to 1954**.**



Source: 1869 to 1946, Steer 1948; 1955 and 1960, USDC Bureau of the Census, Current industrial reports 1956 and 1961; 1965 to 2000, USDC Bureau of the Census, Current industrial reports 1966, 1971, 1976, 1981, 1986, 1991, 1996, 2001 estimated adjusted for underreporting errors as identified in Luppold and Dempsey 1989 and 1994.

Table 1. – Dominant market disturbance characteristics for the three market eras in the Central Appalachian region of the eastern United States.

Era 1 (1869 to 1929) – The end of the Civil War and the large increase in immigration allowed the U.S. economy and population to rapidly grow. Initially, softwood species were harvested in large volume as the building activity increased. The timber resource was considered nearly endless, resulting in heavy nonsustainable harvest levels. Still, harvesting could occur in a two-stage process with the more valuable species harvested first and less valuable species removed a decade later. Large-scale harvesting facilitated the regeneration of mid-tolerant and shade intolerant species.

Era 2 (1932 to 1969) – The Great Depression caused a major reduction in demand. The smaller mills that survived during this era obtained timber through selective removal of wider diameter logs from the residual stands that were too young or left untouched during the previous era. The furniture industry was the dominant user of eastern hardwoods. Selective harvesting favored the regeneration of shade-tolerant species.

Era 3 (1973 to 1999) – A change in the international monetary system brought about floating exchange rates ushering in an era of international trade. International demand increased for both high-quality sawlogs and veneer logs as exports of lumber, sliced veneer, and logs increased. The emerging even-aged forests that regenerated after the era of heavy cutting provided an ample resource that resulted in selective harvesting based on the quality and value of the timber. Continued selective harvesting favored the regeneration of shade-tolerant species.

Softwood lumber produced during this era was used for construction while hardwood lumber was used to produce furniture, barrels, wagon spokes, handles, and others products. The relative magnitude of harvesting during this era is underestimated by lumber production levels (Fig. 1) because the level of tree utilization was considerably lower than today, i.e., large amounts of timber were left on the forest floor as slash or were otherwise underutilized. During this era, only small areas of forests that were immature, less accessible, or not for sale were left undisturbed.

Hardwood lumber production did not exceed softwood production until the late 1890s (Steer 1948). Oak was the most common hardwood lumber produced during the era of heavy cutting, but there is little information on the species group of oak produced. The lone year in which oak production was separated (1905) indicated that the volume of white oak lumber produced exceeded that of red oak by nearly 3 to 1 (Steer 1948). New York was the only state in the region in which red oak production exceeded that of white oak.

Lumber production in the Central Appalachian region peaked at 6.7 billion board feet in 1899 (and 6.3 billion board feet in 1909) and then declined. The two characteristics of this era that influenced future forest composition were near complete overstory removal and uncontrolled slash fire associated with land clearing. Clearcut harvesting allowed multiple species to regenerate, particularly those that are mid-tolerant. The combination of overstory removal followed by wildfires also increased promoted red oak regeneration (Brose et al. 2001).

The Depression through 1973

By 1929, much of the accessible timber in the Central Appalachian region had been harvested as lumber production declined by 57 percent from 1909. However, harvest decreased by an additional 58 percent between 1929 and 1932 with the onset of the Depression. The collapse of the agricultural economy during this period also hastened the abandonment of marginal farmlands. Today, much of this abandoned land in West Virginia is occupied by yellow-poplar.

A major difference between the era of heavy cutting and this second era was the realization by industry that timber supplies were not endless. Only small pockets of timber that had not been disturbed during the previous era were available for harvest (Carvell 1986). The diminished timber base could not continue to supply large band mills (Clarkson 1964). The remaining "smaller" sawmills used the limited volume of available timber. Because higher prices were paid for longer and wider lumber, larger diameter timber was preferred, thus encouraging the practice of diameter-limit cutting.

In the 1940s hardwood lumber production increased reaching a post-Depression high in 1946. The volume of hardwood lumber produced remained relatively constant during the 1950s, 1960s, and early 1970s. In contrast with previous decades, hardwood represented 70 percent of the lumber produced in the Central Appalachian region in 1950 and has yet to drop below this proportional level.

In the 1950s and 1960s, the furniture industries were the principal users of hardwood lumber (USDC Bur. of the Census 1961, 1966, 1971) as walnut, maple, and cherry were the major appearance species (Frye 1996). Yellow-poplar lumber was commonly stained to match walnut and cherry veneers or used as core stock and cross ply material with expensive face veneers. Yellow-poplar's versatility made it a relatively expensive lumber and timber species. In the 1950s, it was common to remove yellow-poplar from a stand but leave the oaks and other species Red oak was emerging as a major component of the inventory during this period (Wray 1952), but it remained a relatively low-value species.

Although hardwoods have traditionally been associated with appearance products, they also have been used for localized construction application, industrial products such as mine props and pallets (during and after World War II), and fine papers. Increased pulpwood production brought about limited clearcut harvesting, but diameter- limit cutting remained the predominant practice. The combination of diameter-limit cutting and different valuation of species resulted in harvesting regimes that removed only part of the canopy. This practice favored the regeneration of shade-tolerant species such as maple, beech, and blackgum.

Post 1973 Era

Implementation of floating exchange rates has been the most significant economic event influencing harvesting activities in the Central Appalachian region since 1973. Previously the rate of exchange between currencies was negotiated periodically between central banks. Floating exchange rates allowed currencies to be valued by currency markets and their implementation coincided with a 475-percent increase in hardwood lumber exports between 1973 and 2000 (Luppold and Araman1987; Emanuel and Rhodes 2003). Much of the initial increase in exports was high-quality lumber to Western Europe and Japan (Luppold and Araman

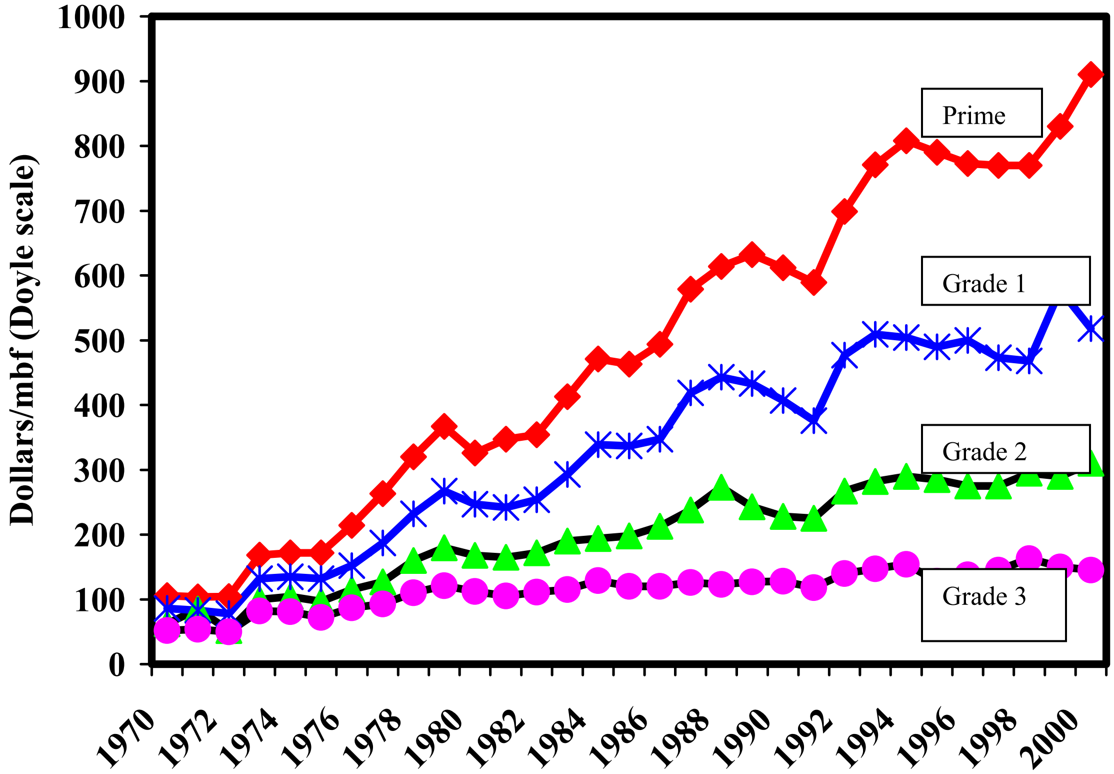
1987), resulting in a change in lumber merchandising practices. Before 1973, higher grades of hardwood lumber (FAS, 1F, and Select) were commonly priced and sold in combination with lower grades of lumber. The advent of export markets resulted in a premium being affixed to the price of higher grades of lumber. Also international demand for hardwood veneer and veneer logs sharply increased the demand for and price of high-quality hardwood sawtimber.

Another major change that occurred in the early 1970s was the acceptance of red oak as an appearance species by the furniture industry. We contend that this increased use of red oak occurred because low prices and ample inventories of this species no longer could be ignored by a furniture industry seeking to minimize production costs.

As a result of these changes in international and domestic demand, hardwood lumber production increased, the average size of sawmills grew, and the level of technology used by these sawmills became increasingly complex. Most of the technology adopted by mills increased the yield of higher-grade lumber that could recover from higher quality logs. These changes in production technology and the increased demand for veneer and veneer logs increased the demand for higher quality hardwood timber. As a result, selective cutting became more of a function of quality (bole clarity). This increase in demand was initially satisfied by increased sawtimber inventories as the forest that regenerated during and after the era of heavy cutting began to mature. However, the continued demand for higher quality logs by sawmills, veneer mills, and export markets caused a change in the relative value of logs by grade (Fig. 2).

By the end of the 20th century, more hardwood lumber and related products were being produced, consumed domestically, and exported than at anytime in U.S. history. While producers of industrial products such as pallets and railroad crossties used significant volumes of hardwood lumber and pulp and manufacturers of engineered wood product used large volumes of roundwood, demand for higher quality lumber and veneer logs drove harvesting activities in most areas of the Central Appalachian region. The demand for high-quality timber was in stark contrast to the increasing supply of lower grade timber that had been left in the forest, or shade-tolerant species that regenerated in uneven-aged stands promoted by repeated selective cutting.

Figure 2. Red oak sawlog prices in Ohio, by grade, 1970 to 2000



Source: Ohio Agricultural Statistical Service (1970 to 2001).

Conclusion

Harvesting disturbance differs from bio/physical disturbance in that it is predicated on the value of the resource as determined by the demand for wood products. The actual volume of timber removed in a given year or from a given site is influenced by timber removal and conversion technology, type of roundwood markets near the resource, and efficiency of the market in distinguishing among various wood products. Although harvesting is constrained by the availability of the resource, it is shifted by economic events, controlled by preexisting demand and supply situations, and augmented by technological changes. In short, the market adapts to what is in the woods contingent on the underlying economy and availability of wood and nonwood substitute products.

The profit maximizing behavior inherent in the market system creates interesting dilemmas. Underutilization of a species or group of roundwood products can lead to biological abundance and low prices for decades. However, in the long run, these low prices may result in new technologies or marketing plans that exploit this abundance and lead to overutilization and economic scarcity as reflected by higher prices. For example, the disturbance pattern that led to its successful regeneration of red oak before the Depression has been replaced by one that favors competing species. Harvesting patterns are based on current market conditions, rather than biological conditions needed to sustain this species (Lorimer 1993).

Another dilemma is that the higher the quality stands, the greater the potential of some form of high grading. This in itself does not pose a problem, but high grading in the absence of treatments needed to sustain species composition can reduce the economic value of a stand. And while hardwood lumber production was higher during the last part of the 20th century than during earlier periods, better timber utilization (a greater percentage of the standing timber transformed into product) and the transition from softwood to hardwood forests that occurred after the era of heavy cutting have allowed hardwood sawtimber inventories to continue to increase (Smith et al. 2001). Still, decades of selective removals of specific species in a patchwork manner have resulted in a complex mosaic of stand conditions for forests in the eastern hardwood region.

Literature Cited

Brose, P, T. Schuler, D. Van Lear, and J. Berst. 2001. Bring fire back, the changing regimes of the Appalachian mixed-oak forests. J. of Forestry, November: 30 - 35.

Carvell, K.L. 1986. Effect of past history on present stand composition and condition. P. 1-7 in Proc. Of guidelines for managing immature Appalachian hardwood stands, Morgantown WV.

Clarkson, R.B. 1964. Tumult on the mountains, lumbering in West Virginia--1770-1920. McClain Printing Co., Parsons, West Virginia. 410 p.

Emanuel, D. and C. Rhodes. 2003. Bulletin of hardwood market statistics: first half 2003. USDA For. Serv. Res. Sta. NE-382.

Frye, L.R. 1996. The most popular furniture woods: the historic perspective. Wood and Wood Prod. 100(14): 304-307.

Lorimer, C.G. 1993. Causes of the oak regeneration problems. P. 14-39 in Proc. oak regeneration: serious problems practical recommendations, Loftis, D.L. and C.E. McGee, (eds.). USDA For. Serv. Gen. Tech. Rep. SE-84.

Luppold, W.G. and P.A. Araman. 1987 Hardwood trade trends: U.S. exports. USDA For. Serv. Res. Pap. NE-611. 8 p.

Luppold, W.G. and G.P. Dempsey. 1989. New estimates of central and eastern U.S. hardwood lumber production. Northern J. of Applied Forestry. 6(3): 120-123

Luppold, W.G. and G.P. Dempsey. 1994. Factors affecting regional changes in hardwood lumber production. Forest Products J. 44(6): 8-14

Luppold, W.G., J.P. Prestemon, and J.E. Baumgras. 1998. An examination of the relationships between hardwood lumber and stumpage prices in Ohio. Wood and Fiber Sci. 30(3): 281-292.

Ohio Agricultural Statistical Service. 1970 to 2001. Ohio timber prices. Ohio Agricultural Statistical Service, Columbus. 2p.

Smith, W.B., J.S. Vissage, D.R. Darr, and R.M. Sheffield. 2001. Forest resources of the United States, 1997. USDA For. Serv. Gen. Tech. Rep. NC-219. 190 p.

Steer, H.B. 1948. Lumber production in the United States 1799-1946. USDA For. Serv. Misc. Pub. 669.

Trimble, G.R., Jr. 1973. The regeneration of central Appalachian hardwoods with emphasis on the effects of site quality and harvesting practice. USDA For. Serv. Res. Pap. NE-282. 14 p.

USDC Bureau of the Census. 1956 to 2001. Current industrial reports, lumber production and mill stocks. U.S. Dep. of Com., Bur. of the Census. Washington, D.C.

USDC Bureau of the Census. 1961. United States Census of Manufacturers: 1958. U.S. Dep. of Com., Bur. of the Census. Washington, D.C.

USDC Bureau of the Census. 1966. United States Census of Manufacturers: 1963. U.S. Dep. of Com., Bur. of the Census. Washington, D.C.

USDC Bureau of the Census. 1971. United States Census of Manufacturers: 1967. U.S. Dep. of Com., Bur. of the Census. Washington, D.C.

Wray, R.D. 1952. Forest statistics for West Virginia. USDA For. Serv. W V No. 1. U.S. 48 p.

The Patterns of Pulpwood Trade within the US South

Maksym Polyakov[19] and Larry Teeter[20]

Abstract

The Southern timber market is the major source of both softwood and hardwood pulpwood in the US. In 1997, three-fourths of total US pulpwood production was produced in the region. The locations of pulpmills and fiber sources determine the patterns of pulpwood trade between the states. Prediction of trade is important for understanding subregional pulpwood markets in the US South and for timber inventory projections on a subregional level. In this paper we estimate determinants of pulpwood trade flows among the states of the US South using a gravity model.

Keywords: Pulpwood, Interregional trade, Gravity Model, Tobit.

[19] Graduate Research Assistant, School of Forestry and Wildlife Sciences, Auburn University, Auburn, AL 36849-5418. Phone: (334) 844 1053; e-mail: polyama@auburn.edu
[20] Professor and Director, Forest Policy Center, School of Forestry and Wildlife Sciences, Auburn University, Auburn, AL 36849-5418. Phone: (334) 844 1045; e-mail: teeter@auburn.edu

The Patterns of Pulpwood Trade within the US South

1. Introduction

Recently, there is increasing interest in timber supply and demand projections on the subregional level in order to understand effects of changes in timber dependent industries, urbanization, and population growth on forest resources on the local level (Abt et al., 2000). Thus, accounting for the interregional aspects is an important part of timber supply and demand modeling.

It appears that, despite the fact it is uneconomical to transport raw materials such as wood long distances, significant volumes of wood in the U.S. South are transported across state boundaries. And, more pulpwood than sawtimber is traded between states in the region. Nearly 30% of the pulpwood consumed by the pulping industry in the region arrives at the mill from other states of the region (while less than 1% is imported from outside of the U.S. South). This is one of the reasons why we have restricted our study to the analysis of pulpwood trade. Most state level econometric studies of supply and demand take trade into account as an exogenous variable. Creation of a model capable of predicting timber supply and demand at the local level requires understanding factors influencing trade of timber products among the states.

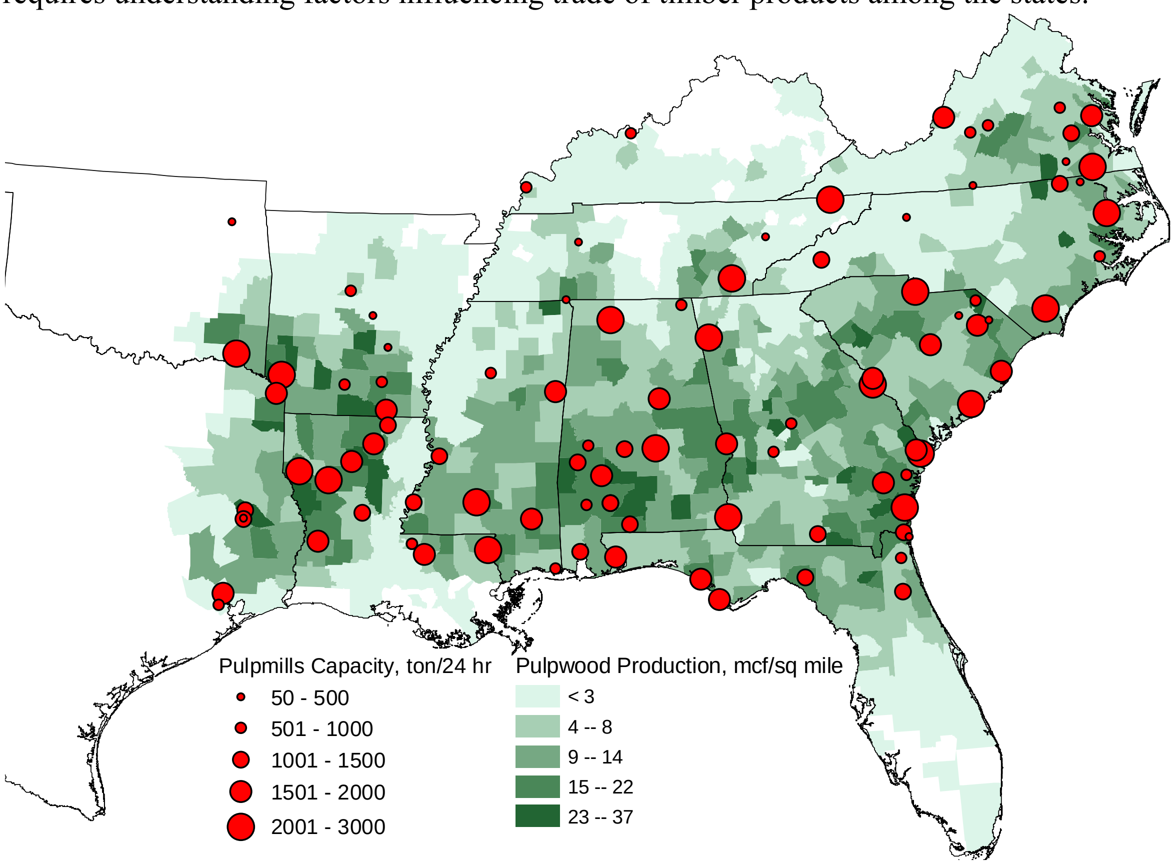


Figure 1: Pulpwood Production and Pulpmills Located in the South

The main reason for the occurrence of cross-state pulpwood trade is the distribution of pulpmill locations and the location of timber harvest, which is determined by the location of mills and location of inventory (see Figure 1). Pulpwood consumption and production in each state occurs not at a single point, but in an area or group of points. Location of production areas and

concentrations of pulping industry do not obey state lines, which in some cases cross areas of concentration of consumption and production. At the same time the statistics are aggregated by states. As a result we observe the trade across state boundaries (often in both directions — "cross-hauling"). Most of such trade takes place between neighboring states, but some amounts are traded between the states which do not share a common boundary, while volume of trade between neighboring states greatly varies.
The objectives of this study are to identify factors affecting pulpwood trade between states of the U.S. South and estimate their influence.

2. Method

Several groups of methods exist for regional interdependence analysis. Among them are fixed trade coefficient models (multiregional input-output models), gravity models, and linear programming models.

Linear programming (LP) models require a large number of parameters behind the mechanism of interregional trade. For timber inventory modeling, LP was used in the Interregional Timber Supply Model (Holley et al., 1975).

In this study we will apply a gravity model, that utilizes empirical trade relationships between industries in different regions.

Tinbergen (1962) and Pöyhönen (1963) independently had the idea of explaining bilateral trade flows by comparing it to the Newtonian law of gravity, where the attraction of two countries "masses" (size of economy represented usually by GDP or population or combination — *Y*) is weakened by the "distance" separating them (transportation costs — *D*) and influenced by other factors (*X*).

$$T_{ie} = \beta_0 (Y_i)^{\beta_1} (Y_e)^{\beta_2} (D_{ie})^{\beta_3} (X_{ie}^1)^{\gamma 1} ... (X_{ie}^n)^{\gamma n} \varepsilon_{ie} \quad (1)$$

This model is usually estimated using a log-log specification.

The gravity equation subsequently became a popular instrument of foreign trade analysis. Early on there was a criticism that it had no theoretical foundation, however a number of works followed (Anderson, 1979; Bergstrand, 1985) which showed that the gravity equation could be derived from the baseline model of trade.

While used widely to analyze various factors affecting trade, such as tariffs, quotas, and trade agreements (including trade of forest products, Kangas and Niskanen, 2003), some studies showed that cross-sectional gravity analysis can yield very wide forecast interval spans around the predicted values, which make it almost useless for estimating trade potentials (Breuss and Egger, 1999).

A number of recent studies suggest that the panel framework has many advantages over the cross-section approach and that the proper econometric specification of a gravity model would be a three-way fixed effect approach (Mátyás, 1997, 1998; Egger, 2000). Furthermore, Egger (2003) argued that proper specification of a panel-based gravity model should include exporter-by-importer bilateral interaction effects. However, the use of bilateral interaction fixed effects makes distance, border and other similar explanatory variables redundant.

In the present study, the following pooled cross-section and time-series gravity model was used:

$$T_{iet} = \beta_0 (D_{ie})^{\beta_1} (B_{ie})^{\beta_2} (C_{it})^{\beta_3} (C_{et})^{\beta_4} (I_{it})^{\beta_5} (I_{et})^{\beta_6} (P_{it})^{\beta_7} (P_{et})^{\beta_8} \varepsilon_{iet} \quad (2)$$

where *i*, *e*, and *t* are importing state, exporting state, and year; T_{iet} is pulpwood trade quantity (thousand cords); D_{ie} is the distance between consumption and production centers of trading states (kilometers); B_{ie} is the dummy taking 1 if states share a border; C_{it} and C_{et} are the pulping capacities (tons per 24 hours); I_i and I_e are timber inventories (mcf); P_{it} and P_{et} are stumpage prices ($ per cord)

The border dummy (B_{ie}) was introduced because distance (D_{ie}) between supply and demand centers of the trading states is not capable of fully reflecting propensity to trade due to the proximity of the states. The border dummy is expected to have a positive regression coefficient. The "size of the economy" is represented by pulping capacities of the trading states. The expected signs of pulping capacities are positive.

The other variables included in the model are pulpwood inventories and stumpage prices. It is expected that a higher stumpage price in the importing state (I_i) and a larger inventory in the exporting state (P_{it}) would increase trade quantity, while a higher stumpage price in the exporting state (I_e) and a larger inventory in the importing state (P_{et}) would negatively influence trade quantity.

3. Data

The data used in the study are the bilateral trade quantities among eleven states during the period 1994–2001. The trade between each pair of states in both directions was accounted for separately. This makes up 880 observations for the each of the traded products (softwood and hardwood pulpwood). The trade is the total quantity in thousand cords of, respectively, softwood and hardwood roundwood pulpwood traded among eleven states of US South. Pulping capacity is annualized daily pulping capacities of states' pulp and paper industries in thousand tons. The sources of data on pulpwood trade and pulping capacity are the "Southern Pulpwood Production" reports, an annual report series from the USDA Forest Service Southern Research Station.

Stumpage price data are from Timber Mart South (Norris Foundation, 1977–2001). Annual prices of softwood pulpwood and hardwood pulpwood were obtained by averaging statewide quarterly data; prices are expressed as U.S. dollars per cord. Forest Inventory Analysis (FIA) inventory data for each of 11 states were obtained from the USDA Forest Service website and included the following inventories: Alabama-2000, Arkansas-1995, Florida-1995, Georgia-1997, Louisiana-1991, Mississippi-1994, North Carolina-1990, South Carolina-1993, Tennessee-1999, Texas-1992, and Virginia-1992.

Euclidean distances between exporting states' centers of inventory and importing states' centers of consumption were determined using ArcGIS. Exporting states' centers of inventory were calculated separately for hardwoods and softwoods as centers of mass of counties for each of the states weighted by, respectively, softwood or hardwood inventory from the latest FIA data. Importing states' centers of consumption were calculated as centers of mass of pulpmills for each of the states weighted by mills' daily pulping capacity (Johnson, 2003).

4. Estimation and Results

Nearly 60% of the observations represent zero trade. In analytical terms this means that the dependent variable is left-censored at zero, since the value of the quantity of trade cannot be negative OLS gives inconsistent and biased estimates in such cases (see Figure 2). The common method for analyzing censored data sets of this type is the Tobit model (Tobin, 1958):

$$\tilde{Y}_i = \boldsymbol{\beta}' \mathbf{x}_i + \varepsilon_i,$$
$$Y_i = \begin{cases} 0 & \text{if} \quad \tilde{Y}_i \le 0, \\ \tilde{Y}_i & \text{if} \quad \tilde{Y}_i \ge 0, \end{cases} \tag{3}$$

where Y_i is the latent dependent variable, $\tilde{Y}_i$ is an observed dependent variable, $\boldsymbol{\beta}$ is a coefficient vector, $\mathbf{x}_i$ is a vector of explanatory variables, and ε_i is an error term.

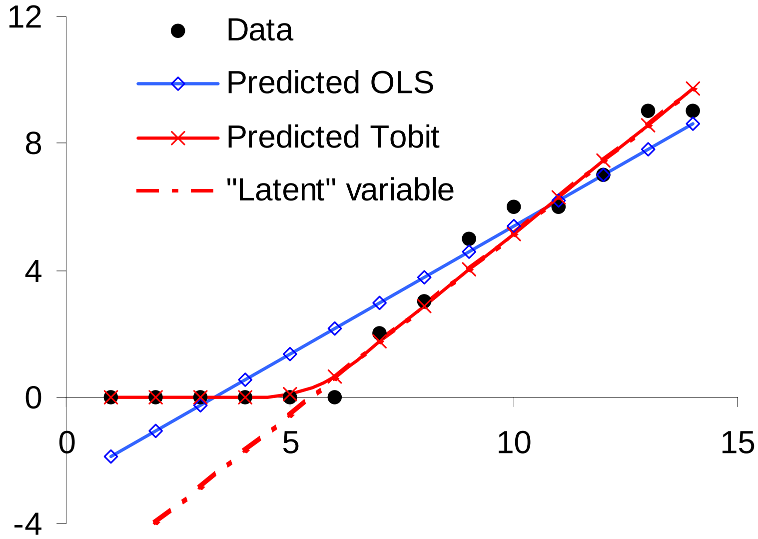


Figure 2: Tobit model vs. OLS

Consistent estimates of the parameters of the Tobit model may be obtained using maximum likelihood estimation procedures (Greene, 2000).

Coefficients of a Tobit regression determine both the probability of the dependent variable being above the censoring limit and the change in the dependent variable if it is above the censoring limit. Changes in the dependent variable due to changes in the explanatory variables, or marginal effects, are nonlinear and are not equal to the regression coefficients.

Tobit model estimation results for the gravity equations, as well as the marginal effects, are presented in Table 1.

Table 1: Tobit Estimates of Gravity Models

	Softwood			Hardwood		
	Estimate	$P > \chi^2$	Marginal effect†	Estimate	$P > \chi^2$	Marginal effect†
Intercept	-14.00	0.110	-6.89	17.14	0.051	9.60
D_{ie}	-7.31	<.001	-3.60	-7.41	<.001	-4.15
B_{ie}	7.33	<.001	3.61	6.68	<.001	3.74
C_{it}	3.48	<.001	1.71	0.73	0.189	0.41
C_{et}	2.40	0.004	1.18	0.70	0.208	0.39
P_{it}	2.04	0.011	1.00	2.93	0.000	1.64
P_{et}	-1.52	0.066	-0.75	-0.12	0.873	-0.07
I_i	-1.11	0.217	-0.55	-0.27	0.581	-0.15

I_e	1.66	0.059	0.82	1.99	<.001	1.12
□	4.79			4.72		
R^2_{MZ1}	0.71			0.69		

†Marginal effects are calculated at the sample mean.

As indicated by the values of the pseudo-R^2's (Veall and Zimmermann, 1994), the gravity models explain 71% and 69% of the variation in the dependent variables (logs of, respectively, softwood and hardwood pulpwood trades between individual states). Coefficients of most explanatory variables are significant and all have the expected signs. As expected, the distance and border variables have the most explanatory power (as indicated by their marginal effects and χ^2). The coefficient of the distance variable has a much higher absolute value than usually indicated in the literature on gravity models, e.g. Kangas and Niskanen (2003). This is due to the fact that roundwood products are uneconomical to transport long distances.

Coefficients of pulpwood inventory for exporting states are significant in both models, and marginal effects (elasticities) are close to unity, which is consistent with the theory. In the softwood pulpwood model, stumpage prices in importing and exporting states have effects of similar magnitude and opposite directions. In the hardwood pulpwood model, quantity of trade is elastic with respect to the stumpage price in importing state, however, it seems that quantity of trade is not effected by the stumpage price in exporting state. Pulping capacities in the hardwood pulpwood model were not found significant probably because of our inability to discriminate between hardwood and softwood pulping capacity.

5. Discussion and conclusion

The paper presents an econometric analysis of pulpwood trade among eleven states of the U.S. South. It estimates a gravity trade equation using a Tobit model and pooled cross-sectional–time series data.

The results indicate that geographic distance between importing and exporting states, size of timber economy, stumpage prices in importing states, and pulpwood inventories in exporting states have been important determinants of the quantity of pulpwood trade.

The next step in this analysis is to evaluate the predictive ability of the model, and compare it with predictive abilities of other models, such as a gravity model estimated with a fixed error component, a fixed coefficient gravity model, and simultaneous equations demand and supply model.

References

Abt, R.C., F.W. Cubbage, and G. Pacheco. 2000. Southern forest resource assessment using the subregional timber supply (SRTS) model. Forest Products Journal 50(4): 25–33.

Holley, D.L., R.W. Haynes, and H.F. Kaiser. 1975. An interregional timber model for simulating change in the softwood forest economy. School of Forest Resources, NC State University, Raleigh, NC.

Tibergen, J. 1962. Shaping the world economy; suggestions for an international economic policy. Twentieth Century Fund, New York, 330 p.

Pöyhönen, P. 1963. A tentative model for the volume of trade between countries. Weltwirschaftliches Archiv 90: 93–99.

Anderson, J.E. 1979. A theoretical foundation for the gravity equation. American Economic Review 69(1): 106–116.

Bergstrand, J.H. 1985. The Gravity Equation in international trade: Some microeconomic foundations and empirical evidence. Review of Economics & Statistics 67(3): 474–481.

Kangas, K., and A. Niskanen. 2003. Trade in forest products between European Union and the Central and Eastern European access candidates. Forest Policy and Economics 5(3): 297–304.

Breuss, F., and P. Egger. 1999. How reliable are estimations of East-West trade potentials based on cross-section gravity analyses? Empirica 26(2): 81–94.

Mátyás, L. 1997. Proper econometric specification of the gravity model. World Economy 20(3): 363–368.

Mátyás, L. 1998. The gravity model: Some econometric considerations. World Economy 21(3): 397–401.

Egger, P. 2000. A note on the proper econometric specification of the Gravity Equation. Economics Letters 66(1): 25–31.

Egger, P., and M. Pfaffermayr. 2003. The proper panel econometric specification of the gravity equation: A three-way model with bilateral interaction effects. Empirical Economics 28(3): 571–580.

Norris Foundation. 1977–2001. Timber Mart-South. The Daniel B. Warnell School of Forest Resources, University of Georgia, Athens.

Johnson, T.G., and C.D. Steppleton. 2003. Southern Pulpwood Production, 2001.

Resource Bulletin SRS-84. USDA FS Southern Research Station, Asheville, NC, 40 p.

Tobin, J. 1958. Estimation of relationships for limited dependent variables. Econometrica 26: 24–36.

Greene, W.H. 2000. Econometric Analysis. Prentice-Hall, NJ, 1004 p.

Veall, M.R., and K.F. Zimmermann. 1994. Goodness of fit measures in the Tobit model. Oxford Bulletin of Economics and Statistics 56(4): 485–499.

An Examination of Regional Hardwood Roundwood Markets in West Virginia

William Luppold[1]   Delton Alderman[2]

USDA Forest Service   USDA Forest Service

[1] Project Leader, USDA Forest Service, Northeastern Research Station, 241 Mercer Springs Road, Princeton, WV 24740. email: wluppold@fs.fed.us; 304.431.2700 (v); 304.431.2772 (fax)

[2] Research Forest Products Technologist, USDA Forest Service, Northeastern Research Station, 241 Mercer Springs Road, Princeton, WV 24740. email: daldeman@fs.fed.us ; Phone: 304.431.2700 (v); 304.431.2772 (fax)

Examination of Regional Hardwood Roundwood Markets in West Virginia

Abstract

West Virginia's hardwood resource is large and diverse ranging from oak-hickory forests in the southern and western portions of the state to northern hardwood stands in the northeastern region. West Virginia also has a diverse group of primary hardwood- processing industries, including hardwood grade mills, industrial hardwood sawmills, engineered wood-product manufacturing facilities, rustic-fence plants, face-veneer operations, a hardwood plywood mill, and several pulpwood concentration yards that supply mills in Ohio, Maryland, and Virginia. Each of these primary hardwood-processing industries has specific roundwood requirements with respect to species and quality, resulting in diverse roundwood markets. We examine the diversity of West Virginia's roundwood markets based on a survey of 30 logging and associated roundwood merchandising operations. The harvesting operations surveyed merchandised roundwood to an average of four markets each. However, the production of sawlogs or peeler logs appeared to be the primary driver of these harvesting operations. Other roundwood markets appear to be secondary and material is merchandised for these markets as profit opportunities emerge. Of the species harvested in West Virginia, yellow-poplar is the most versatile as it is used for sawlogs, peeler logs, and rustic fencing. Yellow-poplar also is the primary species used in the production of oriented strand board.

Keywords: hardwood markets, roundwood, yellow-poplar

[1]This manuscript is publication # FO386 of the Forest and Wildlife Research Center, Mississippi State University.

[2]Graduate Research Assistant, Department of Forestry, Mississippi State University, Box 9681, Mississippi State, MS 39762. bkt2@msstate.edu (662) 325-8358 (v); (662) 325-8726 (fax).
[3]Professor, Department of Forestry, Mississippi State University, Box 9681, Mississippi State, MS 39762. imunn@cfr.msstate.edu (662) 325-4546 (v); (662) 325-8726 (fax).
[3]Professor, Department of Forestry, Mississippi State University, Box 9681, Mississippi State, MS 39762. dle@sitl.cfr.msstate.edu (662) 325-2796 (v); (662) 325-8726 (fax).
[5]Associate Professor, Department of Forestry, Mississippi State University, Box 9681, Mississippi State, MS 39762. rparker@cfr.msstate.edu (662) 325-2775 (v); (662) 325-8726 (fax).
[6]Associate Professor, Department of Forestry, Mississippi State University, Box 9681, Mississippi State, MS 39762. sroberts@cfr.msstate.edu (662) 325-3044 (v); (662) 325-8726 (fax).

Introduction

West Virginia's hardwood resource is large and diverse ranging from oak-hickory forests with extensive quantities of yellow-poplar to northern hardwood stands with significant amounts of hard maple and black cherry (DiGiovanni 1990). West Virginia also has a diverse group of primary hardwood-processing, industries including hardwood grade mills, industrial hardwood sawmills, engineered wood product manufacturing facilities, rustic-fence plants, a face veneer plant, a hardwood plywood veneer mill, and several round- and pulpwood concentration yards that serve mills in Ohio, Maryland, and Virginia. Each of these industries has specific roundwood requirements with respect to species and quality. [21] This large number of markets also creates opportunities to better use hardwood roundwood. However, the form and degree of roundwood product segmentation in West Virginia or other hardwood-producing regions have not been well documented.

In this paper we examine the number of roundwood markets in West Virginia and the distance that roundwood is hauled to end users. Data were developed from a survey of 30 active logging jobs during 2001. The survey provided information on the number and type of hardwood roundwood products merchandised at each site and the distance to market(s). The survey also provided information on the factor that influenced merchandising decisions. We first examine the composition of West Virginia's forest and primary forest-products industry and briefly describe data-collection procedures.

West Virginia's Sawtimber Resource

West Virginia comprises three survey units or regions (Fig. 1) as designated by the USDA Forest Service's Forest Survey and Analysis (FIA) program (DiGiovanni 1990). The Northeastern region contains 40 percent of the state's sawtimber inventory followed by the Southern and Northwestern regions that has 34 and 26 percent, respectively (Table 1). Although yellow-poplar is the most common species in all three regions, the Northeastern region has a higher proportion of currently high-value species: northern red oak, hard maple, and black cherry. While twenty-two percent of the sawtimber volume in the Southern region is yellow-poplar, this region also has large proportions of oak species. The Northwestern region has the higher proportions of select white oaks and other red oaks (e.g. primarily black, pin, and scarlet).

An alternative way to examine the forest resource is to categorize sawtimber by hard and soft hardwood species (Table 1). Hard hardwood species include the oaks, sugar maple, ashes, hickories, and elms. Soft hardwood species include yellow-poplar, soft maple, birch, beech, basswood, the gums, and aspen. Pulp and paper manufacturers in the states that border West Virginia prefer hard hardwood species, while soft hardwood species are preferred by the manufacturers of engineered wood products (EWP) and hardwood plywood. In fact, the high volume of yellow-poplar led to the construction of three EWP facilities and one hardwood plywood peeling operation in West Virginia.

Figure 1. – West Virginia's Forest Inventory and Analysis survey regions.

[21] Luppold, W.G.; Bumgardner, M.S. Regional changes in the timber resources and sawmilling industry in Pennsylvania. In press.

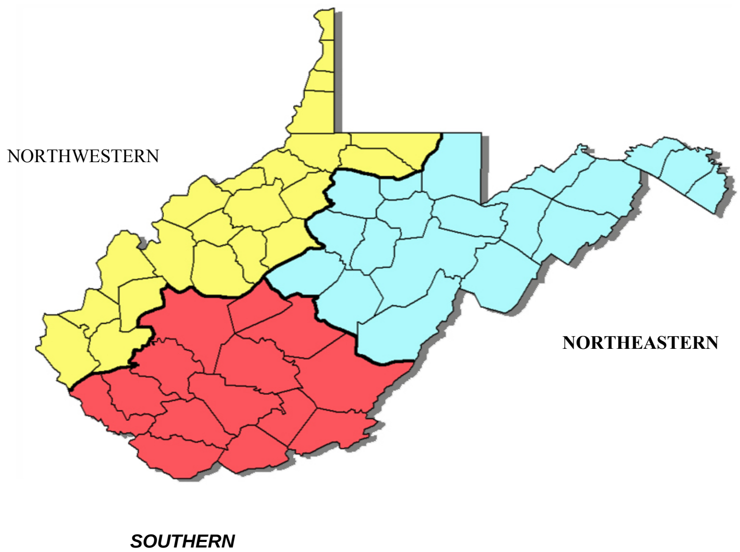


Table 1. – Board-foot and proportional volumes of sawtimber for the Northwestern, Southern, and Northeastern survey regions of West Virginia 2000[a].

Species	Northeastern Volume	Northeastern Proportion	Southern Volume	Southern Proportion	Northwester Volume	Northwester Proportion
	(mmbf)	(percent)	(mmbf)	(percent)	(mmbf)	(percent)
Yellow-poplar	4,113	14.3	5,395	22.5	3,480	18.5
Select red oak	3,418	11.9	2,453	10.3	1,541	8.2
Other red oaks	1,392	4.9	2,168	9.1	2,012	10.7
Select white oak	2,051	7.2	2,025	8.5	2,862	15.2
Other white oaks	2,136	7.4	2,165	9.0	1,383	7.4
Hard maple	2,103	7.4	1,008	4.2	786	4.2
Soft maple	2732	9.5	1,335	5.6	842	4.5
Hickory	1,236	4.3	1,425	6.0	1,318	7.0
Black cherry	1,827	6.4	310	1.3	559	3.0
Soft hardwood pulpwood species [b]	9,690	33.8	9,783	39.6	6,223	30.2
Hard hardwood pulpwood species [c]	13,007	45.4	11,735	49.0	10,743	57.2
Softwoods	2,333	8.1	994	4.2	751	4.0
All species	28,660		23,930		18,782	

[a] Source: USDA Forest Service (2004).
[b] Includes yellow-poplar, soft maple, birch, beech, basswood, gums, and aspen.
[c] All oaks, hard maple, ash, hickories, and elms.

Forest Industry in West Virginia

In West Virginia, hardwood sawmills are the most important operations that consume hardwood roundwood (Table 2). In 1999, the state had more than 160 sawmills, with nearly half in the Northeastern region. Mills in the Northeastern region are more numerous but the Southern mills are on average larger. The Northwestern region has about the same number of mills as the Southern region but production is only about one-third of that in the South. Hardwood mills also can be divided into larger mills that primarily produce graded lumber (National Hardwood Lumber Association Rules) and other mills (Table 2).

Table 2. -- Capacity of hardwood sawmills and number of hardwood sawmills and other major consumers of hardwood roundwood, by region[a].

Mill type	Northeastern	Southern	Northwestern
Number of sawmills	95	41	44
Capacity of sawmills (million board feet)	352	306	96
Number of OSB mills	1	1	0
Capacity of OSB mills (million cords)	450	255	0
Number of peeler mills (LVL[b], veneer, and plywood)	1	2	0
Capacity of peeler mills (million board feet)	40	50	0
Number of pulpwood yards	4	2	4
Number of rustic-fence plants	15	1	2

[a] Source: West Virginia Division of Forestry (2001).
[b] Laminated veneer lumber.

Grade sawmills consume high-quality logs, however the highest quality logs are consumed by the sliced face-veneer industry. In 1999, there was one slicing operation in the Southern region and a second was being constructed in the Northwestern region. However, the logs consumed by this industry usually are sorted in log yards rather than at harvest sites (Wagner et al., in press).

West Virginia has two oriented strandboard mills (OSB) in the Northeastern and Southern regions (Table 2) that primarily consume lower quality soft hardwood and softwood roundwood, including tops and limbs. The Northeastern region also has a laminated veneer lumber (LVL) mill and the Southern region has a rotary veneer mill. Both operations consume yellow-poplar "peeler" logs which are relatively clear upper logs that can be used to a small-end diameter of 8 inches. The Southern region also has a hardwood face-veneer facility that uses a rotary lathe to slice oak and basswood.
Manufacturers of rustic-fences also uses hardwoods. In addition to locust, a hard hardwood, this

industry also uses smaller diameter yellow-poplar logs and other “soft” species in the manufacture of rails. One additional hardwood using industry that exists in West Virginia is rustic-fence manufacturing and most of these operations are in the Northwestern region. There are no pulpwood mills in West Virginia although 10 pulpwood yards provide material to mills in adjoining states. The Northern region has four yards apiece, while the Southern region has only two yards.

Data Collection Procedures

During 2001, 30 logging operations in West Virginia were interviewed and surveyed. Respondents were asked the type of products they merchandised and their destination, one-way haul distance to destination, method of handling products of secondary importance, delivered price, timber ownership, harvesting method, and about the relationship between logger and purchaser. Because West Virginia has three FIA survey regions, it was decided to stratify the sample on the sawtimber in these regions. Thus if 30 sites were selected 12 were indicated for the Northeastern region, 10 in the Southern region, and 8 in the Northeastern region. Loggers willing to cooperate in the survey were located by contacting primary processors and the West Virginia Division of Forestry. The final sample differed slightly from the original design with 13 observations in the Northeastern region, 9 in the Southern region, and 8 in the Northwestern region.

Roundwood Merchandising in West Virginia

Roundwood merchandising for the 30 operations surveyed is summarized in Table 3. In addition to the six markets listed, four minor markets were identified: alloy chips, softwood pulpwood, firewood, and logs for log homes. On average, the harvesting operations surveyed merchandised roundwood to about four markets (Table 3). All but two operations listed three or more roundwood markets and one operation listed six. One operation did not produce hardwood sawlogs as a primary product or at least one additional hardwood product. The lone operation that produced a single product was a softwood pulpwood harvest exclusively.

Peeler logs were the second most common roundwood product merchandised among the surveyed operations. Nearly half of the operations that merchandised these logs considered peelers as additional primary products. The proportion of operations merchandising peeler logs was high as a result of the relatively high price for this material ($350 to $400 per thousand board feet – Doyle scale). A higher percentage of operations in the Southern region merchandised peeler logs as two-thirds of these operations considered peeler logs as a primary product. The LVL plant in the Northeastern region purchases peeler logs to a 7-inch small-end diameter, while the hardwood plywood mill in the Southern region purchases logs to a 10-inch small-end diameter. The Northeastern region had a lower percentage of peeler log merchandising, possibly because rustic-fence manufacturers purchase yellow-poplar logs to a 6-inch small-end diameter.

Table 3. -- Number and percentage of surveyed logging operations mechanizing to major roundwood markets, by region.

Mill type	Northeastern (Number)	Northeastern (Percent)	Southern (Number)	Southern (Percent)	Northwestern (Number)	Northwestern (Percent)
Sawlogs	13	100	9	100	7	88
Peeler logs for LVL and plywood	9	69	8	89	6	75
Number of jobs reporting that peelers a primary product	2	15	6	66	3	38
OSB	8	62	7	78	7	88
Pulpwood	7	54	4	44	5	63
Low-grade sawlogs	7	54	2	22	4	50
Rustic-fence	5	39	1	11	1	13
Average number of markets[a]	4.2		4.1		3.8	
Range in the number of markets	2 to 5		3 to 5		1 to 6	

[a] Includes additional markets for metallurgical chips, log home logs, and firewood.

OSB is the third most common market for hardwood roundwood. This product requires a greater volume of roundwood material than peeler mills, but the relative value of OSB material is considerably less. OSB appeared to be more important in the Southern and Northwestern regions than in the Northeastern region.

Raw material for rustic-fence manufacturers was important only in the Northeastern region (Table 3). That rustic-fence manufacturers can use a portion of logs that otherwise would be shipped to an OSB mill might account for the lower percentage of OSB roundwood merchandising in the Northeastern region.

Pulpwood was merchandised by more than half of the operations appeared to be more important in the Northern regions. The lack of pulp markets in the Southern region is partly due to rough terrain and a lack of major highways in the western portion of this region.

Impact of Market Haul Distance

Transportation economic theory stipulates that the greater the value of a commodity per unit weight, the greater the distance the commodity can travel to the end consumer (Bressler and King 1970). However, there are underlying aspects of the hardwood roundwood market that counters this assumption. Larger sawmills are primary users of higher value hardwood roundwood.[22] These mills are disturbed widely in West Virginia and appear to be competitive in both input and output markets. Still, grade mills obtain sawlogs through a variety of channels, including ownership of standing timber, open-market stumpage purchases, log purchases from independent loggers, and logs purchased from concentration yards. Mid-and low-grade sawlogs usually are processed by numerous smaller sawmills or rustic-fence manufacturers. By contrast, peeler mills, OSB plants, and pulp mills are less numerous (Table 2) and consume greater quantities of roundwood. Therefore, even though these larger users may consume lower value roundwood, their requirements and locations imply that on average, roundwood must be hauled a greater distance from harvest site to the mill.

Average haul distances to various roundwood markets are presented in Table 4. Since all but one of the logging operations sampled was associated with the production of sawlogs, the haul distance to the mill or distribution yard for this primary product is a critical factor. In the three regions, the average distance to the primary sawlog delivery point ranged from 33 to 35 miles. This narrow range would be expected given the relatively even distribution of large and small sawmills located throughout West Virginia. However, there was considerable variation in the haul distances to other roundwood consumers.

Peeler logs were hauled 49 to 86 miles from the logging site to the mill. The haul distance in the Northeastern region may be shorter due to the LVL mill in which can purchase smaller logs, and also to the large number of rustic-fence manufacturers that purchase small-diameter yellow-poplar logs. Roundwood directed to OSB manufacturers was hauled an average of 95 miles from the Northwestern region, which has no OSB facility. The haul distance for pulpwood varied considerably from region to region, perhaps because of the combination of topography and access to highways. Of the three regions, the Northwestern region, relatively speaking, flat when compared to the western portion of the Southern region has some of the greatest average slopes in the eastern United States.

The greater distance that lower grade hardwood roundwood is shipped in West Virginia leads us to believe that these products are merchandised as profit opportunities emerge. Both OSB and pulp mills attempt to compensate loggers for the distance materials are hauled when market conditions merit these premiums. However, these large users also may reduce or eliminate suppliers from distant areas when demand for OSB or pulp declines.

Conclusion

Our examination of "how" roundwood is merchandised in West Virginia demonstrates the complexity of hardwood roundwood markets in this state. Ten markets were identified when harvesting operations were examined. However, sawlogs, peeler logs, OSB roundwood, hardwood pulpwood, low-grade sawlogs, and rustic-fence material were cited most frequently as end-use destinations. On average, there were about four roundwood markets for each logging operation surveyed through the number of markets ranged from one to six.

Other than the distance that sawlogs were hauled and the average number of roundwood markets per logging job, there was little consistency among the three regions as each is different in forest composition, topography, and industries that consume hardwood. Although 29 of the

[22] Face veneer logs are the highest value form of hardwood roundwood. However, these logs usually are transported to a sawmill or mill yard before they are remerchandised to a log buyer.

30 harvesting operations surveyed indicated that “higher grade” sawlogs were a primary product, most of the low-quality roundwood markets appeared to be opportunistic in nature.

One of our most interesting findings was the importance of yellow-poplar to a variety of industries in West Virginia. Total consumption of small diameter yellow-poplar logs by the LVL, hardwood plywood, and rustic-fence industries exceeds 80 million board feet annually. OSB manufacturers also use lower grade yellow-poplar roundwood while yellow-poplar butt logs are processed by sawmills. The multiple uses of yellow-poplar are unique because it is possible that segments of an individual tree could be merchandised for three to five discrete roundwood users.

References

Bressler, R. G.; King, R.A. 1970. Markets, prices and interregional trade. New York: John Wiley & Sons. 426 p.

DiGiovanni, D. M. 1990. Forest statistics for West Virginia --1975 and 1989. USDA For. Serv. Res. Bull. NE-114. 172 p.

Kingsley, N. P. and D. R. Dickson. 1965. Timber production in West Virginia – 1965. USDA For. Serv. Res. Bull. NE-10. 52 p.

US Department of Agriculture Forest Service. 2004. Forest inventory mapmaker version 1.0 U.S. D.A For. Serv. http://ncrs2.fs.fed.us/4801/fiadb/index.htm

Wagner J. E.; Smalley, B.; Luppold, W. G. (in press). Factors affecting the merchandising of hardwood logs in the southern tier of New York. Forest Products J.

West Virginia Division of Forestry. 2001. The forest industry of West Virginia. . West Virginia Bureau of Commerce, Div. of For., 113 p.

Residual stand characteristics of a thinned cherrybark oak plantation

Rebecca A. Montgomery, Research Specialist, University of Arkansas-Monticello School of Forest Resources, Monticello, AR 71656-3468
and
Matthew H. Pelkki, Associate Professor and George H. Clippert Endowed Chair of Forest Management, Economics, and Policy, University of Arkansas-Monticello School of Forest Resources, Monticello, AR 71656-3468
and
Robert J. Colvin, Research Specialist, University of Arkansas Southwest Research and Extension Center, Hope, AR 71801

Residual stand characteristics of a thinned cherrybark oak plantation

ABSTRACT

In 1962 a plantation of cherrybark oak was established on the second bottom of an Upper Coastal Plain creek in Hempstead County in southwestern Arkansas. During the tenth growing season, three replicates were set up for the following treatments: thinning, thinning and pruning, and control (no treatment). Thinning from below was repeated at ages 21, 26, and 31 in both the thinned and thinned/pruned plots. A one-time pruning operation was applied in the thinned/pruned plots during year 10. Trees were measured for height and diameter growth periodically throughout the study. In 2003, tree grade and diameter were determined for all residual stems in the study. Diameter growth was greatest in thinned treatments. Control treatments had a significantly higher percentage of below grade trees than treatments receiving thinning. This is attributed to smaller average diameters and increased stand stress due to higher stand density. Pruning appeared to have no affect on sawtimber value, tree grade, or standing sawtimber value. Due to the small size of the study area and possible edge effects on the small plots (1/10 ac), the reader is cautioned that these results may not be indicative of all cherrybark oak plantations in the South.

Keywords: bottomland hardwoods, tree grade, pruning

INTRODUCTION

The cherrybark oak tree (*Quercus pagoda* var. Raf) is one of the most sought after bottomland oaks in the southeastern United States. This species of oak, with characteristics such as fast growth, large diameter size, and relatively branch-free bole (Fowells 1965) is one of the most valuable bottomland oak species. Few oak trees in the south can match the growth, timber quality, and beauty of the cherrybark oak tree. It is among the largest oaks in the red oak family, often reaching a height of 100 to 130 ft and diameters (dbh) of 3 to 5 ft (Harlow and others 1996). A shade intolerant species, cherrybark oak is widely distributed on high-quality, well-drained loamy soils in bottoms and terraces along the Southeastern Coastal Plain and Mississippi Valley (Krinard 1990).

This study focuses on the residual stand quality of a cherrybark oak plantation established in 1962 at the University of Arkansas Southwest Research and Extension Center in Hempstead County, Arkansas (Roth et al 1993). The main study objective was to determine the effects of repeated thinnings and a one-time pruning on the growth of cherrybark oak. Pelkki and Colvin (2004) reported on the growth characteristics of this stand over time, but did not report on the effect pruning and thinning had on residual stand quality. This paper will focus on residual stand quality and value at age 42.

METHODS

Bare-root 1-0 seedlings were planted on a 7 by 8 ft spacing (778 trees/ac) on a 2- acre old-field site in 1962. The site has Marietta series soils which are fine, loamy and well- drained with a site index of 110 (base age 50) for cherrybark oak. Since the site is located on a creek bottom, it is prone to frequent flooding during the winter months.

The stand was allowed to grow without treatment until year 10. At that time, the stand was divided into nine plots, each plot consisting of nine rows of nine trees (each plot 0.104 acre). Rows of 2-4 trees were left between each plot and the outside of the entire study area as plot buffers. Three treatments (thin only, thin/prune, and control), each with three replicates, were applied to randomly selected plots. Plots which were selected for the thin treatment were thinned periodically over the life of the stand. Plots which were selected for the thin/prune treatment were also thinned periodically over the life of the stand, but trees within these treatments also were pruned once. The control was not thinned or pruned throughout the life of the study.

The first thinning was applied to the thin and thin/prune plots at year 10. This thinning was a pre-commercial thin conducted by removing every other tree in the plot. In addition to receiving the thinning treatment at this time, trees within the thin/prune plots were also pruned to a height of 7 ft. This was the first and last pruning trees within this treatment received. At years 21 and 26, both thinned and thinned/pruned plots were thinned from below to a 75% stocking level based on Gingrich's (1971) guide. At ages 31 and 39, thin plots were thinned again to a 75% stocking level while thin/prune plots were thinned to 80 ft^2 of basal area per acre.

Tree height and dbh measurements have been taken regularly throughout the life of the stand. Total tree height measurements were taken for nine trees designated in each plot, with the most recent measurements occurring prior to thinning at age 39. During the summer of 2003, tree grades were determined for the butt log of all trees in the study and dbh measurements were taken. Total cubic foot volume to a 9" top diameter outside bark (dob) was determined for all sawtimber-sized trees while volume to a 4" top was determined for all pulpwood sized trees using volume tables for cherrybark oak in the South (Clark and Souter 1996). Using Arkansas stumpage prices for oak from Timber Mart-South (2000), current per acre value was calculated for each of the three treatment types based on tree grade and volume. Analysis of variance and Duncan's multiple range test were used to determine treatment differences for average diameter, total standing volume, sawtimber volume, pulpwood volume, pulpwood value, sawtimber value, and graded volume at age 42.

RESULTS AND DISCUSSION

During the initial analysis, Pelkki and Colvin (2004) found that throughout the study, there have been no apparent effects of pruning on diameter, height, or volume produced. Thinning has improved diameter growth rates over the life of the study with thinned plots exhibiting significantly greater average diameters than the control plots (Pelkki and Colvin 2004). No significant differences in total tree height by treatment were observed during the study (Pelkki and Colvin 2004).

Standing total volume was found to be significantly greater in control plots than in the thin and thin/prune plots at age 42 (Table 1). Likewise, standing pulpwood volume and pulpwood value were significantly greater in control plots relative to thin and thin/prune plots. Sawtimber value was significantly greater in thinned plots than in the control plots: however there was no significant difference between the control plots and thin/prune plots or between the thin and thin/prune plots at age 42.

No significant differences in volumes by tree grade were found. Thus, the pruning performed early in the life of the stand had no noticeable affect on tree grade. In this study thinning had no effect on volume by tree grade. The proportion of grade 2 trees was found to be significantly greater in thin only plots compared to control plots, but no difference was detected between the thin/prune plots and control or thin only plots (Table 1). A significantly higher proportion of below grade trees was found in the control plots compared to the thin and thin/prune plots. This is likely due to the smaller average diameter size of trees within the control plots which were classified as below grade because of their size (<9.6").

CONCLUSIONS

Thinning has proven to be efficacious in promoting diameter growth in this cherrybark oak stand. The one time pruning which occurred in this study had no overall effect on tree growth, value, or grade. Plots which did not receive any treatments over the years had a higher proportion of below grade trees than those that received thinning. This is mainly attributed to the smaller diameter size of trees within the control plots which caused trees to automatically be classified as below grade. Due to the small size of this study caution should be exercised before applying these results to other bottomland hardwood areas in the South. Edge effects from this study may have influenced tree characteristics such as grade, epicormic branching, and growth.

Table 1 Stand characteristics of a cherrybark oak stand at age 42.

	Control	**Thinned**	**Thinned/pruned**
TPA	266	99	80

	Avg. dbh (inches)	10.3[a]	13.8[b]	14.7[b]
Residual Stand Volume (ft^3/ac)	*Pulpwood*	2161[b]	56[a]	53[a]
	Sawtimber	1974	2654	2272
	Total volume	4134[a]	2710[b]	2325[b]
Residual Stand Value ($/acre)	*Pulpwood*	$ 261.00[a]	$ 7.00[b]	$ 6.00[b]
	Sawtimber	$1313.00[b]	$1985.00[a]	$1520.00[ba]
	Total value	$1574.00	$1992.00	$1526.00
Volume By Grade (ft^3/ac)	*Grade 1*	0	205	0
	Grade 2	764	1234	722
	Grade 3	641	771	997
	Below grade	569	443	554
Percent Grade By Treatment (%)	*Grade 1*	0%	3.0%	0%
	Grade 2	10.6%[b]	39.1%[a]	28.1%[ba]
	Grade 3	18.8%	29.4%	45.4%
	Below grade	70.6%[a]	28.5%[b]	26.4%[b]

*different superscripts indicate a significant difference among treatments, $\alpha=0.05$

Literature Cited

Clark, A., and R.A. Souter. 1994. Stem cubic-foot volume tables for tree species in the South. USDA For. Serv. Res. Pap. SE-290. 241 p.

Fowells, H.A. 1965. Silvics of forest trees of the United States. Ag. Handb. 271. USDA For. Serv. 762 p.

Gingrich, S.A. 1971. Management of young and intermediate stands of upland hardwoods. USDA Forest Serv. Res. Pap. NE-195. 26p.

Harlow, W.M, E.S. Harrar, J.M. Hardin, and F.M. White. 1996. Textbook of dendrology. McGraw-Hill. 534 p.

Krinard, R.M. 1990. Cherrybark oak. P. 644-649 *in* Burns, R.M. and B.H. Honkala, (eds.), Silvics of North America, Vol. 2, Hardwoods. Ag. Handb. 654. USDA For. Serv. 877 p.

Pelkki, M.H. and R.J. Colvin. 2004. Effects of thinning in a cherrybark oak plantation. South. J. Appl. For. 28(1): 55-58.

Roth, F.A. II, G.L. Wheeler, and R.J. Colvin. 1993. Growth of a cherrybark oak plantation after 29 years on a coastal plain creek-bottom site. P. 479-483 *in* USDA For. Serv. Gen. Tech. Rep. SO-93.

Timber Mart-South. 2000. 2000 Yearly Summary. TimberMart-South, Warnell School of Forest Resources, University of Georgia-Athens.

Trends in Workers' Compensation Insurance Costs in the Logging Industry

Clayton B. Altizer[2], Laura A. Grace[3], and William B. Stuart[4]

Abstract

Workers' Compensation Insurance (WCI) is one of the most complex components of logging cut and haul rates. Logging is recognized as one of the most hazardous occupations, as reflected in the workers' compensation premiums paid by employers in the industry. Significant effort has been made in the last decade to reduce the cost of workers' compensation insurance. These efforts include discontinuing certain types of policies, intensifying payroll auditing, and increasing safety and loss control efforts. Self-insurance funds have become more common, and many markets now insist that wood must be produced by crews with workers' compensation coverage.

This research examines whether the reduction in rates for logging has led or lagged the rate for all employers and whether structural changes in the industry are confounding comparisons. The data set was developed from logging firm financial records covering 401 logger business years between 1988 and 2002. Findings include that while logging WCI rates decreased between 1990 and 2000, those for all employers decreased earlier and by a larger amount. Logging WCI rates started to increase in 2001, while those for all employers remained flat. Changes within the logging industry, especially contracting out trucking operations, have had an effect.

Key Words: Timber Harvesting, Outsourcing, Slippage

Research Supported by:

The Forest and Wildlife Research Center (FWRC) - Mississippi State University

The USDA Wood Utilization Research (WUR) Program

The Wood Supply Research Institute (WSRI)

Introduction

Workers' Compensation Insurance (WCI) is one of the most complex components of logging cut and haul rates. It is mandated both morally and legally. Workers in the industry should be compensated for injuries suffered in the process of transforming a tree from a biological specimen to raw material delivered at the gate of a converting facility. The cost of those injuries should be factored into the price paid for that conversion and delivery. "Repairs to a machine that gets broke are considered business expenses, why shouldn't repairs to a person that gets hurt be the same" (Lindemuth, 1960).

Prior to the passage of workers' compensation legislation, employers had a variety of common law defenses – contributory negligence, fellow servant rule, and assumption of risk – available to avoid responsibility for work place accidents. The Triangle Shirtwaist Company fire of 1911, killing 150 women one day after the New York Court of Appeals ruled the state's first attempt at workers' compensation laws unconstitutional changed the political mood (Wilson, 1989). By 1920, 42 of the 48 states had some form of workers' compensation laws (Hobbs, 1939), with the other six following close behind. These laws were either mandatory, where employers were required to carry insurance on qualifying employees, or voluntary, where the employer was not required to carry insurance but gave up all common law protections for avoiding legal responsibility (Godwin, 1980). By the fall of 2001, Texas remained the only state with a truly voluntary workers' compensation system (Anonymous, 2003).

Workers' compensation is a true "no-fault" insurance. An injured worker accepting workers' compensation coverage forgoes the right to sue the employer for anything but the most extreme negligence. The employer may feel burdened by the workers' compensation premium, but is protected from the risk and potential catastrophic cost of tort actions by employees.

Ratemaking

Insurance is a regulated industry; regulated by the state to assure that the insurance company earns a reasonable, but not excessive profit (generally held to around 2.5% of premiums collected). State insurance commissioners consider the two sources of income for insurance firms when evaluating premium levels, those from the collection of premiums and those from investing financial reserves. When investment markets are doing well, the surplus can be used to buffer premiums, when such markets are not doing well, premium receipts have to cover all expenses.

The fundamental concepts of workers' compensation insurance and pricing is that the risk exposure of each employer is in part a function of the business engaged in, in part a function of past experience, and further influenced by the laws and courts of the state in which that business is based. The National Council on Compensation Insurance (NCCI), the manager of the nation's largest data base on workers' compensation insurance, recognizes over 920 different employment categories or codes used in an attempt to make risk assessment as targeted as possible.

Logging is covered by one nationwide code, 2702, Logging or Lumbering and Drivers, or one of seven state-specific codes, such as 2705, Logging or Lumbering-Pulpwood Only, available in Georgia, Louisiana, Mississippi, North Carolina, and Tennessee, or 2719, Logging or Lumbering-Mechanized Harvesting Exclusively-and Drivers, available only in Mississippi. Some insurance carriers allow trucking to be split from logging and covered under 7228, Trucking: Local Hauling Only, if certain conditions are met. Rates for most classification codes are set as dollars of premium per $100 of payroll, with the exception of 2705 (Pulpwood Only) which is an "upset rate" based on production.

Ratemaking data is collected by NCCI from two major sources, the Unit Statistical Plan Reports containing information on individual policy holders, and from insurance carriers' financial reports. This information is used to calculate rates by classification codes, which are then submitted to individual state insurance commissioners for approval. This "manual rate" is then used as a beginning point for the insurance broker or agent to apply premium discounts, and experience modifiers to determine the premium assessed to an individual firm. Table 1 shows the manual rates for logging, hauling and selected other professions for four southern states.

Table 1. NCCI Manual rates for selected employment codes ($/100 payroll) (Source: NCCI, 2004).

	State			
NCCI Employment Code	**AL**	**GA**	**MS**	**SC**
1164 (Mining NOC - Not Coal - Underground and Drivers)	16.90	11.94	15.43	7.85
2702 (Logging or Lumbering and Drivers)	*34.81*	*57.54*	*44.88*	*25.27*
2705 (Logging or Lumbering - Pulpwood Only - and Drivers)	*N/A*	*178.14*	*136.12*	*N/A*
2719 (Logging or Lumbering - Mechanized Harvesting Exclusively - and Drivers)	*N/A*	*N/A*	*21.64*	*N/A*
5551 (Roofing - All Kinds - Yard Employees and Drivers)	60.85	46.74	37.48	28.98
6003 (Pile Driving)	34.63	31.16	19.38	16.64
6236 (Oil or Gas Well: Installation or Recovery of Casing and Drivers)	63.37	74.12	32.04	34.00
7228 (Trucking - Local Hauling Only - and Drivers)	16.68	14.94	14.27	10.47
8601 (Engineer or Architect - Consulting) [used for Foresters]	1.44	1.50	2.03	1.02
8868 (College: Professsional Employees and Clerical) [used for College Professors]	0.87	0.92	0.77	N/A
8871 (Clerical Telecommuter Employees)	0.91	0.61	0.64	0.31

(Italicized employment codes are those that directly represent logging occupations.)

The difference between the developed rate and the net earned rate can be significant. Since the financial data used to set rates includes both returns from underwriting and investment of funds, the relationship reflects both the loss history and the performance of the investment markets. Discounts can be higher in years of expected high investment returns and less during periods of economic retraction. The premium discounts for four southern states are depicted in Figure 1.

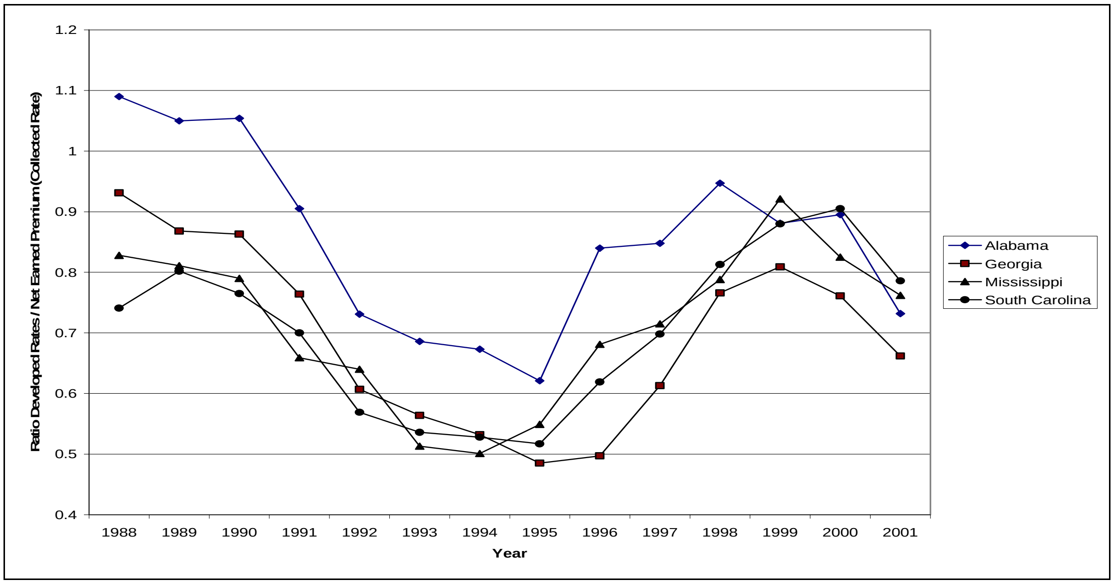


Figure 1. The relationship between developed rates and earned premium (Source: NCCI, 2003).

The differences in overall premium levels among states over time can be demonstrated by matching the total net earned premium for each state (as reported by NCCI) with the total non-farm personal income (as reported by the Bureau of Economic Analysis (BEA)), resulting in an estimate of the premium dollars per $100 of non-farm payroll (NCCI/BEA WCI Index) for each state. The values are approximations; the earned premium is reported, and the non-farm personal income is developed from information collected for other purposes, but does demonstrate that overall WCI rates increased in the late 1980's, but decreased throughout the 1990's (Figure 2).

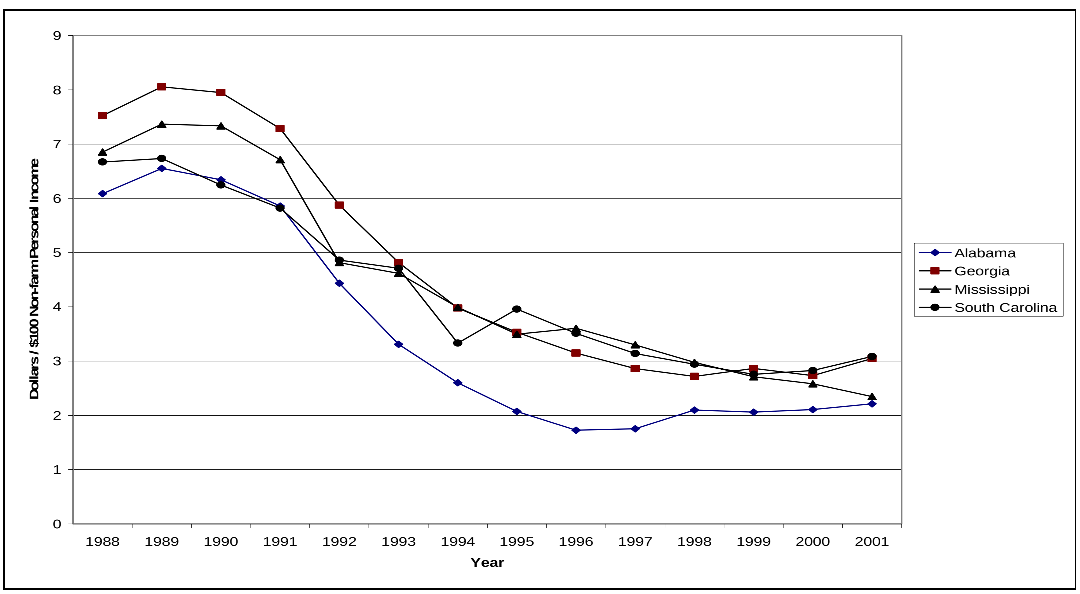


Figure 2. Net earned premium dollars per $100 of non-farm personal income (as an indicator of payroll) for four southern states (Source: NCCI, 2003).

There was a significant downward trend in overall WCI costs from 1988 to 2001. There were likely several reasons for this:

1. The rising workers' compensation rates in the late 1980's caused concern in all areas of employment, not just the forest industry, and several different approaches were used to bring them under control.
2. There was an increased emphasis on work place safety. The opportunity cost of an accident had risen to the point where it was in the interest of the employer to reduce risks.
3. Insurance carriers mounted greater loss control efforts.
4. Systems for reducing slippage were put in place. Slippage occurs when an employer reports fewer employees (or less payroll) than actual to reduce premiums but then turns in all losses. (Unofficial estimates from insurance carriers in the late 1980's were that slippage in the logging industry in some states could have been as high as 40 percent!)
5. "Vendor to" policies, where purchasers of logging services deducted an agreed amount from payment for services that was used to buy coverage for the supplier, were discontinued.
6. There was less reliance on "upset rates" and increased auditing of payroll records.
7. Self insurance funds became more common and more carriers entered the market, increasing competition.

These loss control efforts had an associated cost, part of which is reflected in the expense ratios for the portion of collected premium going to the costs of doing business over the period reported by NCCI (Figure 3). Not all of these costs can be attributed to more loss control specialists and increased auditing expenses, but they do reflect a change in the way of doing business during the 1990's.

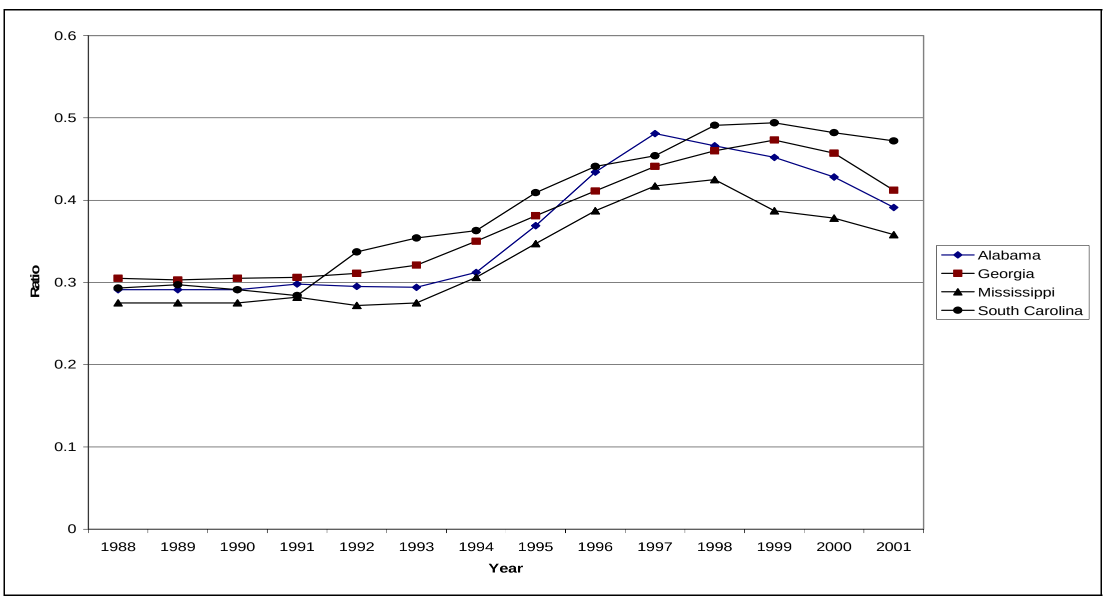


Figure 3. NCCI Expense ratios for 1998-2001 for four southern states (Source: NCCI, 2003).

Timber Harvesting

We have been constructing a data base of detailed cost and productivity information for a sample of logging contractors since 1988. As with any data base of individuals or firms, some data elements may be difficult to separate because of the format in which the data is provided, participation changes over time, new firms are added, and previous participants choose not to continue or leave the industry. The population includes small firms and large, cutting pine and hardwood, performing clearcuts and specialized silvicultural operations (For a more complete description see Stuart, Grace, and Altizer, 2003). Each observation represents a year's work by a firm, a considerable investment of money and time, and therefore too important to dismiss.

Participants reported annual production and costs in six categories: equipment, labor, consumable supplies, contract services, insurance, and administrative overheads. Workers' compensation insurance is included in the labor expense rather than insurance because it is normally a direct function of total payroll. We were able to extract 401 business years of data for 55 firms for which we could separate workers' compensation premium from labor payroll, from this data. The data spans 15 years from 1988 to 2002 (Figure 4).

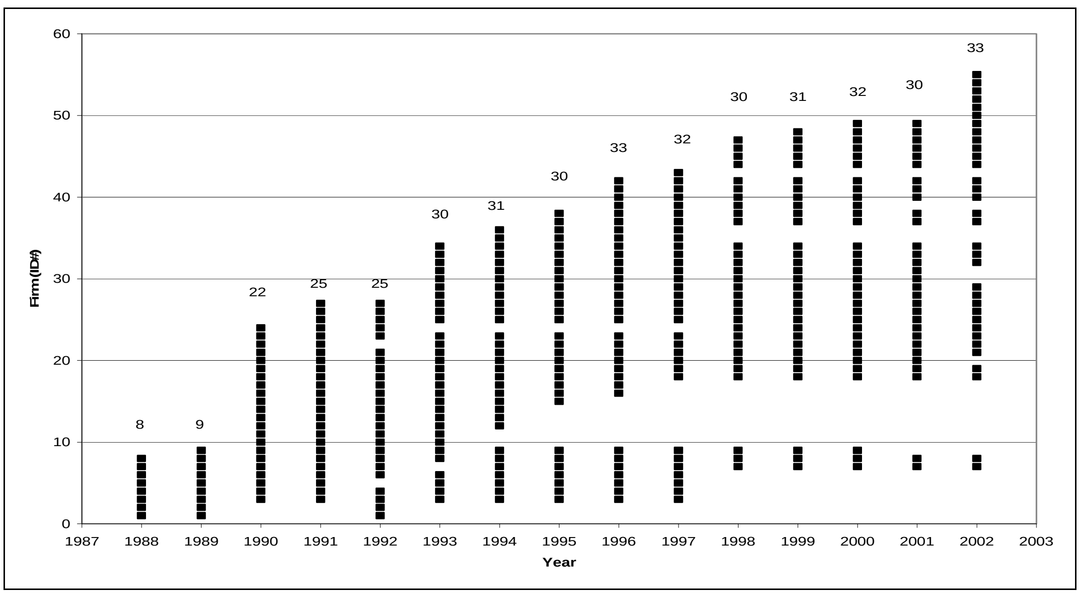


Figure 4. Firms participating in the long-term cost and productivity study by year.

In the early stages of the project, many firms did not separate workers' compensation insurance from total labor costs. Consequently, sample sizes for 1988 and 1989 are rather small and not indicative of the actual level of participation in the overall project for those years. Observations for '88 and '89 have been provided as markers or indicators. The number of participating firms for each year of the study period is listed above each year's respective bar series. The numbers listed along the y-axis are categorized by each firm's respective identification number which was the sole identifier for the entire 15 year study period. As a result these numbers do not necessarily directly correspond to the actual number of participants for any given year. One firm has participated for the full fifteen years, 60% of the firms have provided data for five years or more, and 80%, three years or more.

Box and whiskers plots are used to demonstrate changes in the entire population. The data is divided into quartiles; the box spans the middle 50% of the observations. The median is indicated by a crossbar through the box. That span of the box is termed the inter-quartile range or IQR (roughly equivalent to +/- one standard deviation in parametric statistics). The "whiskers" extending from the ends of the box reach to the last observation lying within 1.5 times the IQR from either end of the box (roughly equivalent to +/- two standard deviations). Values beyond the end of the whisker, but within +/- 3 times the IQR from the ends of the box are moderate outliers and indicated by "0", those beyond 3 times the IQR are extreme outliers and indicated by "x".

Total production cost per ton, unadjusted for inflation, has crept up slowly for these firms over time (Figure 5). Adjusted for inflation, the median cost has decreased by $2.05 or 12% between 1990 and 2002. The distribution of costs flattened and moderate high-side outliers increased in later years as firms struggled to adjust to the altered wood supply system of the late 1990's. It is interesting to note that there were no low-side outliers.

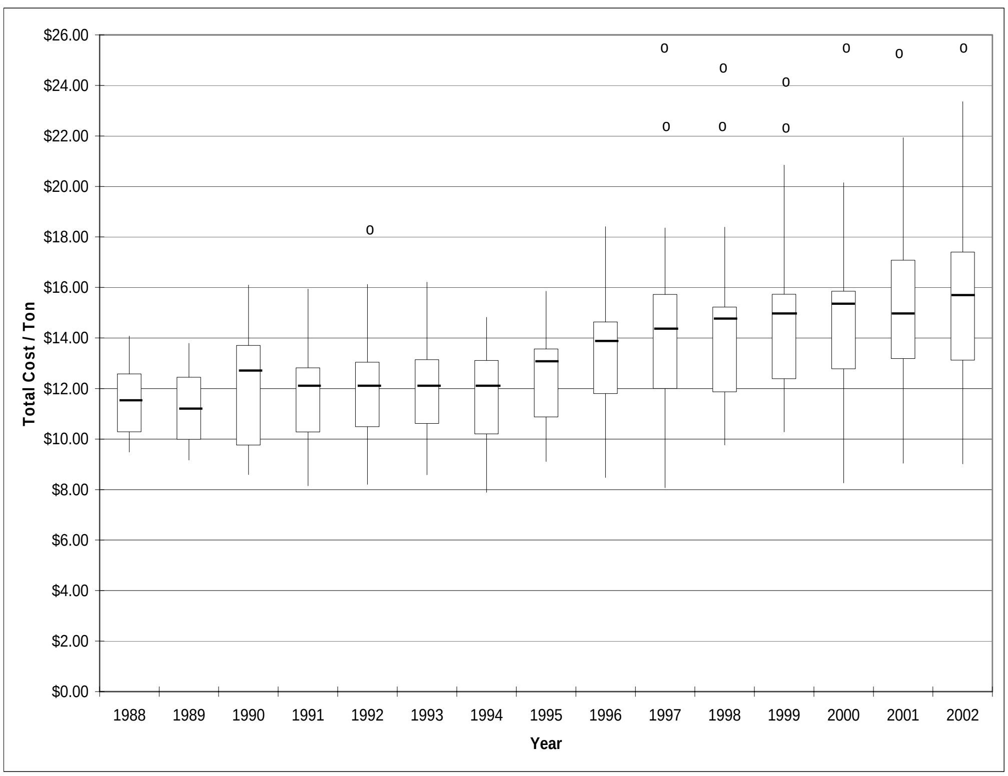


Figure 5. Total cost per ton (unadjusted for inflation).

Workers' compensation costs per ton for these logging firms, in unadjusted dollars, have declined over the period (Figure 6). The total spread between the lowest and the highest rate has been volatile as businesses changed missions and restructured to accommodate changes in the wood supply system. The inter-quartile range has narrowed. The median rate trended downward through the 1990's and then began to creep back up in 2001.

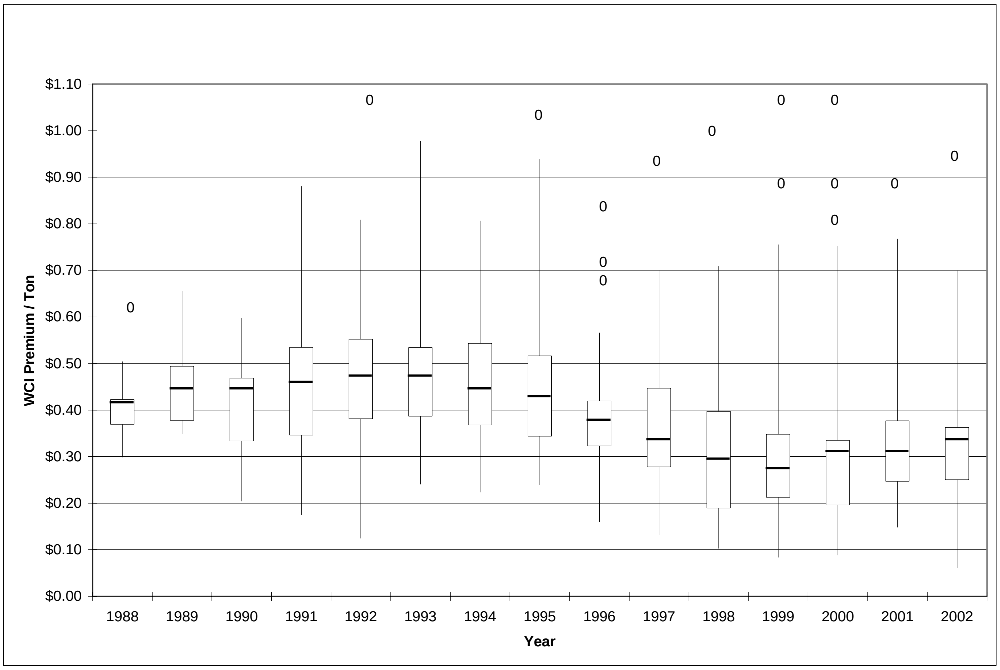


Figure 6. Logging WCI per ton (unadjusted for inflation).

The median WCI rate for 2001 was 50% of that for 1991, indicating that the industry's safety and loss control programs are working. However, as can be seen in Figure 7, WCI rates for all employers decreased earlier and by a larger amount.

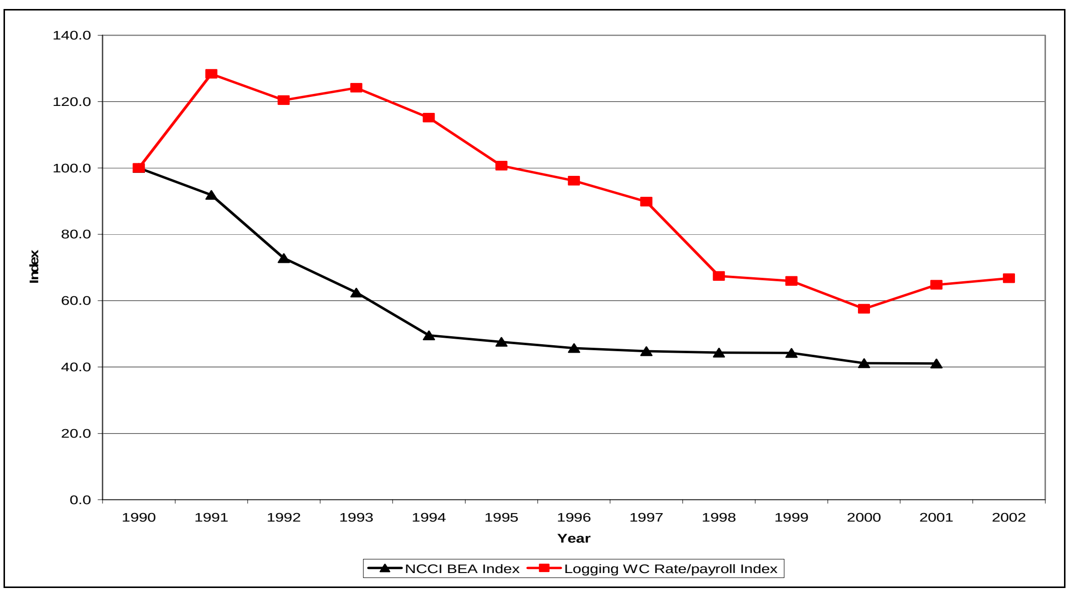


Figure 7. Logging WCI premiums compared to the NCCI/BEA WCI Index.

The decline in the combined statewide rates for the four states shown above for the same period was 65%. Logging made significant gains but trailed the overall trend. This lag might be explained by the additional time needed for the serious loss control measures implemented during the study period to take effect. In addition, logging contractors have turned to other strategies to reduce costs in various aspects of their businesses.

An increasingly common cost reduction strategy that study participants have pursued is outsourcing, particularly for trucking services (Figure 8). The cost of this outsourcing is included in the total cost per ton shown in Figure 5. There may be a significant workers' compensation component within that cost, in the range of 10% of the total, but the exact amount is impossible to extract and report separately at this time.

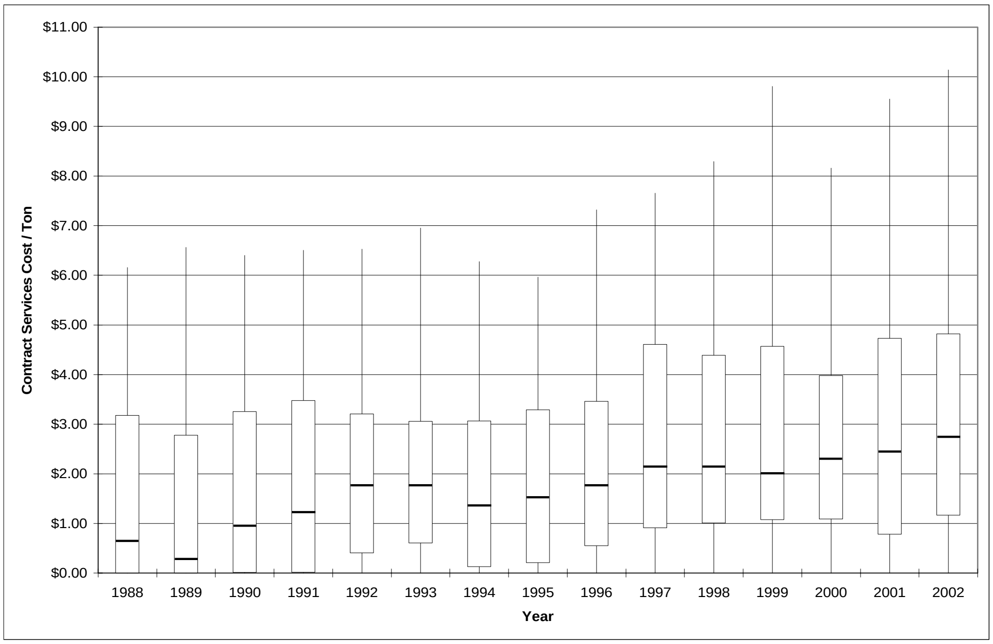


Figure 8. Contract services cost per ton (unadjusted for inflation).

Typically, outsourcing reduces WCI premiums by reducing the number of employees on payroll (reducing total payroll) and by shifting employees into another, lower premium, classification code. The "savings" vary with operation type and policy negotiations (In Mississippi, for example, the premium cost for a truck driver working for a firm classified as 7228, Trucking-Local Hauling Only-and Drivers would be roughly half that of a driver for a firm classified as 2719, Logging or Lumbering-Mechanized Harvesting Exclusively-and Drivers, and roughly one third of that for a firm classified as 2702, Logging or Lumbering and Drivers). The key point is that direct workers' compensation costs to a logging firm decrease with increased outsourcing, as workers' compensation coverage is still paid for but under a different accounting entry.

Avoidance of coverage may also be taking place. A contract trucking "owner/operator" doing the driving and employing no one else is not required to carry workers' compensation insurance. Many states have small business exemptions; Virginia does not require coverage for firms employing three or fewer people, Mississippi has a "four man" exemption. Intended as an aid to small businesses, these exemptions open the door to manipulation. Logging firms are often a family affair, or closely held with the owners working as part of the crew. It is therefore possible for a crew to consist of three "owners", four employees, and three contract truckers, a total of nine and still qualify for the four man exemption.

The concern for all parties in the wood supply system, landowners, loggers, and consuming mills is the effect these changes have had on the cost per delivered ton. The trend in “contract services” cost per ton (Figure 8) follows that of total cost (Figure 5), but is modified by the effect of labor efficiency; tons produced per dollar of labor expenditure and therefore would include the effects of technical and operational gains. Improved loss control and outsourcing have reduced the WCI premiums, although recent evidence shows that insurance rates are beginning to rise.

Conclusions

Workers’ Compensation Insurance rates for the logging industry have tended downward over the 15 year study period. While total, unadjusted, harvesting operational expenses have increased over the study period, the combination of tightened enforcement, outsourcing, the popularity of self-insurance funds, and increased competition in the insurance industry have been crucial to achieving a much needed workers’ compensation cost reduction. Recent indications are that premiums are beginning to increase as insurance carriers reassess individual policies. Additionally, these carriers are choosing not to provide coverage for operations perceived to be unusually hazardous, such as night logging (Anonymous, 2004).

Overall, the loss control measures and changes in business strategy employed in the logging industry have proven to be successful. Unfortunately, those who made the efforts to control the direct cost of workers’ compensation through better working environments for their work force, by heightened safety awareness, by operational changes, and more selective insurance purchases have been able to realize few of the benefits. Lower workers’ compensation insurance rates have been used as argument for reduced contract logging rates. The price paid for logging services (as measured by the producer price index for logging) has decreased by 15% since 1995 (Stuart et al., 2003). The savings have been used to offset the increased stumpage prices and to hold delivered wood costs down. The benefits were captured by landowners and the consuming mills. It may be argued that holding the cost of producing wood down helped advance the US industry’s ability to remain competitive in ever-challenging global wood markets which will have long-term benefits for those who worked to bring about the improvements. It can also be argued that the market for logging services is very inefficient in its ability to reward those who innovate and work to remain competitive.

Literature Cited

Anonymous. 2004. Bituminous nixes night logging. Southern Loggin' Times 33(7):56.

Anonymous. 2003. Biennial Report of the Research and Oversight Council on Workers' Compensation, State of Texas. 223 p.

Godwin, J.R. 1980. Business Law-Principles, Documents, and Cases. Richard D. Irwin, Inc., Homewood, IL. pp. 545-561.

Hobbs, C.W. 1939. Workmen's Compensation, Including Employers' Liability Insurance. McGraw-Hill Book Company, Inc., New York, NY. 707 p.

Lindemuth, M. 1960. Personal Communication. Nofsker Lumber Co., Brookville, PA.

NCCI. 2004. http://www.ncci.com/rws/. Accessed 07/14/04.
.
NCCI. 2003. Policy Year Results by State. 28 p.

Stuart, W.B., L.A. Grace, and C.B. Altizer. 2003. Preliminary 2002 Logging Cost Indices and Demographics of Participating Firms: Third Quarterly Report to the Wood Supply Research Institute.

The Forest and Wildlife Research Center, Mississippi State University, Mississippi State, MS. FWRC # FO 252. 30 p.

Wilson, G.E. 1989. An analysis of Workers' Compensation Insurance for the Southeastern

United States Logging Industry. Ph.D. Dissertation, Virginia Polytechnic Institute and State University, Blacksburg, VA. 252 p.

THE TRAGEDY OF THE POLITICAL COMMONS: EVIDENCE FROM U.S. SENATE ROLL CALL VOTES ON ENVIRONMENTAL LEGISLATION

Anwar Hussain and David N. Laband*
*Respectively, Research associate and Professor, School of Forestry & Wildlife Sciences
Auburn University, AL 36849, USA.

Abstract

This article explores the idea that when the costs of a regulation are externalized, a senator will vote in favor of it because from his/her perspective even small marginal benefits outweigh zero marginal costs. Using the environmental voting records of congressmen from 1991 to 2002, we test the hypothesis that since each politician faces the same incentive in a majority-rule voting context, they will overgraze the regulatory pasture. Our empirical findings are consistent with this insight, and we wonder if effective mechanisms are in place at other levels of the decision making process to mitigate this outcome.

Key Words: Environmental legislation, Majority Voting, Political Commons, Senate Roll Call.

The Status of Mississippi Forest Landowners

by

Marcus K. Measells[1], Stephen C. Grado[2], and H. Glenn Hughes[3]

Acknowledgements: The USDA Southern Region Sustainable Agriculture Research and Education Program for funding the research project. This manuscript is publication No. FO369 of the Forest and Wildlife Research Center, Mississippi State University.

[1] Visiting Research Scientist, Mississippi State University, Forest and Wildlife Research Center, College of Forest Resources, Box 9681, Mississippi State, MS 39762. marcm@ext.msstate.edu. (662) 325-3550 (v); (662) 325-0027 (fax).
[2] Professor, Mississippi State University, Forest and Wildlife Research Center, College of Forest Resources, Box 9681, Mississippi State, MS 39762.
[3] Extension Professor, Mississippi State University, Forest and Wildlife Research Center, College of Forest Resources, P.O. Box 348, Purvis, MS 39475.

The Status of Mississippi Forest Landowners

Abstract

Forest resources are important economic assets to Mississippi; however, many landowners do not realize the full benefit of their forestland. It was believed that few landowners were being served by the many forestry-related educational programs or other relevant activities. Therefore, Mississippi forest landowners were surveyed to determine their served status. Fifteen hundred surveys were mailed statewide to landowners owning 10 or more acres of forestland. A total of 375 surveys were returned for an adjusted rate of return of 29.8%. Landowners' served status was determined by their responses to questions concerning use of a professional forester, information previously received pertaining to forestry, membership in a forestry-related organization, and attendance at forestry-related educational programs. Based on the responses to those questions, 70% of Mississippi's forest landowners were underserved. This indicated a need for more comprehensive outreach efforts to target this underserved audience. Respondents reported marketing, insects/diseases, and best management practices as topics of paramount interest. Top methods for informing landowners about future programs included newsletters, pamphlets/brochures, and letters. Improved marketing skills and increased use of sustainable forestry practices could provide additional family income, help sustain the forest resource, and improve the quality of life for affected landowners and communities.

Key Words: educational needs, surveys, underserved landowners

The Status of Mississippi Forest Landowners

Introduction

Forestry and forest products are important economic components for Mississippi. In 1999, the total forest industry impact on the state's economy was $14 billion and accounted for almost 142,000 jobs, or 9% of all jobs within the state (Munn and Henderson 2003). Forestland is one of the major land uses, and offers both environmental and economic opportunities for landowners. These opportunities are the result of an extensive forestland base, forest ownership dominated by approximately 341,000 nonindustrial private forest (NIPF) landowners, highly productive forests, diverse timber markets, and opportunities for fee hunting, pine straw production, agroforestry, and other alternative land use enterprises (Powell et al. 1994, Birch 1997, Hubbard 1999, Jones et al. 2001).

Unfortunately, most NIPF landowners are not realizing the full benefit of their forestland. Landowners with small- to mid-sized tracts of land generally lack forestry knowledge and training, thus making their lands less productive and more often neglected than other ownership categories. It has been hypothesized that this situation is particularly acute among minorities, females, and other landowners not generally served by current federal, state, and local programs. Landowners are frequently unfamiliar with the maze of federal and state agencies and/or programs available, and thus make limited use of these resources. Additionally, landowners are either unaware of, or perceive that they cannot afford to pay for, private consulting services. For the purpose of this project, "underserved forest landowners" were defined as those who had not obtained assistance from forestry professionals or attended available forestry-related educational programs.

Fortunately, the factors that prevent landowners from realizing the full potential of their forestland are related to a lack of willingness, capital, knowledge, and consequent passive management strategies more so than unproductive land. Knowledge can be gained and landowners can adopt active management strategies if they so desire. Additionally, knowledge will enable landowners to adopt sustainable forestry practices that will contribute to the economic success of current and future generations. Sustainable forestry practices will also improve environmental quality by maintaining or improving water quality, reducing soil erosion, and enhancing wildlife habitat. This monetary and environmental windfall will have a positive, rippling effect on the economies and communities in which these landowners reside.

Improved marketing and production practices from underserved landowner forests could provide additional, and often immediate, family income, create new employment in all sectors of the economy, and improve the quality of life in rural communities. In addition, the value of conservation practices to our environment is at least as important as the economic benefits. A variety of natural resource-based enterprises, from fee hunting to agroforestry to pine straw

[1]This manuscript is publication # FO386 of the Forest and Wildlife Research Center, Mississippi State University.
[2]Graduate Research Assistant, Department of Forestry, Mississippi State University, Box 9681, Mississippi State, MS 39762. bkt2@msstate.edu (662) 325-8358 (v); (662) 325-8726 (fax).
[3]Professor, Department of Forestry, Mississippi State University, Box 9681, Mississippi State, MS 39762. imunn@cfr.msstate.edu (662) 325-4546 (v); (662) 325-8726 (fax).
[3]Professor, Department of Forestry, Mississippi State University, Box 9681, Mississippi State, MS 39762. dle@sitl.cfr.msstate.edu (662) 325-2796 (v); (662) 325-8726 (fax).
[5]Associate Professor, Department of Forestry, Mississippi State University, Box 9681, Mississippi State, MS 39762. rparker@cfr.msstate.edu (662) 325-2775 (v); (662) 325-8726 (fax).
[6]Associate Professor, Department of Forestry, Mississippi State University, Box 9681, Mississippi State, MS 39762. sroberts@cfr.msstate.edu (662) 325-3044 (v); (662) 325-8726 (fax).

management, represent an opportunity for landowners to realize additional income while protecting and enjoying their land.

Researchers studying forest landowners have found that there is no “one-size-fits-all” solution for problems faced by southern forest landowners. The primary reason for owners acquiring and holding forestland varies with, among other things, tract size (Birch 1997). Small landowners tend to own forestland for amenity values (e.g., residence, enjoyment), whereas larger landowners place a greater value on commodity production (e.g., timber). This is best demonstrated by the fact that the most frequently cited reason by landowners in the South for owning forestland was "as part of a residence" (38% of respondents), although these landowners held only 8% of the forestland acreage. Conversely, the percentage of landowners citing timber production as the principle reason for ownership was very low (4% of respondents), but these landowners held 35% of the forestland acreage (Birch 1997).

Regardless of tract size or ownership objectives, most landowners can benefit from minor improvements in their management. Evaluations and case studies by Extension Forestry Specialists show that changes in timber market strategies from passive (i.e., timber sold to someone who makes a “reasonable” offer) to active (i.e., timber marketed by a professional forester) often doubles the income from a timber sale. In addition, such a change protects the land because a good written contract includes provisions on Best Management Practices (BMPs), weather restrictions, and other aspects critical to sustaining long-term productivity.

Developing effective educational and outreach efforts requires knowing more about NIPF landowners. While Birch (1997) surveyed private forest landowners in the South, little is known about their socio-demographics. These landowners and their lands are extremely diverse, and represent a wide spectrum of social, economic, and environmental conditions. Few landowners have large ownerships, possess considerable forestry expertise, or actively manage their forestland. Many landowners have small acreages of forestland, own land “in common” with other family members, do not realize their forests’ economic potential, and are less likely to implement environmental protection practices.

Projected demands for timber indicate that these small forestland ownerships provide opportunities for monetary benefits and sustainable production (Cubbage 1998). Rural economies in the South, in particular, are dependent upon forest resources (Hubbard 1999). However, information is needed on the perceived needs of underserved landowners and the most effective ways to encourage them to act, thereby realizing this opportunity.

Objectives

The primary objective was to assess Mississippi NIPF landowners, their underserved status, as well as their forestry-related educational needs. This required knowledge of their past forestry-related experiences and future educational desires. This knowledge will lead to development and implementation of more effective programming techniques designed to meet the needs of this target audience. Improving landowners’ basic forestry knowledge will lead to enhanced economic viability of forest landowners and an improved quality of life for individuals and families as well as the communities where they reside.

Methodology

The project utilized both focus groups and a mail questionnaire. Responses to each focus group session, coupled with professional judgment from the research team, provided content material for the mail questionnaire. After questionnaire development, approximately 21 landowners from educational workshops across Mississippi were asked to carefully review, complete, and make suggestions for improving the questionnaire. After reviewing these pilot-tested questionnaires, the instrument was refined. The final questionnaire was four pages and contained 44 questions.

Forest landowner databases consisting of all landowners owning 10 or more acres of uncultivated agriculture land were obtained from county tax roll data. Thirty percent of Mississippi's 82 counties (n=25) were randomly selected. Landowners were then randomly selected from each county for a total of 1,500 landowners. This methodology is similar to that used by Kluender and Walkingstick (2000) in their study of Arkansas landowners. Multiple mailings were used in the questionnaire implementation (Dillman 1978, Salant and Dillman 1994). A reminder postcard was sent to non-respondents one week after receipt of the initial mailing. One follow-up mailing consisting of a cover letter and questionnaire was sent to those who had not responded after the third week. A business reply return envelope addressed to Mississippi State University was included in all questionnaire mailings. All data was statistically analyzed using the Statistical Package for the Social Sciences (SPSS).

Results and Discussion

Three moderated focus group sessions were held across the state and involved 21 landowners. Each focus group session was moderated by the same person, audio recorded, and transcribed. Information gathered during focus group sessions was used to develop a refined mail questionnaire.

One thousand five hundred mail questionnaires were sent to randomly selected landowners from randomly selected counties. A total of 375 completed questionnaires were returned. After accounting for the undeliverable surveys, deceased landowners, and landowners who did not own forestland, the adjusted rate of return was 29.8%. This return rate was comparable to studies of other NIPF landowners such as Kluender and Walkingstick (2000), Arano et al. (2002), Bovee and Holley (2003), and Newsom et al. (2003).

Certain key socio-demographic results bear mentioning. Landowners ranged in age from 23 to 91 years with the average age of 62.8. Forty-five percent (n=169) of landowners reported a total household income less than \$60,000, while 27% (n=102) reported total household income between \$60,000 and \$120,000, and 10% (n=38) indicated a total household income greater than \$120,000. The remaining 18% (n=66) did not report total income. Forty-nine percent (n=185) of landowners reported having a college degree (Associate or higher). Only 8% (n=30) received less than a high school education, slightly higher than Kuhns et al. (1998) reported for Utah (4%) and Indiana (6%) landowners. Seventy-one percent (n=267) of respondents were Caucasian, 10% (n=38) African American, 12% (n=46) Native American, and 2% (n=8) reported other. Four percent (n=16) of landowners did not report ethnic background. Females comprised 24% (n=89) of respondents while males encompassed 74% (n=276). Only 3% (n=10) did not reveal their gender.

For this project, underserved forest landowners were defined as those who had not obtained assistance from forestry professionals or attended available forestry-related educational programs. On this account, a series of questions were asked to determine the underserved status of landowners. Responses to these four questions were averaged to determine the overall underserved status of Mississippi forest landowners. It was calculated that 70% of respondents could be classified as underserved. Eighty-five percent (n=320) of landowners do not belong to a forestry-related organization. Forty-two percent (n=157) of landowners had previously used a professional forester, which is slightly higher than the 35% used by Minnesota landowners (Baughman et al. 1998) and the 39% of Oklahoma landowners (Bovee and Holley 2003) yet lower than the 58% usage by Alabama landowners (Zhang et al. 1998). Also, 50% (n=189) of respondents reported they had not previously received information on forestry. Correspondingly, 83% (n=310) had never attended a forestry-related educational program, which is slightly more than 80% of Alabama landowners who had neither formal nor informal forestry training through educational programs or meetings (Zhang et al. 1998). The data indicated that a majority of Mississippi landowners are not taking full advantage of the numerous programs and activities available, which is similar to other states.

Overall, 82% (n=306) of landowners had a somewhat positive to a positive attitude toward forestry. Ninety-five percent (n=357) of respondents felt owning forestland was a good investment. In addition, 85% (n=320) believed forest management was a good investment on their land. Sixty-eight percent (n=254) were not familiar with government cost-share programs and 80% (n=301) were not aware of government tax incentives for forest landowners. Only 26% (n=98) of landowners had previously used either government cost-share programs or tax incentives.

Respondents reported owning a total of 132,465 acres. Of this amount, 73,579 acres (56%) were reported as forestland. Ninety percent (n=337) of landowners reported having a clear title to their property and 61% (n=229) had a written will. The majority (83%, n=312) felt they had an obligation to manage their forestland responsibility. Only 9% (n=34) of landowners reported having a written forest management plan. This is higher than the 5% reported by Birch (1997) for southern forest landowners, comparable to the 9% Bovee and Holley (2003) reported for Oklahoma landowners, and lower than the 16% of Minnesota landowners with a written plan (Baughman et al. 1998). Trees had been harvested by 68% (n=255) of landowners while 51% (n=192) plan to harvest trees in the future and 30% (n=114) said they may eventually harvest trees. The top objectives for owning forestland included as an estate to pass on to children or heirs (55%), investment purposes (44%), and for hunting or fishing (43%) (Table 1). These objectives were similar to the top responses found in Birch (1997), Baughman et al. (1998), Kuhns et al. (1998), and Wicker (2002).

Landowners were also asked which topics would be of greatest interest to them at future educational programs or activities. Munn and Rucker (1994) pointed out most landowners lack adequate experience and knowledge in forest management and timber marketing. Likewise, Mississippi respondents' topics of most interest were marketing timber (44%), insects/diseases

Table 1. Mississippi forest landowners' objectives for owning forestland as reported in a 2002-2003 mail survey.

Objective	**Number**	**Percent**
As an estate to pass on to my children/heirs	207	55.2
Investment purposes	165	44.0

For hunting or fishing	160	42.7
Family tradition	146	38.9
A place to relax/privacy	141	37.6
Part of my residence/farm	139	37.1
Income generation (e.g., forest products, fee hunting)	122	32.5
Wildlife viewing	106	28.3
To enjoy beauty or scenery/aesthetics	106	28.3
To protect the land	102	27.2
For recreation (other than hunting or fishing)	47	12.5
As an estate to pass on to an organization	4	1.1
Other	4	1.1
No answer	23	6.1

(41%), BMPs (38%), harvesting (38%), and wildlife management (38%) (Table 2). The top responses were similar to those reported by Birch (1997) and Baughman et al. (1998). Also, since 49% (n=153) of respondents who had not previously attended educational programs and activities because they were unaware of these programs, it was important to determine their desired methods to be informed about future programs. The top methods for informing landowners included newsletters (49%), pamphlets/brochures (40%), and letters (33%) (Table 3).

Conclusions

Mail questionnaire responses provided insights about underserved forest landowners, their needs and desires, and appropriate methods for promoting effective programs covering desired topics for this target audience. Overall, approximately 70% of Mississippi's NIPF landowners were underserved; however, they had positive attitudes toward forestry and believed forest management is a good investment on their property. Therefore, it is paramount that forestry professionals be proactive and flexible in educating NIPF landowners. If the forestry community pursues educational programs and activities to reach the underserved landowners, landowners can become more knowledgeable on ways to realize the full range of benefits from owning forestland, which should have a positive effect on them and their communities and lead to adoption of technologies and administrative steps addressing the sustainable management of

Table 2. Mississippi forest landowners' topics they would be interested in learning more about at forestry-related educational programs as reported in a 2002-2003 mail survey.

Topic	Number	Percent
Marketing timber	165	44.0
Insects/diseases	155	41.3
Best Management Practices	144	38.4
Harvesting	143	38.1
Wildlife management	143	38.1
Prices	140	37.3
Pine management	130	34.7
Cost-share programs	130	34.7
Regeneration	124	33.1

Hardwood management	124	33.1
Assistance programs/services available	103	27.5
Laws concerning forestry	97	25.9
Forest management planning	88	23.5
Contracts	82	21.9
Estate planning	82	21.9
Tree identification	62	16.5
No answer	60	16.0
Financial planning	55	14.7
Economics	53	14.1
Recreation/fee hunting	48	12.8
Chemicals	46	12.3
Consultant availability	44	11.7
Other	17	4.6

Table 3. Mississippi forest landowners' methods by which they would like to be informed about future forestry-related educational programs as reported in a 2002-2003 mail survey.

Method	Number	Percent
Newsletter	182	48.5
Pamphlet/brochure	150	40.0
Letter	123	32.8
No answer	60	16.0
Newspaper	59	15.7
Magazine	54	14.4
E-mail	50	13.3
Television	28	7.5
Word-of-mouth	25	6.7
Presentation	22	5.9
Radio	20	5.3
Internet	13	3.5
Church	8	2.1
Other	8	2.1

their forests. An area in need of additional study is to determine, through a follow-up mail questionnaire, how many landowners have crossed the line from being "underserved" to now utilizing some of the technical, financial, and educational resources available to them.

Literature Cited

Arano, K.G., T.L. Cushing, and I.A. Munn. 2002. Forest Management Expenses of Mississippi's Nonindustrial Private Forest Landowners. South. J. Appl. For. 26(2):93-98.

Baughman, M.J., J.C. Cervantes, and D.M. Rathke. 1998. Reaching Minnesota's Nonindustrial Private Forest Landowners. P. 165-169 in Improving Forest Productivity for Timber: A key to Sustainability.

Birch, T.W. 1997. Private Forest-Land Owners of the Southern United States, 1994. USDA For. Serv. Northeast For. Exp. Stat. Resour. Bull. NE-138. 195 p.

Bovee, J.K., and A.G. Holley. 2003. Planners vs. Non-Planners: Characteristics and Differences between Nonindustrial Private Forest Landowners in Southeastern Oklahoma Who Engage in Planned and Non-Planned Forest Management. P. 254-267 in Proc. of the 2002 South. For. Economics Workshop, Amacher, G.S. and J. Sullivan (eds.).

Cubbage, F.W. 1998. Development of Decision Support Systems for Improvement of Silvicultural Practices on Farm-Based Nonindustrial Private Forests. South. Region SARE Now Project LS98-91, 44 p.

Dillman, D.A. 1978. Mail and Telephone Surveys: The Total Design Method. John Wiley & Sons, New York, NY. 325 p.

Hubbard, W.G. 1999. Economic Impact of Forestry and Forest Products in the Rural South. South. Perspectives 3:2-5, 16. South. Rural Development Center, Miss. State Univ., Mississippi State, MS.

Jones, W.D., I.A. Munn, S.C. Grado, and J.C. Jones. 2001. Fee Hunting: An Income Source for Mississippi's Nonindustrial Private Landowners. FWRC Res. Bull. FO164, Miss. State Univ., Mississippi State, MS. 15 p.

Kluender, R.A., and T.L. Walkingstick. 2000. Rethinking How Nonindustrial Landowners View Their Lands. South. J. Appl. For. 24(3):150-158.

Kuhns, M.R., M.W. Brunson, and S.D. Roberts. 1998. Landowners' Educational Needs and How Foresters Can Respond. J. For. 96(8):38-43.

Munn, I.A., and J.E. Henderson. 2003. Forestry in Mississippi: The Impact of the Forest Products Industry on the Mississippi Economy: An Input-Output Analysis. FWRC Res. Bull. FO216, Miss. State Univ., Mississippi State, MS. 22 p.

Munn, I.A., and R.R. Rucker. 1994. The Value of Information Services in a Market for Factors of Production with Multiple Attributes: The Role of Consultants in Private Timber Sales. For. Sci. 40(3):474-496.

Newsom, D., B. Cashore, G. Auld, and J.E. Granskog. 2003. Forest Certification in the Heart of Dixie: A Survey of Alabama Landowners. P. 291-300 in Forest Policy for Private Forestry: Global and Regional Challenges, Teeter, L., B. Cashore, and D. Zhang (eds.). CABI Publishing, New York, NY.

Powell, D.S., J.L. Faulkner, D.R. Darr, Z. Zhu, and D.M. MacCleery. 1994. Forest Resources of the United States – 1992. USDA For. Serv. Gen. Tech. Rep. RM – 234. 132 p.

Salant, P., and D.A. Dillman. 1994. How to Conduct Your Own Survey. John Wiley & Sons, New York, NY. 232 p.

Wicker, G. 2002. Motivation for Private Forest Landowners. P. 225-237 in Southern Forest Resource Assessment, Wear, D.N. and J.G. Greis (eds.). USDA For. Serv. Gen Tech. Rep. SRS-53.

Zhang, D., S. Warren, and C. Bailey. 1998. The Role of Assistance Foresters in Nonindustrial Private Forest Management: Alabama Landowners' Perspectives. South. J. Appl. For. 22(2):101-105.

Valuing Habitat Regime Models for the Red-cockaded Woodpecker in Mississippi

Rebecca O Drier[1], Stephen C. Grado[2], Rebecca J. Barlow[2], and Donald L. Grebner[2]

Acknowledgements

Financial support for this project was provided by a Wood Utilization Research grant. We thank K. Hunt and S. Dinsmore for constructive article reviews and comments. We thank B. Meneghin and K. Greer for providing technical support for *Spectrum*. This manuscript is publication No. FO 367 of the Forest and Wildlife Research Center, Mississippi State University.

[1] Graduate Research Assistant, College of Forest Resources, Mississippi State University, Box 9681, Mississippi State, MS 39762. (662) 325-8358. rod1@msstate.edu

[2] Professor , Graduate Research Assistant, and Associate Professor, Department of Forestry, Box 9681, Mississippi State University, Mississippi State, MS 39762

Valuing Habitat Regime Models for the Red-cockaded Woodpecker in Mississippi

Abstract

The management of forested wildlife habitat across different regions in Mississippi is of great concern to both forest managers and the public. The goal of this study was to quantitatively estimate monetary gains and losses and changes in timber inventories relative to the timber growing stock when producing more or less wildlife habitat for the Red-cockaded Woodpecker (RCW) (*Picoides borealis*). The baseline vegetative data set was compiled from the 2000 USDA Forest Service Resource Planning Act (RPA) data. The data set was then analyzed using the USDA Forest Service based forest planning software, *Spectrum*. An important input in the model is habitat quality relative to various forest practices. A self-administered mail survey was developed to obtain information on specific habitat characteristics in regards to defined stand types and common forestry practices and sent to wildlife professionals (n = 4) with knowledge of Mississippi land types and RCWs. A specific model was developed to maximize net present value (NPV) as a baseline scenario over a 50-year rotation. Two alternative models were run; one maximizing high quality RCW habitat, and the other maximizing low quality RCW habitat. The analysis looked at the South Central Hills and Pine Belt regions (7,096,000 acres). As expected, when maximizing for high quality RCW habitat, the revenue forgone was high, approximately $871/acre/year, while low quality was approximately $58/acre/year. High quality habitat yielded approximately 617,499 cunits harvested while low quality habitat yielded approximately 3,060,953 cunits. Lower levels of habitat management allowed for an increased emphasis on timber harvesting. In general, we determined that increases in habitat quality resulted in lower timber harvest levels and increased revenue forgone than the scenarios maximizing NPVs. While this result may be expected, of greater importance are the relative differences between scenarios and the ability to use these values for policy decisions.

Key Words: Equivalent annual income (EAI), land expectation value (LEV), Red-cockaded Woodpecker habitat, *Spectrum*

Introduction

Managing timberland and wildlife populations presents many challenges for foresters. First, both timberland and wildlife have aesthetic, cultural, ecological, monetary, and recreational benefits and values (Grado et al. 1997). Second, maintaining habitat for rare, threatened, and endangered (RTE) species is also important for biodiversity and meeting legal mandates (George 1996). Third, maintaining wildlife habitat is an essential requirement to meet forest certification standards for landowners. This is particularly relevant for RTE species.

Researchers can help decision-makers by providing realistic measures of the benefits and values of maintaining wildlife habitat along with costs to achieve these objectives. Quantitative measures are needed by forest mangers to evaluate investment decisions and monetary trade-offs involving forest manipulation aimed at increasing or decreasing quality and quantity of available wildlife habitat. This process takes on greater importance when dealing with RTE species. Habitat for RTE species is limited, specialized, and protected. Policymakers also need to be aware of the potential impacts on the timber supply if these habitat-related decisions become widespread.

The goal of this study was to examine how timber inventory manipulation may impact timber-habitat relationships for the Red-cockaded Woodpecker (RCW) (*Picoides borealis*), an endangered species in Mississippi.

REVIEW OF LITERATURE

Rare, Threatened, and Endangered Species

During the 1960's in the United States, several laws were passed to list floral and fauna species that were in danger of becoming rare, threatened, endangered, and possibly extinct. Unfortunately, these laws provided minimal protection for species. The Endangered Species Act of 1973 (ESA) was enacted in response to concerns about the decline of flora and fauna species around the world, but applied only to the United States (16 U.S.C. §§ 1531-1544). The purpose of the ESA in the United States is to "conserve the ecosystems upon which endangered and threatened species depend, and to conserve and recover listed species" (U.S. Fish and Wildlife Service 2002). The ESA continues to be reauthorized and amended, most recently in 1988 (U.S. Fish and Wildlife Service 2002). The U.S. Fish and Wildlife Service and the National Marine Fisheries Service administer the ESA and work with other agencies to conserve species and minimize impacts to species and their habitats. Each state is also encouraged to develop and maintain programs to conserve listed species within its borders. Financial and technical assistance is provided for private landowners that may have threatened or endangered species on their property. Incentives were developed to encourage private landowners to promote RTE species, while protecting their interests.

After passage of the ESA, concerns for private landowners and how forestry practices would be conducted on their land became an issue. In 1982, Section 10 of the ESA was amended to include development and implementation of Habitat Conservation Plans (HCP), which allowed "incidental take" permits (Nelson 1999). Nelson (1999) stated that an incidental take permit allowed a property owner to conduct otherwise lawful activities in the presence of listed species. HCP include measures to protect proposed species, as well as species of concern at the time HCP are developed or permits submitted. This may help provide early protection and ensure landowner protection in case a species is subsequently listed.

Mississippi has a Non-game and Endangered Species Conservation Act (Miss. Code Ann. §§49-5-101 et seq.) that protects species and subspecies of animals but not plants (George 1996). Although recovery plans are authorized, they are not required, nor is critical habitat designation and agency consultation. There are also provisions for state-owned lands to help preserve biodiversity. The Mississippi Prescribed Burning Act (Miss. Code Ann. §§49-19-301 et seq.) and the Coastal Wetlands Protection Act (Miss. Code Ann §49-27-1 et seq.) were authorized to ensure biodiversity sustainability, while a statute (Miss. Code Ann. §49-19-53) ensures that forest lands are managed to preserve them for future generations (George 1996).

RTE Species Habitat Requirements

The Red-cockaded Woodpecker is the only North American woodpecker to nest and roost in living pine trees (Dickson 2001). They prefer 80 to 100 year-old pines that contain the red heart fungus (for cavity excavation). Longleaf pines (*Pinus palustris*) are preferred, but other southern species, such as loblolly pine (*Pinus taeda*), are used as well (Dickson 2001). Quality RCW habitat consists of park-like (open stands with little underbrush, and basal area of 50-80 square feet) pine stands with little or no hardwood component (Dickson 2001). The birds may forage in smaller, mixed pine/hardwood stands but prefer older stands for their nests.

The RCW's historic range extended from Florida to New Jersey, as far west as Oklahoma and Texas, and inland to Missouri, Tennessee, and Kentucky (U.S. Fish and Wildlife Service 2003). There are currently an estimated 14,000 birds ranging from southeast Oklahoma and eastern Texas and east to Florida and Virginia, comprising about 3% of the original population at the time of European settlement (U.S. Fish and Wildlife Service 2003). In Mississippi, the RCW mainly occurs in the North Central Hills, South Central Hills, and Pine Belt physiographic regions. Red-cockaded Woodpeckers were federally listed as endangered on October 13, 1970. They are still listed as endangered at both the federal and state level. Suppression of fire and the loss and fragmentation of longleaf pine forests are the main causes for the decline in RCW numbers (Dickson 2001). Shorter rotations, clean forestry practices, and plantings of other less preferred pine species, such as slash pine (*Pinus elliottii*), have also limited RCW recovery (Dickson 2001). Recent attempts in the South to reintroduce longleaf pine back to its original range may ultimately prove beneficial to this species.

Models

Forested habitats contain both monetary and ecological values. Designing forested ecosystems to manage for both of these goals will be important for the sustainability of forest and wildlife habitats. Timber management practices can result in wildlife habitat improvement for a given species (Hall and Holbrook 1980). Cooperation is needed within the natural resource community if forest managers, economists, and ecologists are to correctly interpret impacts made on a landscape scale (Schaberg et al. 1999). Sharitz et al. (1992) explained the need to integrate ecological concepts with southern forest management practices. Increasing public awareness regarding environmental issues and legal mandates are requiring more emphasis for ecosystem biodiversity and RTE species. Additionally, addressing species of concern is critical to most forest ownerships if they intend to seek forest certification.

Quantifying trade-offs between economic and ecological resources and assigning values to ecological components remains an obstacle for land managers, forest planners, and economists (Rohweder et al. 2000). Management costs influence the feasibility of any strategy, regardless of biological merit, and requires knowledge of relative values when optimizing between timber and non-timber commodities (Rohweder et al. 2000).

Li et al. (2000) discussed the use of the Landscape Evaluation of Effects of Management Activities on Timber and Habitat (LEEMATH) as a decision support tool. It provided a framework to integrate empirical and mechanistic models and spatial analysis. This expert systems is integrated to apply the principles of ecosystem management. LEEMATH allowed land managers to plan different scenarios for both wildlife and timber management while also considering habitat quality for different species. Species looked at in their study included the Acadian Flycatcher (*Empidonax virescens*), Bachman's Sparrow (*Aimophila aestivalis*) and barking treefrog (*Hyla gratiosa*). LEEMATH also provided a thorough analysis of habitat quality for wildlife species under various management regimes.

McComb et al. (2000) explored the use of ecological models to map potential habitat at a landscape level using the Northern Spotted Owl (*Strix occidentalis caurina*). Spatial models were developed to quantify possible sites across the Oregon coastal range and provide estimates of habitat capability in future landscapes. The model also assessed the effects of alternative land scenarios should changes occur in federal or state policies regarding habitat protection. Overall, the model provided a basis for understanding possible habitat recovery rates from current forest management practices.

Marzluff et al. (2002) discussed the implications of forest management on wildlife habitat and resulting economic trade-offs. Economic trade-offs for various landscape level projects currently are not considered in existing habitat models (Marzluff et al. 2002). By linking wildlife habitat suitability models with habitat projection, an assessment of possible planning regimes, with both economic and ecological values, was established.

Forest Management Evaluation Criteria

There are several financial models and criteria that can be used to evaluate alternative land use practices. Net present value (NPV) is a valuation technique commonly used to evaluate potential capital investments in forest management (Bullard and Straka 1998). Estimates of all revenues and costs are discounted to the present, with costs subtracted from revenues. Projects are considered acceptable if the NPV is greater than or equal to zero (Bullard and Straka 1998). NPV can also be used to derive equivalent annual income (EAI) and land expectation values (LEVs). An EAI consists of the NPV expressed as an annual amount, and is used to compare returns from forestry with those obtained from other land uses that yield annual returns (Bullard and Straka 1998). EAI assumes NPVs are calculated for a finite period of years. Its criteria also allow for a comparison or ranking of investments that are not equal in duration (Bullard and Straka 1998). If the NPV is positive, the EAI will also be positive and show acceptable results. LEVs estimate the value of growing timber on a tract of land by using the NPV of all revenues and costs used to produce outputs from the forest, with the exception that land costs are eliminated from consideration (Bullard and Straka 1998). LEV can assist in selecting forest management regimes because it represents the bare land value when committed to a certain regime into perpetuity. It allows for ranking of investment decisions, like EAI.

Wildlife Habitat Evaluation Criteria

Wildlife habitat does not have a monetary value directly associated with it. Values are assigned based on choices made by decision makers. There are two ways values can be assigned: choices based on established values or establishing values by choices made (Davis et al. 2001). It is becoming increasingly difficult or impossible to infer values implied by decisions. However, professionals are attempting to assign monetary values on outcomes and conditions for items that do not contain a market value and, by doing so, imply those items are comparable with items containing a market value (Davis et al. 2001). Once monetary values are assigned to non-market outputs such as wildlife habitat, traditional financial valuation techniques can be used.

METHODS

The study area for this project consisted of specific regions within the state of Mississippi. The state is broken down into physiographic regions. Those regions of concern in this study are the South Central Hills and the Pine Belt. Wildlife professionals selected physiographic regions that contain suitable habitat (habitat that meets, or could meet, requirements for RCWs) characteristics to assess different timber activities, and possible effects on the habitat.

The methodology involved four main components: a mail survey process, two sets of vegetation data, the *Spectrum* model, and an economic analysis. Mail surveys or person to person interviews were used to learn the usefulness of certain forest stand types for Red-cockaded Woodpeckers. Wildlife professionals (n = 4) with an expertise concerning RCW habitat and various regions within Mississippi were asked to rate habitat quality on 14 management scenarios for two physiographic regions. These professionals were selected based on academic research and job positions that required them to have working knowledge of RCW and its habitat. These scenarios contain common practices found in timber production (Table 1). The management scenarios were divided into five year increments (i.e., 0, 5, 10…) ranging from age 0 to age 60. For each management scenario, wildlife professionals ranked each five year increment on a scale of 1-5 (1 being lowest quality; 3 being neutral; and 5 highest quality). Assessment scores were averaged for each five year increment to give an overall rating for that timber management scenario over time and its usefulness for RCWs. Those numeric ratings were then used as data entries for the scenario planning generated by the model.

Table 1. The fourteen management scenarios, over a 60-year planning period, that wildlife professionals were asked to rate for habitat quality of Red-cockaded Woodpeckers in Mississippi during the fall of 2003.

Forest Type			
Pine Plantation	Mixed Pine Harwood	Upland Hardwood	Bottomland Hardwood
No activity	No activity	No activity	No activity
One thin		One thin	One thin

One thin-3burn[1]	Two thins	Two thins
One thin-5burn[2]		
Two thins		
Two thins-3burn[1]		
Two thins-5burn[2]		

[1] A burn will be applied every 3 years after the last thin.
[2] A burn will be applied every 5 years after the last thin.

The 1994 U.S.Forest Service (USFS) Forest Inventory Analysis (FIA) and the 2000 USFS Resource Planning Act (RPA) data were acquired from the U.S.Forest Service Southern Research Station to use as vegetative data sets for this project. FIA data includes information collected from a set of permanent plots spaced throughout Mississippi. Each plot is measured every seven to 12 years and data collected on vegetative structure as well as individual tree characteristics (Hamel and Dunning 2000). Growing stock acreage, tree species, and age classes were extracted from the overall FIA data set to locate plots in certain physiographic regions throughout the state. FIA volume estimates were used as a baseline data set for the RPA data. The RPA timber assessment project reports both the current situation and projected changes over the next 50 years for both land and timber resources (Mills and Zhou 2003). A longer rotation was used because the project dealt with wildlife habitat, not just maximizing timber, which normally deals with shorter rotations. The current and projected volumes were data entries placed in the model.

Data analysis was undertaken using the USFS forest planning model *Spectrum*, a model building software. *Spectrum* is a multiple decision modeler that uses linear programming to examine alternative forest management plans (Barlow and Grado 2002). Through matrix development, *Spectrum* generated optimized land allocation and management schedules among different analysis units over a given planning horizon (USFS 1999). *Spectrum* uses a C-Whiz optimizer, which employs a simplex method with custom algorithms for speedy solutions for its mathematical optimization method. In this case, the analysis units were the different habitat management scenarios. The RCW quality rating and volumes were entered into the model for each management scenario. Three situations were developed to compare land management objectives. *Spectrum* contains few assumptions of its own. Most assumptions deal with the data entered into the model. Also, there are four underlying assumptions to consider with linear programming: linearity, divisibility, nonnegativity and independency.

The economic analysis was derived from outputs produced for the various model results. Results focused on inventories, harvests, and monetary values associated with each situation. The model estimated potential monetary gains and losses for each region resulting from the manipulation of growing timber stock for the creation of varying levels of wildlife habitat. Monetary values for each scenario were determined through the use of NPV, LEV, and EAI. These measures also determined landscape level trade-offs or opportunity costs for timber and non-timber values.

RESULTS

Model Outputs

We completed and compared three alternative land management objectives on the 7,096,000 acres of the South Central Hills and Pine Belt regions of Mississippi. The first maximized NPV. The second maximized low quality habitat levels of Red-cockaded Woodpecker (RCW1). The third maximized high quality habitat levels for Red-cockaded Woodpecker (RCW5). Total acres available for harvest remained constant throughout the rotation, but were allocated differently for each scenario (Table 2).

Table 2. Acres harvested and volume removed for each of three management scenarios, net present value (NPV), low quality Red-cockaded Woodpecker habitat (RCW1), and high quality Red-cockaded Woodpecker habitat (RCW5), in the South Central Hills and Pine Belt regions in Mississippi for a 50-year rotation.

Management Objectives	Harvest (acres)	Volume removed (cunits)[a]	Volume/acre (cunits)[a]
NPV	194,038	2,222,223	0.31
RCW1	250,388	3,060,952	0.43
RCW5	55,397	617,499	0.09

[a] 100 cubic feet.

Economic Analysis

LEV and EAI were calculated and compared for each of the three land management scenarios (Table 3). As expected, as habitat quality increased, there was a decrease in LEV and EAI. The difference in revenues forgone greatly decreased as habitat quality increased.

Table 3. The land expectation value (LEV), expected annual increment (EAI) and revenue forgone for providing different levels of habitat quality for the South Central Hills and Pine Belt regions of Mississippi (1994).

Management Objectives	LEV ($/ac)	EAI ($/ac/yr)	Revenue Forgone ($/ac/yr)
NPV	1,143.91	57.20	
RCW1	1,083.36	54.32	2.88
RCW5	273.18	13.66	43.54

DISCUSSION AND CONCLUSIONS

This study examined the impacts of qualitative habitat requirements for the Red-cockaded Woodpecker, and how the forest can be manipulated to create more or less habitat for this species of interest. As expected, when maximizing for NPV, a higher LEV and EAI were produced and fewer acres of available habitat for RCW were allotted. When the goal was to produce higher quality habitat for RCWs in this area, it was determined that an increase in habitat quality resulted in lower timber harvest levels and increased revenue forgone than scenarios maximizing NPVs. One reason is because of the longer rotations associated with producing RCW habitat. For timber production, a rotation may range between 20 and 30 years (Barlow and Grado 2002). RCWs do not use pine trees for nests until the tree is between 80 and 100 years old (Dickson 2001). The delayed harvest results in a monetary loss.

The results of this project may provide land managers or legislators with the ability to compare non-timber land use in terms of opportunity costs. By taking into account timber production and quality of wildlife habitat for RTE species, we were able to examine potential monetary returns that may result in the manipulation of Mississippi's timber supply. In some cases, revenues forgone by creating RTE habitat may be offset by benefits associated with providing other opportunities. For example, fee-based guided tours for birdwatchers may help lessen the monetary losses associated with forgone timber production. Habitat created for RCW also provides habitat for other game species. A fee-base hunt on this land could also provide additional funds for the landowner.

A loss of monetary value is dependent on the ownership type. Lands owned by the government would not be as concerned with monetary losses, whereas private and industry landowners would. Incentive programs set up through the state and federal governments may increase support for private landowners to create habitat for an endangered species on their lands. Values, such as those developed by our model and data, could lend support for determining levels of compensation. Currently, the 2002 Farm Bill provides funding through the Wildlife Habitat Incentive Program (WHIP). This program encourages the creation of high quality habitat for wildlife species and places an emphasis on enrolling lands that contain species in decline. Active maintenance of favorable habitat, set aside for RTE species, could help entities seeking forest certification for other forest land uses. Implicit in this effort is the potential to achieve additional social and economic benefits.

Literature Cited

Barlow, R.B., and S.C. Grado. 2002. Linking scenario planning with GIS to develop a decisions support system for multiple-use in Mississippi. Proceedings of the 31st Annual Southern Forest Economics Workshop. Atlanta, Georgia. pp. 56-60.

Bullard, S.H. and T.J. Straka. 1998. Basic Concepts in Forest Valuation and Investment Analysis. 2nd Edition. Preceda. Auburn, Alabama.

Dickson, J.G. 2001. Wildlife of Southern Forest Habitat and Management. Handcock Publishers. Blaine, Washington. 480 p.

Davis, L.S., K.N. Johnson, P.S. Bettinger, and T.E. Howard. 2001. Forest Management 4th Edition. McGraw Hill Publishers. Boston, Massachusetts.

George, S. 1996. Saving Biodiversity: A Status Report on State Laws, Policies and Programs. Defenders of Wildlife Publishers. Washington, D. C.

Grado, S.C., G.A. Hurst, and K.D. Godwin. 1997. Economic impact and associated values of Wild Turkey in Mississippi. Proc. Annu. Conf. Southeast Assoc. Fish and Wildl. Agencies. 51:438-448.

Hall, L.K., and H.L. Holbrook. 1980. Wildlife management on Southern National Forests. In: R.C. Chabeck and R.H. Mills eds. 29th Annual Forestry Symposium: Integrating Timber and Wildlife Management in Southern Forests. Louisiana State University. Baton Rouge, Louisiana. pp. 33-40.

Hamel, P.B., and J.B. Dunning, Jr. 2000. An approach to quantifying long-term habitat change on managed forest lands. Studies in Avian Biology 21: 122-129.

Li, H., D.I. Gartner, P. Mou, and C.C. Trettin. 2000. A landscape model (LEEMATH) to evaluate effects of management impacts on timber and wildlife habitat. Computers and Electronics in Agriculture 27:263-292.

Marzluff, J.M., J.J. Millspaugh, K.R. Ceder, C.D. Oliver, J.Withey, J.B. McCarter,

C.L. Mason, and J. Comnick. 2000. Modeling changes in wildlife habitat and timber revenues in response to forest management. Forest Science 48(2):191-202.

McComb, W.C., M.T. McGrath, T.A. Spies, and D. Vesely. 2000. Models for mapping potential habitat at landscape scales: an example using Northern spotted owls. Forest Science 48(2):203-216.

Mills, J.R. and X. Zhou. 2003. Projecting national forest inventories for the 2000 RPA timber assessment. Gen. Tech. Rep. PNW-GTR-568. Portland, Oregon: U.S.Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Nelson, M. 1999. Habitat conservation planning. Endangered Species Bulletin. 24(6):12-13.

Rohweder, M.R., C.W. McKetta and R.A. Riggs. 2000. Economic and biological compatibility of timber and wildlife production: an illustrative use of production possibilities frontier. Wildlife Society Bulletin 28(2):435-447.

Schaberg, R.H., T.P. Holmes, K.J. Lee, and R.C. Abt. 1999. Ascribing value to ecological processes: an economic view of environmental change. Forest Ecology and Management 114: 329-338.

Sharitz, R.R., L.R. Boring, D.H. VanLear, and J.E. Pinder, III. 1992. Integrating ecological concepts with natural resource management of southern forests. Ecological Applications 2(3): 226-237.

U.S. Fish and Wildlife Service. 2002. ESA Basics – Over 25 years of protecting endangered species. n. pag. Online. Internet. 05 June 2003. Available http://endangered.fws.gov.

U.S. Fish and Wildlife Service. 2003. Recovery plan for the Red-cockaded Woodpecker (Picoides borealis): second revision. U.S.Fish and Wildlife Service, Atlanta, Georgia.

U.S. Forest Service (USFS). 1999. Spectrum Users Guide. USDA Forest Service. n. pag. Online. Internet. 26 August 2002. Available http://www.fs.fed.us /imi/planning_ center/download_center.html

Small-Scale Non-industrial Private Forest Ownership in the United States: Rationale and Implications for Forest Management

Yaoqi Zhang[23], Daowei Zhang[24], John Schelhas[25]

[23] School of Forestry & Wildlife Sciences, 205 M. White Smith Hall, Auburn University, AL 36849, Phone: (334) 844 1041; Fax: (334) 844 1084, Email: yaoqi.zhang@auburn.edu.

[24] School of Forestry and Wildlife Sciences, Auburn University, AL 36849
Tel: (334)-844-1067; Fax: (334)-844-1084. Email: zhangdw@auburn.edu

[25] Southern Research Station, USDA Forest Service, Tuskegee University, AL
Phone: 334-727-8131, Fax: 504-589-3961, Email: jschelhas@fs.fed.us

Rationale and Implication of Small-Scale Non-industrial Private Forest Ownership

Abstract

The paper explores rationales of the rise and expansion of small scale non-industrial private forestry. The historical aspects of the small scale of forests are also briefly reviewed. In particular, the paper seeks to explain the reason for the increasing number of nonindustrial private forest ownerships with smaller holding size or private forestland parcelization. The main arguments are that small-scale family forestry expands with economic needs that in turn reflect structural changes in demand for and supply of forest products and services. We suggest that the cause of the increasing number of small-scale family forests should be focus on changes in the demand for forest products and services, while the causes of shrinking forest landholding ownerships should be examined with reference to the supply of forestland. Under this interpretation, small-scale family forest owners behave more like forestland consumers than timber producers. Thus efficiency in small scale family forestry is reflected will be found in the efficiency of forestland consumption for non-timber purpose for transaction costs savings, not in efficiency of timer production. Policy analysts should expand their focus beyond the analysis of production to consumption and distribution efficiency.

Key words: forest land parcelization, timber supply, transaction costs, economic efficiency, land use change, the U.S.

1. Introduction

Land ownership is a key factor in many social-economic and environmental issues, and forest ownerships are particularly complicated and diversified. One segment of forest land owners is the non-industrial private forest (NIPF). The NIPF owners are diverse in characteristics and land ownership objectives, and some argued that the name of NIPF is not appropriate (see, Finley et al., 2001; Wiseman, 2003). The number of NIPF owners is large, and they represent an important component in forestry. In the United States in the mid 1990s, an estimated 9.9 million private forest-land ownerships units held about 390 million acres of forest land. About 94% of the private ownerships are individuals, collectively holding 59% of the private forest land (Birch 1996) and supplying about half of the country's round wood timber supply. The share of timber supply is expected to rise to 60% by the year 2030 (Harrell 1989).

Over the past several decades, there have been many discussions, meetings, articles and arguments that talk about the "problem" of NIPFs (e.g., see Clawson 1957, Binkley 1981, Cubbage 1983, Row 1978, Siry 2002). With the exception of non-industrial private forests owned by Timber Investment Management Organizations (TIMOs), the majority of NIPFs are small scale: 40% owned less than 10 acres, 96% owned less than 100 acres (Birch 1996). In this paper we only examine small-scale forest ownership, and thus use the term small scale non-industrial private forest to distinguish family-owned NIPFs from the institutionally-owned TIMOs. The small land holding is still under subject of Parcelization, the reduction in size of forestland ownerships as a result of properties during land transfer. It refers mainly to the ownership subdivision, rather than forestland fragmentation which refers to the breaking up of large tracts of forest into smaller fragments. In the U.S., large forestland ownerships with a primarily purpose of timber production remain largely intact at present but the acreage in midsize woodlots is shrinking and the class representing the smallest landhlodings is growing (Birch 1996, DeCoster 1998). For example, from 1978 to 1994, the total number of all private timberland ownerships in the U.S. South increased by nearly one-third, or 1.1 million units. Acreage held in tracts of <10 acres increased by 51%; 10- to 99-acre tracts increased by 25%; 100- to 499-acre tracts decreased by -15%; 500- to 999-acre tracts decreased by -9%; and 1,000+-acre tracts increased by +9% (Moulton and Birch 1995). Preliminary results from the most recent survey by USDA indicated that the total of family owners had increased by 11% (from 9.3 million to 10.3 million) from 1994 to 2002 (see Forest Inventory and Analysis: National Woodland Owner Survey 2003). Currently, NIPF owners hold an average of 24 acres per individual, and it is expected the average size will drop to 17 acres by 2010 (Tyrell and Dunning 2000).

In order to design appropriate policies that encourage NIPF owners to manage their land to meet social goals, we need to understand these landowners, their objectives and behaviors. Although many studies have been conducted in these areas (e.g., Greene and Blatner 1986, Romm et al. 1987, Hyberg and Holthausen 1989, Kuuluvainen 1989, Newman and Wear 1993, Kuuluvainen et al 1996, Karppinen 1998), it is still not clear why NIPFs appear, survive and even expand since, from a timber production point of view this decreases efficiency. In this paper we attempt to provide a rationale for NIPF expansion, in particular, to address why the number of smaller NIPF ownerships has been increasing. We will begin by providing some historical background on the evolution of forestland ownership in the U.S., followed by possible economic explanation of NIPF expansion. We then address the implications for forest management in our final discussions. Our main conclusions are that NIPF expand due to economic needs and reflect efficient consumption markets since NIPF owners behave more like forestland consumers than timber producers. We suggest policy analysts should expand their focus beyond the analysis of production to include consumption and distribution efficiency.

2. History

The share forest ownerships in NIPF vary greatly from country to country, and historical context explains a great deal of the difference since the institution of ownership has some path dependence and rigidity. Alexander and Hall (1998) pointed out that the major impediment to small-scale forestry in Australia is the lack of historical farm forestry in Scandinavia and Japan. The present forest ownership in the U.S. has developed over three hundreds years and cannot be understood without considering that long history. Earliest land ownership policies in the U.S. had great influence on the current pattern. For instance, the first objective of colonial politicians was to build economic and military strength and the usual objective in New England was to establish compact settlements of small, family-size farms. Free market thinking and a fear of monopoly plays an important role in shaping the forest ownership throughout the history. American Revolution and the demographic traditions which it fostered strengthened the trend towards small ownership.

Since England intended to claim all North America when it colonized the New World, the Crown made large grants of land to the London Company, the Plymouth Company, and later to other individuals and groups. Gradually, the lands of the 13 original states of the Union came to have numerous individual ownerships. As settlement extended westward after the Revolutionary War, the territory beyond the Appalachians was given to settlers through land bonuses to war veterans and grants and sales (Clepper and Meyer 1965). After the Louisiana Purchase obtained all the western territory, one of the most significant policies was the Homestead Act of 1862, which was designed stimulate populate the new territory quickly. A clamor for ever-increasing liberalism in the disposition of these lands led to the formation of a demand of the Free-Soil party in 1830, which called for free distribution of such lands. The Homestaed Act allowed anyone to file for a quarter-section of free land (160 acres) if improvements were made within 5 years. The improvement activities include building a house, digging a well, plowing 10 acres, fencing, or living in the land. Additionally, a settler could claim a quarter-section of land by "timber culture" (commonly called a "tree claim"). This required that you plant and successfully cultivate 10 acres of timber (Hibbard 1965).

Another aspect that needs to be noted is the strong link between forestry and farming. Forest management has often been viewed as kind of agriculture. Farmers were thought to be most desirable owners of the private forests land and able to devote the most care and attention on the management of their wood lots. In 1920, there were 6.5 million farms in the U.S. with average size of only 149 acreages (USDA 1997). The large number of farms could be an important factor in what ultimately became a large number of individual forestland ownerships. Farm woodlands also contributed significantly to total farm income; and holding some forest land on a farm is often considered to be economically efficient because combining forestry and agriculture allow financial diversity and efficient use of labor and capital. Even today, forestry is still important for farmers. For example, Selter (2003) observed that farms holding larger amounts of forest land were more likely survive in Germany. During the period from 1971 to

1995, 90% of the enterprises that managed more than 5 ha (12 acres) forest land survived. These farms were not only able to continue as forest enterprises, but also as mixed farms, retaining their agricultural land.

Table 1: Timber land ownership in the U.S., 1952-2002.

			NIPF		
Year	Public	Industry	Total	Farmer	other private
1952	145, 436	58, 979	304, 441	172, 781	131, 660
1962	146, 157	61, 434	307, 528	143, 645	163, 883
1977	138, 169	68, 937	285, 250	114, 485	170, 765
1987	131, 025	70, 347	283, 564	95, 791	187, 773
1992	131, 493	70, 455	287, 605	82, 484	205, 121
1997	145, 967	66, 858	290, 840		
2002	147, 280	65, 596	290, 663		

Sources: Forest Resources of the U.S., 1992, 1997, 2002. Unit: 1000 acres.
Note: Data regarding the ownership between farmer and other private are not available probably because it is becoming more difficult to distinguish the farmers and non-farmers.

Extensive public ownership of forest land in the U.S. began in the late 1800s, and by the middle of 1900s a private-public division of forest landownership was firmly established. Private industry firms expanded their forestland ownership dramatically in the first half of the 20th century and then gradually stablized (see Table 1). The biggest change since 1950s has been within the non-industrial private forests, most notably the shift from farm forest to other kinds of NIPFs as individuals outside traditional forest business began to acquire more private forest land.

3. Economic Rationale

3.1 The efficiency of NIPF

The efficiency of the NIPF for timber production has been questioned for a long time. With the exception of Sutton (1973), a majority of studies (e.g., Clawson 1957, Wilstrom and Ally 1967, Row 1978; Noer 1975; Gardner 1981) have found that small parcel size significantly increases the production costs per unit in harvesting operation, plantation, and management. Since NIPF are in general is smaller in size than industrial forest, it is believed that NIPFs have lower economic efficiency than industrial private forests (Doll and Orazen 1978, Cubbage, 1983). Other studies have shown that timber supply has a positive relationship with holding size (e.g., Binkley 1981, Greene and Blatener 1986; Romm et al. 1987). Towell (1982) even claimed that, by a conservative estimate, private nonindustrial forestlands are producing only half or less of what they are capable of. More recent surveys have also showed that NIPFs are generally managed less intensively than their larger counterparts (see Siry 2002). Only very a few studies have found that land holding size has only slight influence on timber supply (Dennis 1989, Hyberg and Hothausen 1989; Kuuluvainen 1989).

It is not a surprise that NIPFs have lower efficiency in terms of timber production based on the economy of scale. However, the number of owners with decreased holding size continues to rise across the world. As we know, manufacturing began with small family owned firms also, but smaller firms were gradually replaced by firms with growing scale through time. In agriculture, although family farms are still important in North America, the farm size has been dramatically increasing, going from an average size of 149 acres in 1920 to 500 acres in 1997 (USDA 1997). This trend is more or less same in Europe. So the question is: What is the difference between agriculture and forestry? There must be some economic rationale for small scale forestry, or it would not have survived for centuries and continue to expand.

One explanation for the larger number of small land holdings is related to the partitioning of forest land during generational transfers. However, if dividing the forestland dramatically reduces the total value (because of low efficiency), there is no reason why it should proceed, as is the case in agriculture and other industries. Furthermore, according to a survey in Florida by Jacobson (1998), 70% of the owners acquired their land through purchase. Similarly, Kennedy and Roche (2003) found that 64% of landowners acquired their land through purchase or trade in Alabama. This is a relatively large number considering that traditionally much of the private forest land used to be inherited by heirs.

Another common explanation is the nature of multiple uses of forests and the increasing number of landowners with non-timber objectives: residential use, aesthetic enjoyment, timber production, hunting, moral commitment, nature conservation, estate investment, etc. This explanation has merit, but to economists it is incomplete. We have multiple needs and a growing number of wants, but we get more and more of our goods and services from markets due to the efficiencies of specialization and market development. So, we suggest that the fundamental reason for increasing number of NIPF must lie in its efficiency, but that efficiency must be understood broadly. More timber produced from the same land is just one aspect of efficiency; efficiency also includes the stages of production, distribution and consumption. If one person is willing to pay higher rent than another, that means the former's holding can generate higher value (at least the private value) that may come from the saved cost, or increased products value, or saved transaction costs.

3.2. Why more people holding forestland?

Regarding the increasing number of the NIPFs, demand analysis may be more appropriate. Either the total number of households increases, or there is a increased change in preference to hold forestland can lead to more people hold forestland. The first cause is clear in the US, the second cause is likely based on the number of NIPFs has been growing faster the growth of population. The most important characteristic of such demand is the use forest land as a consumption good, not for timber production.

Holding or not holding a piece of forestland depends on the goods and services generated from the forest land satisfying an individual's needs and the transaction costs he must spend to acquire these goods and services through the market, if he does not already own land. Transaction costs are determined by the numbers of trade and per unit cost of trading. Owning a piece of forest land may be more efficient than buying the multiple goods and services from the land when demands for these goods and services is strong and the transaction costs to acquire these goods and services via market are high. Alternatively, selling the service generated from forest land is not as efficient as selling the land itself. Centuries ago, landlords hired labor, now in general capital hires labors. But in information technology industry, it is often technological labors hire capital, at least a few years ago. Fundamentally, the purposes of holding NIPFs are to save transaction costs from different perspectives (Zhang 2001):

Capital transaction costs: Using borrowed funding to invest in NIPF is unlikely attractive since NIPF may need to pay higher capital costs compared with a large-scale business or forestry operation. But if the owners have extra capital, the owners may still be better off when the return rate is slightly higher opportunity investment value (e.g., deposit interest rate), but lower than the interest rate for money borrowed from banks. The prevailing interest rate (loan) based criterion of investment for NIPF owners may not be very well grounded.

Labor transaction costs: The transaction costs of labor can be divided into fixed and variable costs with the relative transaction costs for searching for jobs (or hiring) being relative high for one person's partial labor force. Farmers are more likely to own some NIPF since it is more costly when only part-time labor (seasonal jobs) in transaction [rewrite this sentence]. In addition, the opportunity cost of occasional and self-chosen time spent working in a farm forest could be very small, even negative since the work may be a form of recreation. Minimum wage (or prevailing wage level) is largely irrelevant for this category of work. Timberland management is often fun and brings contentment.

Forest land transaction costs: High taxation and difficulties in measurement in land transactions lead higher transaction costs. Transaction costs may be relatively lower between relatives or when both sides know the land very well, so it is quite often that NIPFs are transferred between relatives who become new NIPF owners rather than between strangers and private industrial forest owners. It is particular as the value of cultural and heritage of the forests for family and friends is often higher than for other potential buyers. *Forest product (wood and non-wood) transaction costs*: The transaction costs for timber are high. As Vardaman (1988) argued, "no market I know of is like the timber market. A phone call can get you a firm price on many common items: stock, bond, groceries, clothing, commodities, autos, and so on. But a phone call to 20 timber buyers will likely get you 20 different estimates, and each buyer will want to see your timber before making a firm offer." But the transaction cost for timber is still moderate compared to recreational goods. Demands for non-timber services from forests are increasing rapidly. It is not difficult to imagine how costly it is to go through the stages of searching, contacting, negotiating, and purchasing these products and services, such as renting a summer house or acquiring hunting access from other owners. Recreation products generated from the forests cannot be moved and do not have standards. Asymmetric information is serious, so when such demands become frequent, it is likely that the owning and used for one's own production and consumption is more efficient than partial "buying" the services produced by others.

The above analyses are only for illustrative purposes. The owners may have all the above characteristics, saving the various transaction costs mentioned above. Farm owners of forests were the majority in the past, so saving transaction costs of labor may have been their a major reason for forest ownership. But this has gradually been replaced by saving transaction costs of recreational services for other kinds of owners. Currently the most fundamental drive for the increasing NIPF come from more wealthy individuals who are affordable to buy a piece of land as second home for seasonal residency and recreation, or as an investment (for the appreciation of the land value, not timber value). Evidence shows that more and more retired people and white collar professionals hold NIPF. Investment and timber income is only the 6th and 7th place in the list of their holding reasons (Tyrrell and Dunning 2000, p. 10).

Based on the above argument, some general conclusions about ownership decisions for NIPF owners can be made: (1) many NIPF owners have some saved capital or stable and high income, or is at least free of debt, unless he/she is a farmer and expects to use forestry as seasonal employment; (2) they also include retired or aging people with low opportunity costs for their time, who enjoy the increased space and peaceful living on forest land the forest, and (3) NIPF owners have some tendency toward continuity from generation to generation since, transaction costs are significantly higher for other owners.

3.2. Why are people holding smaller amounts land?

The shrinking size of forestland holding can be explained from the supply side. Without considering supply or assuming constant price, wealthy individuals will like to hold bigger forestland regardless of whether it is for hunting or for a second home. But increasing demand from OTHERS together with the decreasing supply (land is fixed) due to other competitive uses drive up the forestland price, particularly at the suburban fringe. We contend that it is becoming less affordable for families to the same amount of land (which has increased in value) becasue the opportunity costs cannot justify the marginal value for them. In other words, the marginal value of increasing wealth cannot catch up the land appreciation (opportunity costs). Hence, holding smaller land is rational even without considering taxation (See Figure 1).

Mehmood and Zhang (2001) also found that taxes were not statistically significant in parcelization. But we should note that for timber production, the holding size is based on the production efficiency of timber production, and holding size may increase further. For the consumption purpose of many NIPF owners, the optimum size is based on consumption efficiency. So it can co-exist that the scale of forestland holding for timber production increases, while the scale of NIPF declines. The small sizes become more concentrated to non-timber purpose for the owner, while the larger size holding still serve as timber production.

This is consistent with evidence from U.S., Finland and other countries. In the U.S., the largest parcels remain intact at present, but the acreage in midsize woodlots is shrinking and the bottom class is growing (DeCoster 1998). Seen from Table 2, the number of small holders with less than 100 acres has increased since 1978; the medium holding size holders has declined (Birch 1996, p.14). In the Southern U.S., tracts of fewer than 10 acres increased by 51%, 10-49 acre tracts increased by 83%, and 50-99 acre tract by 18%; but the holdings between 100-1000 acres have declined by 15%; tracts over 1000 acres have increased by 9% (Moulton and Birch 1995). Bliss and Sisock (1998) also found that the share of private forestland owned by the largest 1% of the owners had increased from 51% to 58% from 1978 to 1993 in Alabama. In Finland the number of medium-sized forest holdings (20-50 ha) is decreasing, and the number of small- and large-sided holdings is increasing (Ripatti 1999). This is not surprising, since increasing size may increase efficiency in terms of timber production, while reducing size may increase efficiency for consumption of forest land for non-wood production purpose.

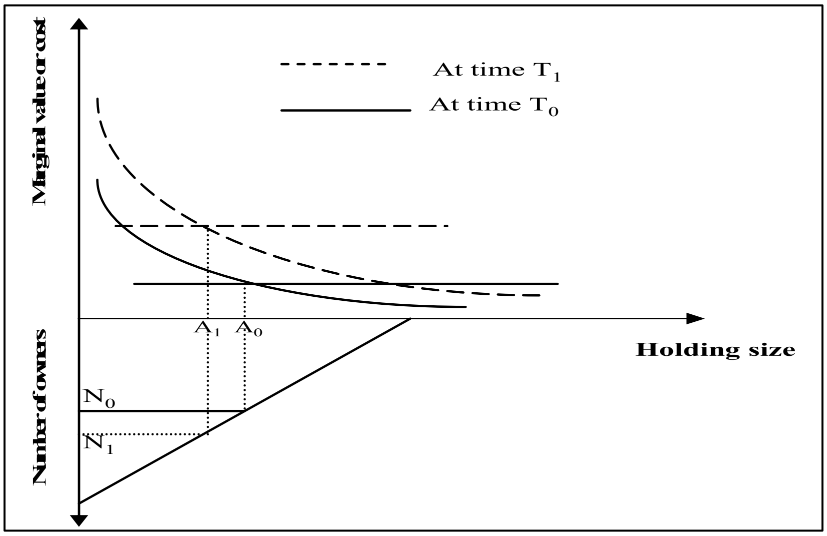


Figure 1: Shrinking holding size and increasing number of forestland owners.

Table 2: Changes in private forest ownership and percentage of total forest acreage

	1978		1994		2010	
	Ownerships	Percent	ownerships	percent	ownerships	percent
less than 100	7, 156	21.60%	9, 274	31.60%	11, 550	38.00%
100-499	538	30.80%	559	23.30%	570	18.80%
500 and above	63	47.60%	68	45.10%	68	43.20%

Sources: DeCoster (1998). The 1978 and 1994 data from Birch (1996), while the 2010 data was estimated.

4. Implications for Forest Management

Is the boom in forest owners really a bust for forestry? The patterns of forest ownership change have some relation to forest management (e.g., Stanfield et al. 2002), but the potential impacts need to be carefully assessed. Following aspects are our major concerns and questions.

4.1. Conversion to non-forest use and fragmentation?

Although forest fragmentation (large and contiguous forest landscapes broken into smaller, more isolated fragments) differs from land parcelization (larger number of owners with smaller land), they are definitely related. The United States loses more than half a million acres of privately-owned timberland to development each year, and NIPF has often been claimed as one of the causes and/or victims. On the one hand, NIPF might be easier to convert to non-forest use if the value of the other land use (e.g., market value for development) is higher than owner's perceptional value in forest use. On the other hand, NIPF owners may prevent forestland from going to other uses, since the NIPF owners value the forest use more than the value of timber, thus increasing competitiveness with other uses. So this question may be more complicated than has generally been thought. Parks or urban forests can be found in many big citie, but rarely urban agriculture! Forest land value increases with the rising number of NIPF owners who value the land more than the timber and timber productivity. Interestingly, Drzyzga and Brown (2002) found more small scale private forests lead to higher forest cover.

If we look at longer time periods the multiple uses of forests, which may be less intensive in terms of timber production, may reverse the forest decline to forest expansion. A higher population density, under given socio-economic circumstances, increases the absolute land value in every use, but probably most for residential and industrial use value. Land either in agriculture or in forests is likely to be converted to residential and industrial uses as the economy develops and population grows. If forest land is used for more than timber production, the relative value for forestland may rise faster than agricultural use. If that is the case, NIPF owners may play a positive role in retaining forests. For example in New York State, 63% of the land was forested in 1780, 25% in 1880 and 63% again in 1980 and the percentage is even higher today (Larson 2000). Therefore, NIPF might be a factor in the increase since they consume the forest in situ and do not care about the profitability generated from wood production.

4.2. Reduced management intensity?

As introduced above, evidence suggests that NIPF reduce forest management intensity in terms of timber production. Typically, as the average parcel size declines to some threshold, owners are less likely to actively manage their forests for sustainable timber. New U.S. Department of Agriculture Assessment clearly shows such situation (Table 3).

Table 3: Management intensity of Forest Industry, TIMO, and NIPF

		2000			2020		
		Industry	TIMO	NIPF	Industry	TIMO	NIPF
Planted Pine	Standard	14	6	11	2	2	8
	Superior	46	38	64	25	28	46
	High Yield	40	56	25	73	70	46
Natural Pine	Lower	61	59	79	71	40	52
	Higher	39	41	21	29	60	48
Oak-Pine	Lower	95	75	85	95	73	76
	Higher	5	25	15	5	27	24

Source: Siry (2002)

It is likely that there are three major reasons for the reduced management intensity: 1) Intensive management is difficult and more expensive on the smaller tracts that are usually owned by small forest land holders; 2) multiple objectives of the NIPF owners mean that less intensive management is preferred, and that in turn can lead to greater non-timber value of the forests at the expense of timber production; 3) the owners do not know how to improve the management.

Evidence and study also support that timber production and profit maximization is still the objective of many NIPFs owners (McComb 1975, Newman and Wear 1993). In addition, NIPF prefer hardwood and longer rotation of timber management (see Figure 3). Can we say this is less intensive management? Maybe it is less intensive in terms of timber production, but more intensive in non-timber forest management--that is good since it generate positive externalities to the society.

4.3. Impacts on timber supply?

Decreasing timber supply has been the major concern from decreasing land holding size. But do we really need to worry about the future supply due to the parcelization? If we see timber as a private good, then we do not need to worry since the market can use price to adjust the demand and supply. In spite of the fact that NIPF may not be very sensitive to timber price as incentive to timber management investment, most owners still get some economic resturns from timber production, particularly the medium size of holders. If the timber price rises, the land value for industrial timber management will rise too, then it will be more expensive for the NIPF to hold larger forest tracts, and opportunity costs cutting timber will be greater. At a minimum, that will defer the land transition from industrial to small land holder, and it may induce even more intensive timber management.

Another important point is that we need to pay attention not just to the rapidly growing number of NIPF owners, but also the total acreage they hold. In spite of the fact that NIPF landholdings are increasing in both number and rate, the percentage their holdings of all forestland or timber land is still small. For example, the total acreage of holding size less than 100 acres had doubled from 1978 to 1994, but only 10% of the total forestland (from 21.6% to 31.7%). In other words, if the rest of 70% of the forestland can increase 5% of timber productivity that that can compensate the reduction of productivity of 30% of the increased amount of holding size less than 100 acres (10% of the total forestland).

Globalization of timber supply has prevented substantial increase in regional wood price. Other goods and service from land, such as residential houses, cannot be imported. Consequently the value of other uses/or multiple uses (particularly the residential and recreational) for wood land rises in some regions (e.g., the US) faster than that of the value for timber production. It is likely that private forests, particularly those in smaller ownerships, will not intensively be used for timber production, simply because it is too trial to pay attention the benefit from the wood production at the expense of non-wood benefit from the forests. It is also not worth obtaining the technology to increase management intensity for small woodlands. Globalization leads to land allocation for timber production globally. If we are concerned with timber supply, we need to think globally. Timber supply from Southern hemisphere is becoming more and more important since it is more economically efficient (Zhang 2004).

5. Discussion

Before World War II, farmers were seen as the best managers for private forests, while the forest industry was viewed only as loggers and speculators. Since then, forestry industry has come to play a major role in private forest management; while NIPFs have been criticized for managing their land less intensively. The fact is that, as Harrison et al. (2002) observed, "throughout the world, there appears a trend to move from industrial forestry towards landholder-based forest management and community forestry and small-scale (often referred to as 'smallholder') forestry is of growing importance."

"Are we trying to hold back the tide?" as raised in Tyrrell and Dunning (2000). Our answer may be "don't trying to hold back the tide". First, generally speaking, land parcelization is the process of exchange between the land rich but cash poor people and land poor but cash rich people. The exchange generates social welfare and leads to welfare redistribution. Some studies have found that more small private forest ownerships lead to social-economic development (Sisock 1998). In Finland, some attempts have been made to circumvent the partitioning process. It was proposed by the Finnish Forest 2000 program that the partitioning of NIPF holdings into units small than 10 ha should be made illegal, but this has never been implemented in practice (Ripatti 1996). Secondly, as argued throughout the paper, NIPF expansion has its own economic rationale—the efficiency of consumption of forest based products and services. From the perspective of the whole society, the sum of millions of individuals' net benefits (demand or value minus transaction costs) in each owning a small piece of forestland may far outweigh the sum of the benefits in fewer large scale private forestland ownerships (the latter benefits come primarily from economy of scale) largely because the production and consumption is more directly connected. NIPF expansion may not necessarily be associated with forest land loss, decreased management intensity, and reduced timber supply. The impacts may be more reflected in the form of forest land, type of management, and type of timber supplies. As the demand and supply change, so do number of owners and their holding sizes. The dynamics of holding size change (or parcelization) is actually the adjustment of the supply for and demand of the forestland. Any changes in individual characteristics (e.g., change in income and age), society (e.g., population growth and wealth), and environment (e.g., the accessibility to recreation resources from public lands) will change the holding size and management strategies.

We do not intend to suggest that there are no problems with NIPF, sicne some policy changes are definitely needed. Forest land not only generates timber but also provides many ecological and environmental services that are public goods. It is more widely agreed that parcelization break down the integrity of biodiversity, watershed and ecosystem. That means the private costs and benefits differ from public costs and benefits. Therefore, welfare loss occurs and public policies are desired. We need to carefully evaluate and design effective policies to reduce the negative impacts. As pointed out in Larson (2000), "attention should focus on the more important goal of helping new and old forest owners manage their forest effectively, rather than preventing 'fragmentation' per se."

We need to compare and examine the costs and benefits (both social and private) of different policies. So far, a variety of management approaches are suggested to reduce the diseconomies of NIPF or small track of land. The most common way is to provide technical and financial support from government. Row (1978) suggested that effects on financial returns can be reduced by managing small tracts in groups, cooperatives, or other aggregations of owners. Uusivuori and Kuuluvainen (2001) also suggest collaboration in timber selling. These are important questions that need to be addressed. It is unclear what policy is more efficient, but this is an interesting and important field for future study.

References

Alexandra, J. and M.Hall. 1998. Creating a viable farm forestry industry in Australia. What will it take? RIRDC Publication No 98/74. Canberra.

Binkley. C. 1981. Timber Supply From Private Nonindustrial Forests. Yale School of Forestry and Environmental Studies, Bulletin No. 92.

Birch, T.W. 1996. The private forest-land owners of the United States, 1994. USDA Forest Service, Northeastern Forest Experiment Station, Res. Bull. NE-134, 183p. Radnor, PA.

Bliss, J. C., M. L. Sisock. 1998. Ownership matters: forestland concentration in the rural Alabama. Society and Natural Resources 11 (4): 401-410.

Clawson, M. 1957. Economic size of forestry operation. Journal of Forestry 55: 521-526.

Clepper, H. and A.B. Meyer. 1965. The world of the forest: Prepared in cooperation with the Society of American Foresters. D.C. Heath and Company, Boston.

Cubbage, F. W. 1983. Economics of Forest Tract Size: Theory and Literature. USDA, Forest Service. General Technical Report 41.

DeCoster, L. A. 1998. The boom in forest owners - A bust for forestry? Journal of Forestry 96(5):25-28.

Dennis, D. F. 1989. An economic analysis of harvest behavior: integrating forest and ownership characteristics. Forest Science 35 (4): 1088-1104.

Doll, J. P., F. Orazen, 1978. Production Economics: Theory with Application. Grid Incorporation, Columbus, Ohio.

Drzyzga, S.A. and Brown, D.G. 2002. Spatial and Temporal Dynamics of Ownership Parcels and Forest Cover in Three Counties of Northern Lower Michigan USA, ca. 1970 to 1990. In S.J. Walsh and K.A. Crews-Meyer, Eds., Remote Sensing and GIS Applications for Linking People, Place, and Policy, Dordrecht: Kluwer, p. 155-185.

Finley, J. C. , S.B. Jones, A.S. Reed, M.G. Jacobson, G.R. Glover. 2001. Finding a name to fit the owner. Journal of Forestry, 2001 (March): 48.

Gardner, W. E. 1981. Effect of tract size on cost of reforestation. State University of North Carolina, Raleigh, M.S. Thesis.

Harrison, S., J. Herbohn, A. Niskanen. 2002. Non-industrial, smallholders, small-scale and family forestry: what's in a name? Small-scale Forest Economics, Management and Policy,1 (1): 1-11.

Hibbard, B. 1965. A History of the Public Land Policies. Madison: U. of Wisconsin Press.

Hyberg, B. T., D.M. Holthausen. 1989. The behavior of non-industrial forest land owners. Canadian Journal of Forest Research 19: 1014-1023.

Karppinen, H. 1998. Values and objectives of non-industrial provate forest owners in Finland, Silva Fennica 32 (1): 43-59.

Kuuluvainen, J. 1989. Nonindustrial private timber supply and credit rationing: Microeconomic foundations with empirical evidence from Finnish case. Swedish University of Agricultural

Sciences, Dept. of Forest Economics, Report 85.

Kuuluvainen, J., H. Karppinen, V. Ovaskainen. 1996. Landowners objectives and nonindustrial private timber supply. Forest Science 42 (3): 300-309.

Larson, K. 2000. Taxation, regulation and fragmentation of forestland. Paper presented at the Forest Fragmentation 2000: Sustaining Private Forests in the 21st century. Annapolis, MD, September 17-20, 2000.

McComb, W. H. 1975. Mismanagement by the small landowner: Fact or fiction? Journal of Forestry 73(4):224-225.

Mehmood, S. R., D. Zhang. 2001. Forest parcelization in the United States. Journal of Forestry 99(4): 30-34.

Moulton, R. J., T.W. Birch. 1995. Southern private forest land owners—a profile. Forest Farmer Magazine. September/October: 44–46.

Newman, D. H. and D.N. Wear. 1993. Production economics of private forestry: A comparison of industrial and nonindustrial forest owners. American Journal of Agricultural Economics 75:674-684.

Noer, H. 1975. An evaluation of economic disadvantages associated with fragmentation of forest holdings. Tidsskrift for Skogsbruk 83 (2): 233-248.

Romm, J., R. Tuazon, C. Washburn. 1987. Relating forestry investment to the characteristics of nonindustrial provate forestland owners in the northern Califonia. Forest Science 33 (1): 197-209.

Row, C. 1978. Economics of tract size in timber growing. Journal of Forestry 76: 576-579, 582.

Sampson, N., L. DeCoster. 2000. Forest Fragmentation: Implication for sustainable private forests. Journal of Forestry 98 (3): 4-8.

Selter, A. 2003. Farm forestry in the Black Southern Nature Park from a soci0-political point of view. Small-Scale Forest Economics, Management and Policy, 2 (1): 37-48.

Siry, J. 2002. Intensive Timber Management Practices, In Southern forest resource assessment , edited by Wear, David N.; Greis, John G., eds. 2002.. Gen. Tech. Rep. SRS-53. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station.

Sisock. M. L. 1998. Unequal Shares: Forest Land Concentration and Well-being in the Rural Alabama. Master Thesis, Auburn University. AL, USA.

Stanfield, B. J., J. C. Bliss, T.A. Spies. 2002. Land ownership and landscape structure: a spatial analysis of sixty-six Oregon (USA) Coast Range watersheds. Landscape Ecology 17 (8): 685-697.

Sutton, W. R. J. 1973. The importance of size and scale in forestry and forest industries. New Zealand Journal of Forestry 18 (1): 63-90.

Tyrrell, M., G. Dunning. 2000. Forestland Conversion, Fragmentation, and Parcelization. Yale Forest Forum Series Publication Vol. 2, No. 6.

U. S. Department of Agriculture (Forest Service). Forest Resources of the U.S., 2002. http://ncrs2.fs.fed.us/4801/fiadb/rpa_tabler/Draft_RPA_2002_Forest_Resource_Tables.pdf

U. S. Department of Agriculture (Forest Service). 2001. Forest Resources of the U.S., 1997. General Technical Report NC-219.

U.S. Department of Agriculture (Forest Service). 1994. Forest Resources of the U.S., 1992. General Technical Report RM-234.
USDA National Agricultural Statistics Service. 1997. Census of Agriculture.

Uusivuori, J., Kuuluvainen, J. 2001. Benefits of Forest-Owner Collaboration and Imperfect Capital Markets. Forest Science, 47, 428-436.

Vardaman, J, M.1988. How to Make Money growing Trees. John Wiley & Sons, New York.

Wilstrom, J. H., J. R. Ally. 1967. Cost control on timber growing on the National Forests of the Northern Region. U.S. Department of Agriculture, Forest Service, Intermountain Forest Range Experiment Station Research Paper 42.

Wiseman, L. 2003. Family forests: let's call them what they are. Journal of Forestry, 2003 (April/May): 60.

Zhang, Y. 2001. Economics of transaction costs saving forestry. Ecological Economics 36(2): 197-204.

Zhang, Y. 2004. Multiple-use forestry versus forestland-use specialization revisited. Forest Policy and Economics (in press).

Comparing Hunting Lease Prices: A Price Decomposition Approach[26]

by

I.A. Munn, E.K. Loden, S.C. Grado, J.C. Jones, and W.D. Jones

Abstract

Landowners in the coastal and Delta regions of Mississippi were surveyed to determine hunting lease prices in each region. Lease prices in the Delta averaged $2,317 more than lease prices in the coastal region, a 60% difference. Hedonic hunting lease price equations were used to decompose this price difference into differences due to the characteristics of the lease and differences due to the valuation of the characteristics. Both components explain a portion of the price difference. Hunting leases are, on average, 25% larger in the coastal region; however, per acre values for agricultural, forested, and other acres were all substantially higher in the Delta. In contrast, landowner expenditures on wildlife habitat increased landowner revenues and profits in the coastal counties but did not affect lease prices in the Delta.

Key words: Hunting leases, hedonic prices, lease characteristics, Mississippi Delta, price decomposition

[26] Approved for publication as Journal Article No. FO-393 of the Forest and Wildlife Research Center, Mississippi State University.

Comparing Hunting Lease Prices: A Price Decomposition Approach

INTRODUCTION

Hunting leases can be an important source of income for private landowners (Southwick 2003); however, lease prices can vary substantially as evidenced by lease prices reported by Timber Mart-South (2004). Per acre prices depend on various factors such as cover type or land use, abundance and diversity of game species, and additional amenities that landowners may provide (Loomis and Fitzhugh 1989; Hussain et al. 2004). Lease prices often vary substantially between regions, states, and even within states (Jones et al. 2001, Timber Mart-South 2004). Understanding why leases prices vary between specific regions is important for a number of reasons. Knowing what drives lease prices would enable landowners to maximize lease revenues by modifying relevant lease characteristics under their control. Furthermore, landowners could take advantage of public and private assistance programs that enhance high value lease characteristics. Public policies favoring wildlife-based economic development depend on accurate information regarding factors that determine lease values.

Leases can be viewed as differentiated goods that vary in terms of size, habitat quality, game species, and location. Because lease prices are a function of such characteristics embodied in the lease, the hedonic model (Rosen 1974) is appropriate for analyzing lease prices. Price differences between similar differentiated goods occur because the: (1) characteristics of the goods differ, and (2) characteristics are valued differently. Hunting lease prices can be decomposed into these two components. Price decomposition was originally developed to examine wage differentials between people working in similar occupations. See, for example Oaxaca (1973), Blinder (1973), and Jones (1983). The objective of this study is threefold: (1) determine average hunting lease prices in two Mississippi regions, 2) decompose the differences in the regional lease prices into differences in characteristics and differences in the valuation of characteristics, and (3) identify opportunities for landowners to enhance their lease values.

METHODS

Study Area

Four counties in the lower Mississippi Delta (Warren, Issaquena, Sharkey and Washington) and six coastal counties (Hancock, Harrison, Jackson, Pearl River, Stone, and George) comprised the two study regions. The lower Mississippi Delta counties lie primarily in the Mississippi Alluvium physiographic region with western Warren County lying in the Upper Thick Loess region. The coastal counties encompass the Gulf Coast Flatwoods Region and portions of the Lower Coastal Plain. Land-use differs dramatically between the study regions. Agriculture is the primary land-use in the Delta counties with forests covering only 40% of the region. In the coastal counties, timber production is the primary land-use and forests cover 76% of the region (Hartsell and London 1995).

Data

Hunting lease information was obtained by surveying landowners in the two regions. Names and addresses of landowners were obtained from the county tax rolls. In 1997, mail surveys were sent to approximately 1,300 Delta landowners who owned 40+ acres. A single follow-up mailing was sent to all non-respondents, approximately two weeks after the initial mailing. In 1998, mail surveys were sent to approximately 2,000 Delta landowners who owned 40+ acres. No follow-up mailing was sent. The survey instrument solicited information about the amount and composition by land-use of land included in hunting leases, wildlife species included, and wildlife and habitat management-related expenditures.

Analysis

Hedonic price equations for regional hunting leases were modeled as:

(1) $P^D = X^D\beta^D + \varepsilon^D$

(2) $P^C = X^C\beta^C + \varepsilon^C$

where

P = the average hunting lease price for a region,
X = a vector of characteristic means,
β = a vector of characteristic coefficients for the regional hedonic price equations,
ε = a normally distributed error term and,
C and D superscripts represented the coastal and Delta regions, respectively.

Average lease prices and hedonic price equations were estimated for each region. The empirical specification of the hedonic lease price is:

(3) Lease Price = f(land characteristics, lease characteristics, landowner effort)

where land characteristics included the number of acres of forested, agricultural, and other acres and the % wetlands included in the lease; lease characteristics included whether waterfowl, major game species (deer *Odocoileus virginianus* and turkey *Meleagris gallopavo*), and minor game species (squirrel *Sciurus spp.*, dove *Zenaida macroura*, quail *Clinus virginianus*, rabbit *Sylvilagus spp.*) were included in the lease; and landowner effort was the dollars spent on wildlife management.

The difference in average prices was decomposed into differences due to characteristics (DDC) of the leases and differences due to valuation of the characteristics (DDVC) as follows:

(4) $\Delta P = X^D b^D - X^C b^C$

where

ΔP = the difference in average regional lease prices and, b = a vector of estimated characteristic coefficients for the regional hedonic price equations estimated from the data.

By adding $X^D b^C$ - $X^D b^C$ to the right hand side and rearranging terms, we have

(5) $\Delta P = (X^D - X^C)b^C + X^D(b^D - b^C)$

(6) $\Delta P =$ DDC + DDVC

Thus, DDC was equal to the difference between the regional characteristic means times the coastal region hedonic price for the respective characteristic and DDVC was equal to the difference in the regional hedonic prices for each characteristic times the mean value of the respective characteristic for the Delta region.

RESULTS

The survey response rate averaged 30% for both regions after adjusting for surveys returned for incorrect addresses, deceased landowners, and property sales. Leasing hunting rights was more common in Delta counties (14% of respondents) than coastal counties (8% of respondents). Coastal respondents leased hunting rights on 73% of their land while Delta respondents leased 52% of theirs. Most of the unleased portion was agricultural land. Annual lease revenues averaged \$6,112 per landowner in the Delta, \$2,300 more than in the coastal counties (Table 1). The average acres leased per landowner was 25% larger in coastal counties (1,291 ac) than in Delta counties (973 ac). Coastal county leases were almost exclusively forest land while 30%, on average, of Delta leases were agricultural and other land. Deer and turkey were included in approximately 90% of leases in both regions. Game species such as quail, dove, squirrel, and rabbit were included in approximately 45% of leases in both regions. Waterfowl were more frequently included in Delta county leases (55%) than in coastal county leases (28%).

Table 1. Mean variable values for hunting leases in six coastal and four Delta counties of Mississippi reported by survey respondents for the 1996-1997 and 1997-1998 hunting seasons.

Variables	Coast (n = 69)	Delta (n = 39)
Annual Revenues (\$)	3,795	6,112
Forested acres	1,250	690
Agricultural acres	5	168
"Other" acres	36	115
% wetland	1.5	0.8
Waterfowl	0.28	0.55
Deer and turkey	0.95	0.87
Other species	0.44	0.46
Wildlife mgt. expenses (\$)	488	3,737

Only two coefficients for characteristics in coastal county leases were statistically significant[27] in the estimated hedonic price equation (Table 2). Each forested acre contributed \$2.05 to the total lease price. Wildlife management expenditures increased total lease prices by \$1.26 for every dollar spent. In the Delta region, all land characteristics were statistically significant in the estimated hedonic price equation. Each agricultural acre contributed \$8.00 to the total lease price; each forested acre contributed \$4.91; and acres in other land uses contributed \$4.71. For each 1% increase in wetlands as a percent of the total leased acres, lease prices increased \$810.44 in the Delta region but had no significant effect in the coastal region. Wildlife species included in the lease were not significant in either region.

Table 2. Estimated coefficients for hedonic price equations for hunting leases in six coastal and four Delta counties of Mississippi based on survey responses for the 1996-1997 and 1997-1998 hunting seasons.

Variables	Coast (n = 69)	Delta (n = 39)
Intercept	405.05	951.39
Forested acres	2.05*	4.91*
Agricultural acres	-1.38	8.00*
"Other" acres	2.61	4.71*
% wetland	11.76	810.44*
Waterfowl	187.76	610.21
Deer and turkey	-22.62	-2,114.47
Other species	148.06	1,261.22
Wildlife mgt. expenses	1.26*	0.03

*significantly different than zero at α= 0.10.

The price decomposition analysis revealed that price differences were due primarily to land characteristics; however, in some instances, the differences due to characteristics and differences due to valuation of characteristics were partially offsetting (Table 3). Consider forested acres, for example. Hunting leases in the Delta counties had, on average, 560 fewer acres of forested land than their coastal counterparts. Evaluated at the coastal county price for forestland of \$2.05/ac, 560 fewer forested acres should reduce Delta lease prices by an average of \$1,480 relative to coastal lease prices; however, forested acres in Delta counties were valued at \$2.86 more per acre (\$4.91 versus \$2.05) thereby increasing Delta lease values by \$1,973. The net impact of forested acres was to increase Delta lease values by \$825 relative to coastal lease prices. Agricultural acres were both highly valued in the Delta and represented a larger component of Delta leases compared to coastal counties, thereby increasing Delta lease prices by \$1,351. This amount was the largest total for any of the characteristics with at least one significant coefficient. Note that if both coefficients, i.e., corresponding coefficients for Delta and coastal counties, were not significantly different from zero, then the difference in lease prices due to that characteristic could be assumed to be minor despite the magnitude of the estimated value, e.g., differences in lease values due to including deer and turkey in a lease.

The amount of other acres and % wetland increased Delta lease values while wildlife management expenditures, although greater in the Delta, had a smaller impact on Delta lease

[27] α = 0.10 was used for all tests of statistical significance.

values. In total, forested, agricultural, and "other" acres increased Delta lease prices by an average of $2,624. Other characteristics combined to reduce this total by approximately $300.

Table 3. Decomposition of annual hunting lease price differences between Delta and coastal counties in Mississippi into differences due to characteristics (DDC) and differences due to valuation of characteristics (DDVC) based on survey responses for the 1996-1997 and 1997-1998 hunting seasons.

Characteristic	DDC	DDVC	Total
	$	$	$
Intercept	0	546	546
Forested acres	(1,148)	1,973	825
Agricultural acres	(225)	1,576	1,351
"Other" acres	206	$242	448
% wetland	(8)	$639	631
Waterfowl	51	232	283
Deer and turkey	2	(1,820)	(1,818)
Other species	3	512	515
Wildlife mgt. expenses	4,094	(4,597)	(503)
Total	2,975	(687)	2,278

SUMMARY

Hunting lease prices often differ substantially from region to region. This study examined differences in hunting lease prices between two Mississippi regions using price decomposition, a technique developed by labor economists to analyze wage differences between segments of the labor force doing similar jobs. Hedonic price equations were estimated for hunting leases in both regions. In the coastal region, only the number of forested acres and wildlife management expenditures had a statistically significant effect on lease prices. In contrast, the number of forested acres, agricultural acres, other acres, and % wetland had a statistically significant effect on lease prices in the Delta region.

Annual lease prices in the Delta averaged $2,300 more than annual lease prices in the coastal region. This price differential was decomposed into differences in characteristics embodied in the leases and differences in valuation of these characteristics. Price decomposition revealed that, although coastal county leases averaged 300 acres larger than leases in the Delta region, all types of land were valued much higher in the Delta. This premium accounted for almost all of the net difference in lease prices.

Also of interest is the effect of wildlife management expenditures. Landowners spent over seven times as much on wildlife management in the Delta as in the coastal region, yet coastal landowners received a greater return on their money in terms of increased lease prices. The impacts of greater expenditures for wildlife management in the Delta were more than offset by greater returns on wildlife management expenditures in the coastal counties. The net effect of wildlife management expenditures on lease prices was $503 less in the Delta region than in the coastal region. In summary, price decomposition of lease prices in this study showed that simply comparing average lease prices or coefficients from hedonic price equations can miss key factors influencing lease prices.

DISCUSSION

Based on these findings, landowners can potentially improve lease prices in two ways. In coastal counties, landowners should explore ways to improve wildlife habitat. Investment in habitat improvement generated a 26% return. In contrast, relatively high wildlife management expenditures in the Delta which resulted in virtually no increase in the average lease price, suggested that some minimal amount of habitat management by the landowner was necessary before properties could be leased. Landowners should also consider including more land in the leases. In the coastal region, adding forested acres increased lease prices. In the Delta region, adding agricultural land had the greatest impact; however, adding acres of any type increased lease prices. In both regions, landowners did not lease all their land. Whether the unleased portions were reserved by the landowner to minimize damage to crops and essential infrastructure such as roads and levees, or were not wanted by the hunting clubs is not clear from this analysis and warrants further investigation. Other issues that deserve further attention include: 1) a finer breakdown by land use type, e.g. pine versus hardwood forest types, rice versus other row crops, 2) the impact of pre-selection, i.e., which landowners lease and which landowners don't, and 3) for landowners that do lease, what determines how much of their total ownership is leased.

LITERATURE CITED

Blinder, A.S. 1973. Wage discrimination: Reduced form and structural estimates. J. Human Resour. 8(4):436-455.

Hartsell, A.J., and J.D. London. 1995. Forest Statistics for Mississippi Counties – 1994. USDA For. Ser. Res. Bull. SO-190. 89 p.

Hussain, A., D. Zhang, and J.B. Armstrong. 2004. Willingness to pay for hunting leases in Alabama. South. J. Appl. For. 28(1):21-27.

Jones, W.D., I.A. Munn, S.C. Grado, and J.C. Jones. 2001 Fee hunting: An income source for Mississippi's non-industrial, private landowners. FWRC Research Bulletin FO-164. Forest and Wildlife Research Center, Mississippi State University.

Jones, F.L. 1983. On decomposing the wage gap: A critical comment on Blinder's method. J. Human Resour. 18(1):126-130.

Loomis, J.B., and L. Fitzhugh. 1989. Financial returns to California landowners for providing hunting access: Analysis and determinants of returns and implications to wildlife management. P. 202-209 *in* Transactions of the North American Wildlife and Natural Resource Conference.

Oaxaca, R. 1973. Male-female wage differentials in urban labor markets. Internat. Econ. Rev. 14(3):693-709.

Rosen, S. 1974. Hedonic prices and implicit markets: Product differentiation in pure competition. J. Pol. Econ. 82(February):34-55.

Southwick, R., 2003. Earning revenue from your land's fish and wildlife. P. 64-67 *in* First National Symposium on Sustainable Natural Resource-Based Alternative Economic Enterprises for Private Landowners. Mississippi State University Extension Service/Department of Wildlife and Fisheries, Mississippi State University.

Timber Mart-South. 2004. Quarterly Price Report. T. Harris, *ed.* Daniel B. Warnell School of Forest Resources, The University of Georgia. Athens, Georgia.

Taking a Benefits-Based Approach to Understanding, Planning, and Managing Nature-Based Recreation in Florida

Taylor V. Stein[28]
Associate Professor
School of Forest Resources and Conservation
University of Florida

Julie K. Clark
Project Manager
School of Forest Resources and Conservation
University of Florida

Acknowledgments: This research was funded by the Florida Fish and Wildlife Conservation Commission and supported by the Florida Agricultural Experiment Station. Jerrie Lindsey and Dennis David deserve special recognition for their enthusiasm and dedication to this research effort. Finally, we thank Rachel Albritton for her detailed review and work on this paper.

[28] Associate Professor, School of Forest Resources and Conservation, University of Florida, PO Box 110410, Gainesville, FL 32611-0410, Phone: 352-846-0860, Fax: 352-846-1277, Email: tstein@ufl.edu

Taking a Benefits-Based Approach to Understanding, Planning, and Managing Nature-Based Recreation in Florida

Abstract

Nature-based recreation planners and managers have a difficult time describing what they provide to society. In order to better identify, plan, and manage for the benefits of nature-based recreation, researchers and natural resource professionals have adopted a new approach to recreation management: benefits-based management (BBM). BBM seeks to identify the positive outputs of recreation and highlight these benefits in management plans to help provide for these benefits. In collaboration with the Florida Fish and Wildlife Conservation Commission, University of Florida researchers examined local and non-local visitors to five natural areas in southwest Florida. Researchers used a behavioral approach to recreation in conjunction with integrative planning to identify holistic planning recommendations for local and non-local visitors to natural areas. Results showed all visitors have similar preferences for recreation activities and settings, but their motivations for participating were different. Non-local visitors placed a high priority on exploration and education. Local visitors were looking for stress relief and a sense of independence. To help non-local visitors achieve their desired experiences, planners could develop easily accessible education materials (e.g., visitor centers, maps, nature tours) and trails designed with tourists' motivations in mind (e.g., explore, enjoy, and learn about nature).

Key Words: Benefits-based management, nature-based recreation, motivations, recreation opportunities

Introduction

Nature-based recreation professionals work in a mysterious world. Unlike most natural resource professionals, recreation and tourism planners and managers do not have clear outputs. For example, when managing for timber production, managers base their success on board-feet. For grazing, productivity is measured in animal unit months. What is the measure of success for recreation? Traditionally, the output of recreation and tourism management efforts was easily quantified as numbers of users per unit of time (e.g., visitor days). However, this ignored visitor satisfaction and the quality of the on-site recreation experience (Wagar, 1966). In fact, visitor research has consistently shown that nature-based visitors rate "meeting new people" and other social experiences as undesirable and conflicting with more desirable experiences (e.g., solitude, experience nature, and stress relief).

If visitor numbers are the goal of recreation management, managers can not bask in the glory of their "success." Increased visitor numbers inevitably result in increased environmental impacts, and for many public land management agencies, environmental conservation is just as important, and sometimes more important, than providing recreation access. This contradiction is highlighted in the National Park Service's Organic Act, which is to "conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations." Many argue this is a conflicting mission and the NPS cannot manage for both environmental conservation and visitor enjoyment. When managers measure their recreation success using visitor numbers, this argument is correct. The NPS and all public land management agencies, which manage for conservation and recreation, will continuously struggle in attracting numerous visitors and then managing for the impacts of those visitors.

Greater research and better science will not solve the problem of the conflicting mandate. More visitors will always equal more impacts. However, if natural resource planners and managers re-think what nature-based recreation provides and can potentially provide to society, they might not be stuck in a lose-lose situation. In fact, with an increased awareness of the benefits of nature-based recreation and tourism, a win-win situation is entirely possible.

This paper will examine a new approach to managing for recreation outputs: benefits-based management (BBM). It will briefly discuss BBM, the types of benefits recreation potentially helps produce, and conceptual frameworks that form BBM. The paper will end with a discussion of a benefits-based study that examined visitors to several nature-based recreation areas in Florida. It will show that an examination of visitors' desired benefits could improve recreation management of natural areas.

Benefits-based Management

Since the mid-1970s wildland recreation researchers have broadened the idea of what should be considered the outputs of nature-based recreation and tourism (Brown, 1984; Driver, 1994; Driver and Brown, 1975; Driver and Bruns, 1999). They argued that recreation and tourism outputs adds value to people's lives and these valued outputs (i.e., benefits) should be the primary goals of recreation managers (Anderson, Nickerson, Stein, and Lee, 2000). Specifically, people travel to parks and preserves for stress relief, physical fitness, family bonding, education, and a multitude of other benefits (Anderson, et al., 2000). Also, communities look to recreation and tourism for economic stability, increased jobs, pride, quality of life, and other larger-scale type benefits (Stein, Thompson, and Anderson, 1999). Finally, the environment also benefits from nature-based recreation tourism. The national and state parks, national forests, and wildlife refuges contain some of the U.S.'s last remnants of pristine ecosystems, and often, the only use of these areas is for recreation and tourism (Rolston, 1991). In 1991, research that identified and described recreation and tourism benefits was catalogued in the book *Benefits of Leisure* (Driver, Peterson, and Brown, 1991).

Benefits-based management (BBM) provides natural resource managers with a framework to help provide for the hard-to-measure benefits associated with nature and connects management to these measurable outputs (Anderson, et al., 2000; Driver, 1996). "Benefits-based management focuses on what is obtained from amenity resource opportunities in terms of consequences that maintain or improve the lives of individuals and groups of individuals, and then designs and provides opportunities to facilitate realization of those benefits" (Lee and Driver, 1992, p. 11).

Although BBM incorporates all the benefits associated with leisure, recreation, and tourism, this paper focuses on providing on-site benefits to recreation visitors. How a person benefits from a recreation engagement is defined by what motivates that person to take part in the recreation activity (Stein and Lee, 1995), and extensive visitors studies have examined these motivations (i.e., desired benefits) – eventually grouping them into 18 categories (Table 1). Researchers have used these benefits, or recreation experiences, to study nature-based recreation visitors over the last three decades (Manfredo, Driver, and Brown, 1983; Virden and Knopf, 1989; Stein and Lee, 1995).

Table 1. Major categories of personal benefits of recreation.

Personal Benefits (Driver, Tinsley, and Manfredo, 1991)	
Enjoy Nature	Achievement/Stimulation
Learn New Things	Physical Rest
Family Relations	Teach/Lead Others
Reduce Tension	Risk Taking
Escape Physical Stress	Risk Reduction
Share Similar Values	Meet New People
Independence	Creativity
Introspection	Nostalgia
Be with Considerate People	Agreeable Temperatures

Using Recreation Motivation as a Planning Objective

Early recreation research focused on descriptive approaches that examined which activities recreationists participate in, such as fishing, swimming, hiking, etc. (Lee and Driver, 1992). Although this is useful for understanding activity preference, descriptive methods do not address why people participate, what other activities they might have been done if other options were available, what satisfaction or rewards come from each activity, or how a quality experience can be enhanced (Driver and Tocher, 1970). A behavioral approach to recreation research can address these questions.

Behavioral approaches to recreation research are partially rooted in expectancy value theory (Lawler, 1973; Manfredo, Driver, and Brown, 1983). Expectancy value theory states that people engage in activities in specific settings to realize a group of psychological outcomes, which are known, expected, and valued (Lawler, 1973; Fishbein and Ajzen, 1974). In general, it means that expectations are beliefs that a given response will be followed by some known outcome (Tolman, 1960). Driver and Tocher (1970) describe this concept by saying recreation behavior is goal-oriented and aimed at need satisfaction.

As researchers better characterized the essential outputs of a recreational engagement, elements of the landscape were identified to help afford those outputs. The Recreation Opportunity Spectrum (ROS) is one system that was developed to help managers understand the relationships between landscapes and recreation outputs. Using the expectancy value theory and other behavioral theories related to recreation behavior, ROS was based on the concept that people choose a specific setting to participate in recreational activities in order to realize a desired set of experiences (i.e., benefits) (Driver, Brown, Staneky, and Gregoire, 1987). ROS offers a framework for understanding the relationships between settings, activities, and people's desired experiences (Manfredo et al., 1983; Virden and Knopf, 1989; Stein and Lee, 1995). However, researchers also point out that a direct relationship between activities, settings, and desired benefits are difficult to identify. According to Virden and Knopf (1989, p. 175), "It appears, at least in this study, that some desired experiences are more activity-dependent, while others are more setting-dependent."

Based on the wealth of information pertaining to benefits-based management and the benefits of leisure but the need to continue to better understand how to provide for these benefits, recreation professionals have begun to implement BBM projects throughout the U.S., Canada, and New Zealand. Many of these projects used social science research to identify potential benefits and then integrated the research findings into practical applications. In 2000, the Florida Fish and Wildlife Conservation Commission (FWC) was looking to broaden its constituency and contracted with the University of Florida to investigate potentially new nature-based recreation opportunities on FWC property in southwestern Florida. UF researchers took a benefits-based approach to this research to identify potentially new recreation opportunities. The remainder of this paper describes the study and research implications.

BBM Research in Florida

This study describes an examination of local and non-local visitors to five natural areas in a fast-growing area of southwest Florida. Researchers used a behavioral approach to recreation in conjunction with integrative planning to identify holistic planning recommendations for local and non-local visitors to natural areas.

Research Methods

In order to obtain a representative sample of nature-based recreation and tourism users to natural areas in the region, researchers selected five natural areas throughout the Fort Myers region that provide for a variety of nature-based recreation activities. Both coastal and inland natural areas were selected, representing a variety of recreation activities and settings ranging from passive activities in a moderately developed setting (e.g., guided tours and boardwalks) to less developed settings and more active recreation activities (e.g., kayaking along a mangrove shoreline). The areas surveyed included a national wildlife refuge, two state recreation areas, a state wildlife management area, and a nature sanctuary operated by the National Audubon Society.

The sampling period began September 2000 and continued until December 2000. Data were collected using a combination of brief on-site interviews and mail-back questionnaires. Trained interviewers were stationed at major exit points including boat ramps, trailheads, and visitor centers and selected random individuals (at least 18 years of age) from randomly selected groups during an on-site recreational engagement. After completing a short on-site interview, participants were given a mail-back survey and asked to complete and return it within two weeks using the postage-paid return envelope provided. Researchers used mailing procedures suggested by Salant and Dillman (1994) to maximize response rate.

Interviewers contacted 402 visitors and gave each person a survey packet. Two visitors declined to participate in the mail-back survey. A total of 255 useable questionnaires were returned for a response rate of 63 percent.

Results and Discussion

Results show that locals and non-locals have no difference in their preferences for settings and only a few differences in their preferences for recreation facilities and services. Based on all participants' top ten facilities and services, locals and non-locals had distinct preferences (Table 2). For instance, locals preferred access to more diverse fishing opportunities, expanded camping facilities, and a shooting range. Non-locals preferred a sheltered education/visitor center and guided nature-based tours.

When visitor's motivations (i.e., desired benefits) are included in the analysis, the recreation manager's job becomes much clearer. Non-local visitors placed a high priority on exploration and education (Table 3). Local visitors were looking for stress relief, sense of independence, skill building, and a feeling of achievement. Not one type of recreation opportunity (i.e., setting and activity) will satisfy both groups. Recreation planners would likely not design quality recreation opportunities for either group if they simply provided the activities and settings the groups rated highest.

To help non-local visitors achieve their desired experiences, planners could develop easily accessible education materials (e.g., visitor centers, maps, nature tours) and trails designed with tourists' motivations in mind (e.g., explore, enjoy, and learn about nature). Also, tourism planners should work with local tourism organizations and businesses (e.g., tourism development councils and hotels) to better inform non-local visitors about available and appropriate nature-based recreation opportunities.

To help local visitors achieve their desired experiences, planners should provide for a diversity of recreation activities that offer opportunities for locals to spend several hours in natural areas as a small group or by themselves. Since locals have had experience in public natural areas, planners do not have to provide basic information nor highly developed access and infrastructure to accommodate this group. Locals likely already know about the areas and have preferred recreation opportunities in the natural areas. The developed zone described for non-local visitors might be used as staging areas for local visitors when they first arrive on-site, but it should help these more experienced visitors move out to other parts of the natural areas to take part in the diversity of recreation activities they might find satisfying.

Table 2. Preferred facilities and services, percent of use by local and non-local visitors in the Ft. Myers region.

Activities[1]	**n**	**Never/Rarely (%)**	**Frequently/Often/Always (%)**	χ^2	***p***
Maps listing nearby recreation area amenities and habitat types				3.65	0.056
Local	135	16.3	83.7		
Non-Local	101	7.9	92.1		
Watchable wildlife opportunities				3.47	0.063
Local	133	21.8	78.2		
Non-Local	104	12.5	87.5		
Access to more diverse fishing opportunities (boat ramps, improved bank fishing, etc.) [2]				49.62	<0.001
Local	136	31.6	68.4		
Non-Local	100	78.0	22.0		
Sheltered education/visitor center[2]				8.42	0.004
Local	134	47.8	52.2		
Non-Local	100	29.0	71.0		
Non-motorized multi-use trails				0.103	0.749
Local	124	43.5	56.5		
Non-Local	99	41.4	58.6		
Canoe/kayaking trails				2.05	0.153
Local	132	55.3	44.7		
Non-Local	99	64.6	35.4		
Expanded camping facilities (with amenities like electricity, shelters, etc.) [2]				17.19	<0.001
Local	134	56.0	44.0		
Non-Local	99	81.8	18.2		
Shooting range[2]				40.18	<0.001
Local	134	56.0	44.0		
Non-Local	103	93.2	6.8		
Guided nature-based tours[2]				8.01	0.005
Local	131	60.3	39.7		
Non-Local	101	41.6	58.4		

Regularly scheduled educational programs				0.56	0.456
Local	126	61.9	38.1		
Non-Local	102	66.7	33.3		

Table 3. Motivations for local and non-local visitors visits to five selected natural areas in the Ft. Myers region.

	Type of Visitor					
	Local		**Non-Local**			
Motivation	n	x[1]	n		*t*	*p*
Enjoy nature[2]	132	4.0	103	4.3	-2.6	0.010
Reduce tensions and stress from everyday life	125	3.8	100	3.5	1.7	0.096
Escape noise/crowds	127	3.6	102	3.5	.66	0.511
Explore the area and natural environment[2]	128	3.5	106	3.8	-2.4	0.015
Be with friends and family	128	3.4	103	3.4	-.199	0.843
Learn about the natural environment of the area[2]	125	3.2	104	3.7	-2.9	0.005
Feel a sense of independence[2]	128	3.2	98	2.5	4.1	<0.001
Be in an area where I feel secure and safe	130	3.2	100	3.0	0.8	0.416
Strengthen family kinship	122	3.0	100	2.7	1.5	0.136
Promote physical fitness	123	2.8	102	2.6	1.1	0.286
Depend on my skills and abilities[2]	131	2.8	100	2.1	4.0	<0.001
Engage in personal/spiritual reflection	125	2.7	100	2.5	1.6	0.117
Continue personal or family traditions[2]	127	2.7	99	2.3	2.0	0.052
Challenge myself and achieve personal goals[2]	125	2.6	98	2.1	3.3	0.001
Learn about the history and culture of the area	125	2.5	102	2.8	-1.7	0.099

Meet new people	126	2.0	101	2.1	-0.6	0.553
Take risks	124	1.8	101	1.6	1.7	0.097

[1] Based on 5-point Likert scale: 1=Not at all important, 2= Not very important, 3=Important, 4=Very Important, 5 = Extremely important

[2] Significant at the 0.05 level

Conclusion

This study helps to clarify the primary goals of recreation and tourism planners in the Fort Myers region when planning for the needs of local and non-local visitors to public natural areas. If not viewed within the context of the recreation benefits production process as described by Brown (1984), results could have misleading implications for planners. For example, traditionally, recreation planners first focused only on the activities people demanded and second on the type of setting characteristics they found preferable (Driver and Brown, 1975). They would have missed the essential reasons (i.e., desired benefits or motivations) why people are choosing to take part in these activities and settings.

This study showed there are significant differences between locals and non-locals' preferences for benefits (i.e., motivations) and recreation facilities and services. When this information is integrated, recreation planners and managers are much more likely to design effective recreation opportunities. For example, since non-local visitors preferred visitor centers more than local visitors, managers can provide information that orients the visitor to the site and surrounding area in order to help non-local visitors explore the area and natural environment – a benefit non-local visitors rated significantly higher than local visitors.

BBM moves beyond simple activity and setting management. As this study showed, to provide for quality recreation opportunities, managers must understand that nature-based recreation visitors have a diversity of motivations (i.e., desired benefits), and, therefore, require different mixes of settings and activities. Focusing on desired benefits as the goals of their planning will result in more efficient and acceptable recreation management in the long run.

Literature Cited

Anderson, D.H., R.G. Nickerson, T.V. Stein, and M.E. Lee. 2000. Planning to provide community and visitor benefits. P. 197-211 in Trends in outdoor recreation, leisure, and tourism,Gartner, W.C. and Lime, D.W. et al. (eds.). CABI Publishing, Wallingford, UK.

Brown, P.J. 1984. Benefits of wildland recreation and some ideas for valuing recreation opportunities. P. 209-220 in Valuation of wildland resource benefits, G.L. Peterson & A. Randallet al (eds.). Westview Press, Boulder, CO.

Driver, B.L. 1994. The benefits-based approach to amenity resource policy analysis and management. Paper presented at: Recreation: Benefits and other positive effects, November 15, 1993. Lillehammer, Norway. 43 pp.

Driver, B.L. and P.J. Brown. 1975. A social-psychological definition of recreation demand, with implications for recreation resource planning. P. 62-88 in Assessing demand for outdoor recreation. National Academy of Science, Washington, D.C.

Driver, B. L., P. J. Brown, G. H. Stankey, and T. G. Gregoire. 1987. The ROS planning system: Evolution, basic concepts, and research needs. Leisure Sciences. Notes 9:201-212.

Driver, B.L., P.J. Brown and G.L. Peterson (eds.). 1991. Benefits of Leisure. Venture Publishing, State College, PA. 483 p.

Driver, B.L. and D.H. Bruns. 1999. Concepts and Uses of the Benefits Approach to Leisure. P. 349-369 in Leisure Studies: Prospects for the Twenty-First Century E.L. Jackson and T.L. Burton et al. (eds.). Venture Publishing, State College, PA. Venture.

Driver, B.L. and Tocher, S.R. 1970. Toward a behavioral interpretation of recreational engagements with implications for planning. P. 9-29 in Elements of Outdoor Recreation Planning, Driver, B.L. (ed.). University Microfilms Michigan, Ann Arbor, MI.

Driver, B.L., Tinsley, H.E. and Manfredo, M.J. 1991. The paragraphs about leisure and recreation experience preference scales: Results from two inventories designed to assess the breadth of the perceived psychological benefits of leisure. P. 263-286 in Benefits of leisure, Driver, B.L., Brown, P.J. and Peterson, G.L. et al (eds.). Venture Publishing, State College, PA.

Fishbein, M. and Ajzen, I. 1974. Attitudes towards objects as predictors of single and multiple behavioral criteria. Psychological Review. Notes 81(1):59-74.

Lawler, E.E. 1973. Motivations in Work Organizations. Brooks/Cole Pub. Co, Monterey, CA. 292 p.

Lee, M.E. and Driver, B.L. 1992. Benefits-based management: A new paradigm for managing amenity resources. Paper presented at the Second Canada/U.S. Workshop on Visitor Management in Parks, Forest, and Protected Areas. Madison, WI.

Manfredo, M.J., B.L. Driver, and P.J. Brown. 1983. A test of concepts inherent in experienced based setting management for outdoor recreation areas. Leisure Research. Notes 15(3):263-283.

Rolston, H. III. 1991. Creation and recreation: Environmental benefits and human leisure. P.303-331 in Benefits of leisure, B. L. Driver, P. J. Brown, and G. L. Peterson et al. (eds.). Venture Publishing, Inc. State College, PA.

Tolman, E.C. 1960. Purposive behaviors in animals and men. Meridith Publishing Co., New York.

Salant, P. and Dillman, D. 1994. How to conduct your own survey. John Wiley and Sons, Inc. New York. 256 p.

Stein, T.V., D.H. Anderson, and D. Thompson. 1999. Identifying and managing for community benefits in Minnesota State Parks. Park and Recreation Administration. Notes 17(4):1-19.

Stein, T.V. and M.E Lee. 1995. Managing recreation resources for positive outcomes: An application of benefits-based management. Park and Recreation Administration. Notes 13(3):52-70.

Wagar, J.A. 1966. Quality in outdoor recreation. Trends in Parks and Recreation. Notes 3(3):9-12.

Virden, R.J. and Knopf, R.C. 1989. Activities, experiences, and environmental settings: A case study of recreation opportunity spectrum relationships. Leisure Sciences. Notes 11: 159-176.

Forest Property Rights Evolution in Response to Forest Paradigms in Canada

Yaoqi Zhang[29], Shashi Kant[30]

[29] Assistant Professor, School of Forestry and Wildlife Sciences, Auburn University, M. W. Smith Hall, AL 36849; Phone: (334) 844 1041; Fax: (334) 844 1084; Email: yaoqi.zhang@auburn.edu.
[30] Associate Professor, Faculty of Forestry, University of Toronto, M5S 3B3, Ontario, Canada; Phone: (416) 978 6196; Fax: (416) 978 3834; Email: shashi.kant@utoronto.ca.

Forest Property Rights Evolution in Response to Forest Paradigms in Canada

Abstract

This paper, using Canadian forest property rights evolution, generalizes a simplified trend in forest property rights evolution in response to changing forest paradigms. To accommodate the new imperatives of scarcity in non-wood product, wood and environmental services, forest property rights evolve from less defined one, such as open access and commons, to more defined one, such as private ownership. However, unlike other property, forest property rights have some tendency toward multiple stakeholders or even more "public" as forest value is becoming more reflected in environmental aspects.

Key words: forest transition, community forestry, environmental policy, forest management, forest transition.

Introduction

Throughout history, certain patterns of forestry development are discernable: (1) utilization of non-timber products from the abundant forest resources; (2) utilization of timber primarily from natural forests; (3) silviculture and utilization of managed forests; (4) multiple uses of forests from active natural forest management and plantation in the post-industrial society (Lane and McDonald 2002). We call each period as forest management paradigm (FMP). Throughout these paradigms, forests in terms of area and volume first experienced shrinkage, then stability, and finally an expansion (see, Mather 1992, 2000, 2001; Pfaff 2000; Zhang 2000). Such transition is an evidence for environmental Kuznets curves.

Forest property rights (FPRs) and FMPs are closely related, but despite the existence of general theories on property rights evolution, evolution of FPRs has not been investigated adequately. Many studies in forestry are still limited to the assessment of impacts of FPRs on the forest management with the exception of Kant (2000), Kant and Berry (2001) and Zhang (2001a). The impacts of FPR on resources management have been widely recognized (Bromley 1991; Besley 1995; Deacon 1999; Zhang 1996; Fisher 1999), but it has been proved difficult to reach optimal forest property rights after many decades' theoretical works and practices across the world. Investigating historical evolution of FPRs may be the best way to provide some insights about the future directions. On this paper, we will start from the "physical" change generally, and then see the FPRs changes of forests in Canada.

Economics of Forest Management Paradigm Change

Forest uses are adjusted by human beings to respond to relative scarcity of outputs from forests. Change in forest land use can be economically justified when marginal change in land use (e.g., forest land conversion to agricultural land) would bring net positive value. In response to changes from abundance to scarcity, social attitude, value and perception change. Human judgment and action on forest and land use are conducted on the margin. Land shifting between forest and agricultural crop usually occurs at the margin. A large part of history of human beings is a history of movement at the frontier where natural forests were logged and converted into agricultural land. Seen from Figure 1, let us assume land is used only for agriculture and forestry. At the margin (Point A) agriculture and forestry generate same value. Within forestry land, we distinguish three situations: 1) not economically accessible trees (right to C); 2) economically accessible trees, but not economically manageable land (between B and C); 3) economically accessible trees and manageable land (left to B). For illustrative purpose, FMPs may be divided into the following periods.

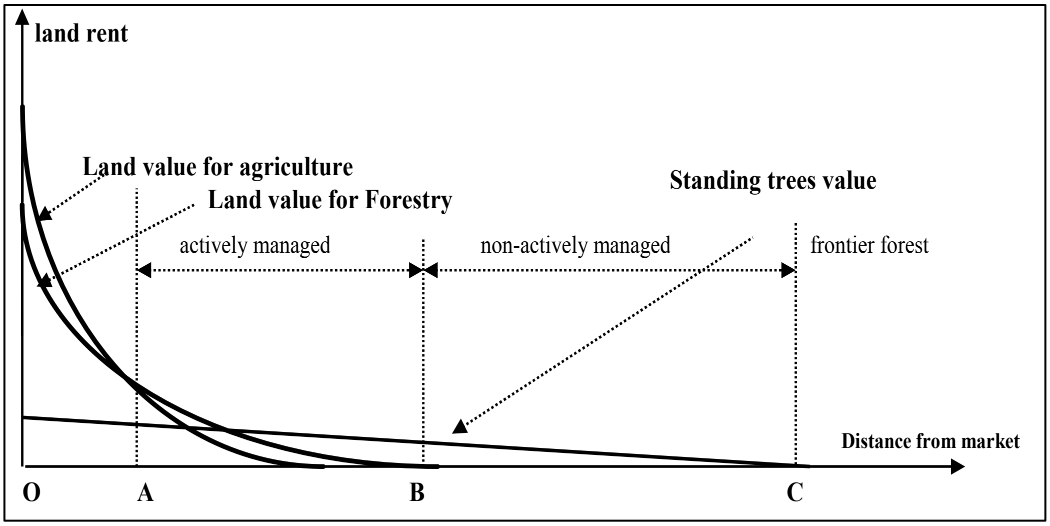


Figure 1: Natural forests, plantation forests and agricultural land

In the initial period of post hunter-gather society, forest management was simply equivalent to logging, like mining. The difference of logging from mining industries lies in the fact that logging deals with renewable while mining with non-renewable resource. In this phase, forests were completely left alone for natural regeneration. Only some standing forests (trees) had value, forest *land* hardly created any rent. At this stage, logging and transportation technology were most critical for "forestry" development. Historically, this kind of *forestry* lasted for the longest period.

In the second stage, forest resources become scarcer, so managing forest and harvesting became competitive with logging from natural forests, and forest management emerged to catch up *land* value. Usually this happens when natural stock is significantly depleted and timber prices rise to a level that can justify forest management (investment). Timber in most cases is viewed as the only product from forests although forests do provide environmental services, which are not noticed because they are not scarce, just like air and water. Economists do not study such values; politicians do not put them on agenda (e.g., legislations on these rights). At this stage, the section between A and B in Figure 1 become more and more significant, and finally become dominant. If point A starts to move leftward and replace some agricultural land, then forest transition occurs.

In the third stage, along with economic development and forests decline (especially the natural forests), environmental goods from forests become relatively scarcer, and marginal value of environmental goods (such as *in situ* value) increases more rapidly than value in timber. These changes correlate with economic development that results in structural changes in human needs and wants, generating demand for better environment and recreation. Mather (2001) calls this transition as the "emergence of post-productivism" in forestry. At this stage, point B extends rightward to cover all forestland (no non-actively managed forests and frontier forests left). Point A moves leftward to replace some marginal agricultural land. More importantly, some multiple use forests (e.g., the broadleaved trees) replace mono-functional forests (e.g., coniferous trees).

Evolution of Forest Property Rights in Canada

There are different theories that explain as to why property rights change. But the theory developed by Alchian and Demsetz, among others, is probably the most widely accepted by economists and supported by historical evidences (Demsetz 1967; Alchian and Demsetz 1973; North and Thomas 1973; North 1990; and Sethi and Somanathan 1996, Posner 1980; De Alessi 1980). As we understand, there are two major points in this theory.

First, any property right arrangement may consist of a bundle of property rights, and every property right can be allocated to different people or agencies. This is particularly relevant to FPRs. Many forest tenure systems can be characterized by a mix of state, private, common, and open property right regimes, and it is often hard to say that who owns some forests. It is quite common that multiple parties have, on a single piece of forestland, rights to different kinds of forest produce. Second, the bundle of private property rights increases with economic scarcity of the property. Seen from Figure 2, it shows that defining property right is a function of marginal value created from defining with marginal costs to define. The second point seems problematic in the context of forest property rights evolution. We argue that property rights generally change from less ambiguous rights to more defined rights rather than just from more "public" to more "private" (Zhang 2001a).

Forest and forest management in Canada follows the general path of change (or see, Apsey, et. al. 2000). Canada has most complicated and diversified forest property rights arrangement. Currently, Canada has 418 million ha of forested area, of which about 244 million ha are classified as capable of timber production (or called timber-productive land). Approximately 210 million ha is non-reserved multiple-use forest. Even though most of Canada's forests were owned by the Crown since the beginning of European settlement, some deliberate changes have been taking place, and FPRs have been evolving.

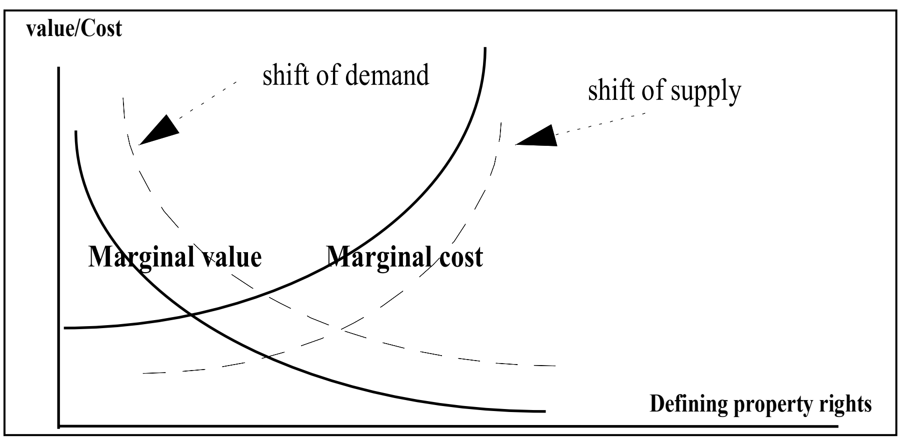


Figure2: Value versus property rights

Absence of formal Forest Property Rights

For a long period of time and especially in the northern part, timber was barely valuable in Canada. Hunting, fishing, trapping, berry and herb gathering were (are) simply the keys to physical survival. The forests were more a base of wildlife, and source of hunting than wood resource. Although the early settlers had their customary hunting and trapping areas, there was no concept of formal ownership. During the pre-European era, the concepts of property rights and ownership were absent in the territory, which is now known as Canada.

However, absence of formal property rights does not mean absence of informal institutions, or informal property rights. Aboriginal people have well established system of governance, and institutions with respect to their use of natural resources such as fishing, hunting, and trapping (Dickason 1997). The belief and customs were informal institutions. “Living in harmony with Mother Earth” and “The Earth does not belong to man, man belongs to the Earth” were commonly shared values of aboriginal people throughout the world (Chief Seattle, cited in Oakes et al. 1998). The main features of aboriginal belief system were Supremacy of nature, Non-ownership of scared land and natural resources, and Living for seven generations (or inter-generational equity). The aboriginal people defined themselves in terms of the land that saw land as part of their soul.

For the European immigrants and their early descendants since the late 15th century, forest was a place to fear, so they saw forest as an obstacle to human progress and economic development. Even in more recent history prior to industrial use of timber, the muskeg and thick stands of aspen, polar, and spruce trees joined the harsh, unpredictable climate as obstacles to pushing the agricultural frontier northward. Such worthlessness or even negative value of timber to them can only be justified by open access. Hence for a significantly long period of time and for a large part of forests, even under some Crown land, forests were more or less open access resources in Canada.

Crown and Aboriginal Owned Forests Property Rights

European settlements began in the late 15th century. John Cabot landed in Newfoundland in 1487 and Jacques Cartier in Quebec in 1534 (both east coast), but it was more than a century later in 1647 that the first explorer, James Cook, landed at Nootka, on the west coast (Rawat 1985). The colonial power switched between France and Britain for about two centuries, depending upon whose troops had won the last round of battle on these lands. During French period (prior to 1763), mainly oak and pine timber were valued for military purpose, and the Government reserved all rights to itself over these species of forest.

Forest property rights in Quebec were most influenced and shaped by the French system. The aim of the French in colonizing was to reproduce, as far as possible, in the spirit and in form the political and social institutions of France. They faithfully copied the French feudal system that was characterized by a distinct class of Seigniors, who were the only class to hold their titles directly from the crown, and receiving their grants on the express condition of subdividing them among their tenants. Other conditions of land grants included rent payment, performance of number of duties and obligations, and numerous reservations and conditions affecting the land. In terms of forests, the main features of these land grants were (i) the government reservations of timber adapted for naval and military purposes, mainly Oak and some white pine timber; and (ii) customary, but not strictly legal, reservation by the Seigniors, of timber for various purposes out of the holdings leased to their habitants (Southworth and White 1907).

By 1763, at the end of the seven years war, the British conquest brought all Canadian colonies under the effective control of Great Britain. After the British victory in war in 1763, the first twenty years of the British rule made little impact either on land or on trees due to the British recognition of the French system of land tenure (1771) and civil law (1774) (Lambert and Pross 1967). But after the war of American independence, when the tide began to turn against Britain, land tenure system moved towards English Common Law. The Crown ownership was adopted more or less intact by the colonial authorities on the West Coast and, after 1871, by the new provincial government. In 1930, when the Prairie Provinces acquired control of their forest resources, they adopted tenure policies modeled on those which evolved in the other provinces during the previous century (Apsey et al. 2000).

The first obvious evidence of the Canadian government to exercise the rights, beginning with New Brunswick's timber-cutting duties in 1817, had nothing to do with forest use, but were intended to raise public revenues. Nine years later, Ontario and Quebec adopted similar laws, establishing the claim of the administration to ownership of the forests within their jurisdictions, and the rights to collect revenues for the use (Apsey et al. 2000). Since then, the governments exercised the rights by selling a variety of licenses to lumbermen and some land use rights to forest management companies, but keep the land ownership. This is an evidence of the separation of ownership between trees and land.

An important characteristic in Canada is the treaties made between aboriginal communities and the Crown. It was during this early period in Canadian history that certain but still poorly defined rights over forests were granted to aboriginal communities in the forms of treaties. Additional tenure rights have subsequently been granted on much of this same land by various provincial governments. The rights were not needed and not possible to be carefully defined at that time since there was no such complicated bundle of rights at that time.

Along with loss of forests, Aboriginal values and Aboriginal rights came to forefront in the 1970s. Forests are critical for life-style of Aboriginal people, but till the 1970s the different governments of Canada did not recognize the rights of Aboriginal people or the social and economic importance of Aboriginal forest values. As forests shrank and marginal values became significant to the Aboriginal people, the demand for their rights, the need to assess old treaties (According to the Canadian government, 67 historic Indian treaties were known to have been made between the Crown and the Indian people of Canada) arose again (Nichols and Rakai 2001; Ross and Smith 2002). The Supreme Court of Canada, in a case (*Calder et al. v. Attorney General of British Columbia*) of the conflict of resource use between the Aboriginal people and government of British Columbia, recognized the Aboriginal claims on natural resources, including forests, in 1973. The decision was followed by many other similar decisions in the Canadian courts, and these decisions resulted into Comprehensive Claim Agreements (CCA).

Towards Diversified Private Property Rights

Towards private property rights, the first step was to privatize timber use rights. The English system of freehold land tenure was introduced in the lands ceded by the Indians. In the beginning, harvesting rights were given only for giant oak trees, for use as masts, spars and hulls in the British Navy, but during the Napoleonic wars (1763 and 1775), when Britain encouraged North American timber supplies through preferential trade paradigm (low tariffs), harvesting rights were extended for red and white pines. As per the Constitutional Act of 1791, all land in Upper Canada was to be granted in freehold; but one-seventh was set aside for the use of the Crown and one-seventh for the support of the Protestant, and the Crown also reserved for itself all timber, such as red and white pine, suitable for ship-building (Lambert and Pross 1967). During the period of 1776 to 1826, harvesting rights were granted to a select number of royal contractors to supply timber to the Royal Dockyards, who in turn transferred their rights to Canadian lumberman (Southworth and White 1907).

In 1826, the British Parliament, through a proclamation, extended harvesting rights from the Crown land to anyone on a payment of certain fee, and the fee schedules included species other than oak, red pine, and white pine (Southworth and White 1907). All the regulations related to the harvesting rights to a common lumberman were given statutory shape by the first Crown timber Act 1849. In 1851, value of timberland, in addition to value of timber, was recognized, and the Crown Timber Act was amended to include the payment of annual ground rent.

By the time of confederation in 1867, when most of provinces were given exclusive ownership and authority over their public lands, the two main features of forest property rights were a system of an annual license to cut Crown timber and a system of Crown charges based on land area and timber volume. The Crown continued the reservation of timber for military purposes on lands allocated as free-hold in Ontario and Quebec. These features of property rights established at the time of confederation continued till the end of the 19^{th} century. By the end of the 19th century, it was recognized that timber had a great value as a source of industrial development. Technological developments, specifically in the area of pulp and paper sector, strengthened this view. The contribution of the forestry sector to the Canadian economy over last century provides empirical evidence for this. Pulp and Paper technology also allowed the use of small diameter trees and other conifer species such as spruce.

The gradual process of private property rights evolution in Canada is quite illustrative. The evolution of property rights to natural forests has been largely a process of transfer from the public to the private sector (Nelles 1974). The regulatory jurisdiction over Canada's forest was also largely transferred from the federal to provincial hand in the 1930 (Moen 1990; Haley and Luckert 1990; Pearse 1988). After centuries' evolution, Canada has very diversified FPRs system. The most common forms of land tenures are Tree Farm Licenses and Forest Licenses in British Columbia, Forest Management Agreement Area (or called, Forest Management License Area, Forest Resources Licenses, Forest Management Agreement Area) in Alberta and Saskatchewan, Manitoba, and Ontario. Even thought different names are used, they have quite same nature in terms of the rights and responsibility to forests and lands. Usually the governments have the rights to take the forests and land back. Comparatively, in Nova Scotia and New Brunswick, the forest and forestland are more close to "private" in terms of duration, controllability (the government cannot takes the rights back).

For most of the productive forestland, the Crown usually opted not to privatize the resource (even grant fee simple title), but rather provided access through complex systems of licenses, claims, and lease. Canadian forest tenures are typically granted to industrial licensees such as large mills. It was initiated in the post-war period to attract investment in the forest industry. Usually the rights are limited to the trees for specific periods of time. Dependence of certain communities and townships on these large firms made the health of these companies equally important to the government. Hence, FPRs were amended to accommodate the continuity of forest resource use, or availability of raw material to these industries in long-term. Large areas of Crown forests were allocated to big lumber companies or pulp and paper companies. Initially, these allocations were for one year but could be renewed indefinitely, but later duration of harvesting rights was extended to twenty-one years. It was estimated about 50% the forests are currently managed under industrial tenure (Global Forest Watch 2000). In most provinces, industry pays the government fees (stumpage fee) for harvesting trees. The harvesting is usually subject to government-determined rate of cut (annual allowable cut) that is based on the concept of "sustainable yield". To encourage forest management and silviculture from industry, the AAC is calculated by the expectation of faster second growth accelerated by the silvicultural investment. This is called "Allowable Cut Effect".

The property rights are gradually evolving with the scarcity. Just a few decades ago, many wood species were not valuable to forest industry. Therefore, their property rights were not clarified when contracts of valuable species (often coniferous) transaction were made. However, the new wood-processing technology made these species valuable. Consequently, renegotiation had to be made with regard to these property rights. For instance, until the mid-1980s, there was little commercial use of the hardwood tree species in Alberta. Forest tenures were established considering only land that supported commercial softwoods. However, with the development of new pulp mills and oriented strand board plants capable of utilizing the hardwood, rights to the hardwoods resources had to be established. The emergence of wood processing technology for Medium Density Fiberboard (MDF) and Oriented Strand Board (OSB) and establishment of MDF and OSB mills in 1980's extended the forest property right arrangements from softwood species to hardwood species, specifically Aspen.

The privately owed trees and land are still very small, only accounting for about 6% of the total forestland in Canada. Since almost all private forestland has high productivity for timber production or close to infrastructure and easily accessible, private forestland accounts for about 11% of timber productive forestland or 23 million ha. But the private forests produce 19% of the Canadian wood supply partly because the private land is more productive, or more intensively managed. This private forestland can be roughly divided into 5 million ha of industry-owned private land and 18 million ha of family-owned private wood-lots by about 450, 000 families (Rotherham 2003; Dansereau and deMarsh 2003). Most of private forestlands are geographically located in Eastern Canada, and southern Vancouver Island.

Towards Multiple Stakeholders

By the 1940s, heavy exploitation of timber resources, without any long-term considerations regarding future timber supplies or the stability of communities dependent upon timber utilization, made the government and industry to think seriously about sustained yield policy (Wetton 1977). In British Columbia, the Royal Commission Report by Justice Sloan (1945) and in Ontario, the Royal Commission Report by Major-General Kennedy (1947) showed their concern regarding lack of proper forest management, and argued to manage forest resources so as to get a sustained timber supply in perpetuity. Based on these reports, timber acts were revised, and the FPRs were reshaped. The long-term (twenty-one years) harvesting right holders were allowed to cut timber volume less than allowable annual cut (AAC). This was against the previous system of no limit on harvestable volume. The revised acts also imposed penalties on operators using wasteful harvesting practices. Such constraints on current timber harvest rights were in fact designed to recognize partial property rights (or the externalities) for the future generation.

Environmental values of forests have been getting more and more important in Canada in the past few decades (Adamowicz and Veeman 1998). In Canada, satisfying the public demand for parks and wilderness areas and to setting Aboriginal land claims and addressing resource depletion have led to the withdrawal of private rights (Schwindt and Globerman 1996). Such paradigm changes call for the redefinition of property rights in forests. In the 1960s and 1970s, a large share of forest areas, due to growing pressure from environmentalists and conservationists, was reserved as wilderness areas, which reduced the productive forest base. Moreover, a forest inventory indicated a potential timber supply shortage in future. This led to a new property right arrangement, known as Forest Management Agreements in Ontario, Forest License and Tree Farm License in British Columbia, and Timber Supply Agreements in Quebec, which included partial transfer of management responsibility to harvesting right holders (private companies).

In the past ten years, Canadian provinces have amended their FPR arrangements to ensure that forests are managed more holistically, in a way that recognizes Canadian Council of Forest Ministers Criteria and Indicators, and reflects Canadians' diverse forest goals (Canadian Council of Forest Ministers 1995; Canadian Forest Service 2002). Therefore, forests are increasing subject to more regulations that are partial takings of property rights from the private users. As resources are becoming less plentiful, the federal and provinces have started to fight encroachments on federal jurisdiction over wildlife and other natural resources. They adamantly oppose enclaves of tribal jurisdiction further eroding their authority, and are not willingness to share authority with tribal entities. Since the legal authority for establishment of enclaves of tribal jurisdiction over wildlife management in the North Canada is too small, divisions of jurisdiction would lead to illogical boundaries, making ecosystem management difficult if not impossible (Osherenko 1988; Luckert 1992).

One reflection of the increasing number of state holders in FPRs is the calling for community forestry in Canada. It has been argued that absentee corporate owners are less likely than the local owners to manage the forest for multiple values, such as hunting value, long-tern ecosystem heal and continued employment. There are many different ways to be involved by the local community in the forest management decision making. Broadly community forestry is the general terms of local involvement. Other forms include the employee and management buyouts of wood-processing mills (Marchak 1983; Krogman and Beckley 2002). Such trend counters the trend of increasing concentration of the ownership of wood-processing industry.

Co-management arrangement between Aboriginal people rights and forest industry and governments could be an important form of multiple stakeholders. In these co-management agreements, specific rights and duties have been assigned to different partners. For example, in the case of Mistik agreement in Saskatchewan, three partners are Mistik Management Ltd. (formed by NorSask and Millar Western pulp mill in 1990), local communities, including more than 20 communities, mostly consisting of the Aboriginal people, and the provincial government. Since it is expected that the values and vision of the local community differ significantly from the government and industry, local management boards are formed to make the management more responsive to the values of local people. But at the same time, a regional board, consisting of outfitters, Metis groups, first nations, trappers, commercial wild rice producers, tourism and environmental groups, and representatives of the oil and gas industry, is a part of agreement to handle issues that transcended the boundaries or concerns of local management boards (Beckley and Korber 1998).

Conclusions and Discussion

While the impacts of FPR on forest management have been well recognized, its evolution has not been paid attention. No single property right is superior to others in any socio-economic environment. The ownership is evolving towards more specified ownerships due to changes in scarcity. The Canadian experience provides an interesting example of how forest property rights have evolved in response to changing resource values. Canada was very slow to develop silvicultural activities due to its abundant natural forests. It was not until the 1950s that the implementation of sustained-yield practices and reforestation became a priority and eventually, a standard practice. Lack of motivation for reforestation is an indicator that plantation forests are not economically competitive with natural forests, and extremely low value of the *land*. Many people may not have too much motivation to privately own such kind of land when investment is not profitable even if the government allowed and encouraged private investment.

In more valuable land, government obtained revenues from lumbermen, then gave or sold the cleared land to farmers, who could be taxed in perpetuity. Settlers were pared much of the hard labor involved in clearing land. To obtain raw materials, lumbermen were not required to tie up scarce capital buying the timberland—paying for timber only after it was cut, not taxes on the land (Apsey et al. 2000). Land for lumbermen had no value for tree growth since plantation was not competitive. Currently various licenses reflect the relationship between the land tenure and the land value. We should, however, note that many other factors may have significant impacts on the property rights formulation and evolution. For instance, difference exists between Quebec and the rest of the countries. Quebec has more characteristics of French system. Another episode, the conservationist ideas in the North America during the 19th century further entrenched state ownership of the Canadian forests (Apsey et al. 2000).

Turning to current challenges, does Canada need to change such forest land tenure? The answer is definitely yes, but how to change is a big question. The tenure systems, which were designed to deal with over mature natural timber, may not be suitable for second-growth forest management in which a significant investment is needed. In timber-dominant use forests, the transaction costs of timber play a crucial role in determining the organization of the forest ownership. Timber or fiber oriented forest management (second growth) requires intensive management and significant investment, so privatization of such forestland may be a good option. In environment-dominant forests, the transaction costs of environmental services play a dominant role. The main purpose of such forestland is to provide public goods and maintain the integrity of ecosystems, privatization may be not a good option.

We are not able to design an optimal path of evolution of FPRs. That does not mean we cannot have any conceptual thoughts by learning from history and other places. The evolution of FPRs is endogenous in the socio-economic system and natural environment, but conceptual direction will be important too. To model forest transition, Zhang et al. (2000) and Perz and Skole (2003) recommend to consider differences between primarily and secondly forests; to guide reform in FPRs, we may need to consider the differences of a variety of forests, their structure, their functions and management (e.g., primary and secondly forests, timber oriented and environmental oriented forests).

References

Adamowicz, V. and T. Veeman. 1998. Forest policy and the environment: Changing paradigms. Canadian Public Policy 24 (Supplement 2): S51-S61.

Alchian, A. and Demsetz, H. 1973. The Property rights paradigm. Journal of Economic History 33: 16-17.

Apsey, M., D. Laishley, V. Nordin and G. Paille. 2000. The perpetual forest: using lessons from the past to sustain Canada's forest in the future. Forestry Chronicle 76 (1): 29-43.

Beckley, T. M. 1998. Moving towards consensus-based forest management: a comparison of industrial, co-managed, community and small private forests in Canada. Forestry Chronicle 74 (5): 736-744.

Beckley, T. M. and D. Korber.1996. Clear Cuts, Conflict, and Co-management: Experiments in Consensus Forest Management in Northwest Saskatchewan. Information Report Nor-X-349. Canadian Forest Service, Northern Forestry Centre, Edmonton.

Besley, T. 1995. Property rights and investment incentives: theory and evidence from Ghana. Journal of Political Economy 103 (5): 903-937.

Bromley, D. W. 1991. Environment and Economy: Property Rights and Public Policy. Oxford: Blackwell.

Canadian Council of Forest Ministers (CCFM). 1995. Defining Sustainable Forest Management: A Canadian Approach to Criteria and Indicators. Canadian Forest Service, Ottawa.

Canadian Forest Service (CFS). 2002. The State of Canada's Forests: 2001-2002. Ottawa: Canadian Forest Service.

Dansereau, L. and P. deMarsh. 2003. A portrait of Canadian woodlot owners in 2003. The Forestry Chronicle 79 (4): 774-778.

De Alessi, L. 1980. The economics of property rights: a review of evidence. Research Law and Economics 2: 1-42.

Deacon, R. T. 1999. Deforestation and ownership: evidence from historical accounts and contemporary Data. Land Economics 75 (3): 341-359.

Demsetz, H. 1967. Toward a theory of property rights." American Economic Review 57 (2): 347-359.

Dickason, O. P. 1997. Canada's First Nations: A History of Founding People from Earliest Times. Toronto: Oxford University Press.

FAO 2000. Criteria and indicators of sustainable forest management. FAO Expert Consultation organized in collaboration with UNEP, ITTO, CIFOR and IUFRO, 15-17 Nov. 2000. Rome.

Fisher. R.F. 1999. Devolution and decentralization of forest management in Asia and the Pacific. Unasylva 50 (199): 3-5.

Global Forest Watch and World Resources Institute 2000. Canada's Forests at a Crossroads: An Assesment in the Year 2000. Washington DC.

Haley, D. and M.K. Lukert. 1990. Canadian forest tenures: A framework for policy analysis. Information Report E-X-43. Ottawa: Forestry Canada.

Kant, S. 2000. A dynamic approach to forest paradigms in developing economies. Ecological Economics 32: 287-300.

Kant, S. and R. Berry. 2001. A theoretical model of optimal forest paradigms in developing economies. Journal of Institutional and Theoretical Economics 157(2): 331-355.

Lambert, R. S. and P Pross. 1967. Renewing Natures Wealth. Ontario, Canada: The Department of Lands and Forests.

Lane, M. B. and G. McDonald. 2002. Towards a general model of forest management through time: evidence from Australia, UAS, and Canada. Land Use Policy 19: 193-206.

Luckert, M. K. 1992. Changing resource values and the evolution of property rights: the case of wildness. In Growing demands on a shrinking heritage: Managing resource-use conflicts, (eds.) M. Ross, and J. O. Saunders. pp 85-99. Calgary, Canada: Canadian Institute of Resource Law.

Marchak, P. 1983. Green Gold: the Forest Industry of British Columbia. Vancouver: University of British Columbia Press.

Mather , A.S. 2000. South-North Challenges in the Global Forestry. P. 67-82 in World Forests from Deforestation to Transition? Palo, M. Vanhanen, H. (eds). Kluwer Academic, Netherlands.
Mather, A.S. 1992. The forest transition. Area 24: 367 -379.

Mather, A.S. 2001. Forests of consumption: postproductivism, post materialism, and the postindustrial forest. Environment and Planning C: Government and Policy 19, 249 -268.

Ministry of Agriculture and Forestry M(MoAF) 2001. A National Exotic Forest Description (as at 1 April 2000),

Moen, A. B. 1990. Demystifying forestry law: an Alberta analysis. Environmental Law Centre, Edmonton.

Nelles, H. V. 1974. The politics of development: forests, mine, and hydroelectric power in Ontario, 1849-1941. Macmillan, Toronto.

Nichols, S. and M. Rakai. 2001. Canadian land reform - an overview of Aboriginal rights and land claims settlements. Land Reform, Land Settlement, and Cooperatives *1:* 92-103

North, D.C, and R.P.Thomas.1973. The Rise of the Western World: A New Economic History. Cambridge, England: Cambridge University Press.

North, D.C. 1990. Institutions, Institutional Change and Economic Performance. Cambridge University Press,

Oakes , J., R. Riewe, K. Kinew, K. and E. Maloney. 1998. Sacred Lands: Aboriginal World Views, Claims, and Conflicts. Canadian Circumpolar Institute, University of Alberta, Edmonton, Canada.

Osherenko, G. 1988. Sharing power with native users: co-management paradigms for native wildlife. Ottawa: Canadian Arctic Resources Committee.

Pearse, P. H. 1988. Property rights and development of natural resources policies in Canada.. Canadian Public Policy 14 3): 307-320.

Perz, S. G. and D. L Skole. 2003. Secondary forest expansion in the Brazilian Amazon and refinement of forest transition theory. Society and Natural Resources 16: 277-294.

Pfaff, A. 2000. From deforestation to reforestation in New England, United Stat. P. 67-82 in World Forests from Deforestation to Transition? Palo, M. Vanhanen, H. (eds). Kluwer Academic, Netherlands.

Posner, R. 1980. A theory of primitive society, with special reference to law. Journal of Law and Economics 23: 1-53.

Rawat, J. K. 1985. Forest tenure systems in Canada and their role in the investment behavior of integrated forestry firms. Ph. D. Thesis. Toronto: University of Toronto.

Ross, M. M. and P. Smith. 2002. Accommodation of Aboriginal Rights: the Needs for Aboriginal Forest Tenure. A Synthesis Report Prepared for Sustainable Forest Management Network. Edmonton: University of Alberta.

Rotherham, T. 2003. Canada’s privately owned forest lands: their management and economic importance. The Forestry Chronicle 79 (1): 106-109.

Schwindt, R and S. Globerman. 1996. Takings of private rights to public natural resources: a policy analysis. Canadian Public Policy 22 (3): 205-224

Sethi R. and E. Somanathan.1996. The Evolution of Social Norms in Common Property Resource Use. The American Economic Review 86: 766-788.

Southworth, T. and A. White. 1957 [1907]. A History of Crown Timber Regulations from the Date of the French Occupation to the Year 1899. Ontario: Department of Land and Forests. Reprinted in 1957.

Wetton, E. A. F. 1977. Variation in implementing sustained-yield forestry in Canada –British Columbia. Forestry Chronicle 57(1):26-31.

Zhang, D. 1996. Forest tenure and land value in British Columbia. Journal of Forest Economics 2 (1): 7-30

Zhang, Y. 2001a. Institutions in Forest Management: Special Reference to China. P. 353-364 in World Forests, Market and Policies, Palo, M. , J. Uusivuori, and G. Mery (eds.), Kluwer Academic, Netherlands.

Zhang, Y. 2001b. Economics of Transaction Costs Saving Forestry." Ecological Economics 36 (2): 197-204.

Zhang, Y. 2000. Deforestation and Forest Transition: Theory and Evidence from China. P. 41-65 in World Forests from Deforestation to Transition? Palo, M. Vanhanen, H. (eds). Kluwer Academic, Netherlands.

Participatory Forest Management and State Forestry Agencies: Modeling the Perceptions of Foresters

Sushil Kumar[31] and Shashi Kant[32]

Abstract

In transition to community-based forest management (CBFM) paradigm, transformation in the role of foresters from ‘controller’ to ‘facilitator ‘, is taken for granted. Given the militaristic culture of forestry agencies in most developing countries, this change is bound to face resistance. Using structural equation modeling technique, this paper examines two dimensions of resistance – disapproval of CBFM regime by the foresters at individual level and organizational level, and four categories of causal factors of resistance – personality traits, organizational factors, external environmental factors, and socialization factors. Study suggests that while members of four state forest departments of India, at an individual level have less resistance, but they show high resistance to implementation of CBFM by the organization. Results further suggest that fear of losing prestige and authority is major cause of resistance at personal level while hierarchical attitude is a primary causal factor of resistance to organizational level implementation.

Keywords: Organizational Resistance, Community forestry, India, Institutions, SEM

[31] Ph. D. Candidate, Faculty of Forestry, University of Toronto, 33 Willcocks Street, Toronto, Ontario Canada, M5S 3B3 E-mail: kumar.sushil@utoronto.ca

[32] Associate Professor, Faculty of Forestry, University of Toronto, 33 Willcocks Street, Toronto, Ontario Canada, M5S 3B3 E-mail: shashi.kant@utoronto.ca

Participatory Forest Management and State Forestry Agencies: Modeling the Perceptions of Foresters

1.0 Introduction

The 'sustained yield timber management' paradigm is increasingly getting replaced by the 'sustainable forest management'. The new paradigm aims at the integration of social, ecological, and economic values of forest resources. Integration of social values and social sustainability of forest management, to a large extent, depends on appropriate institutional and organizational arrangements that can ensure direct participation of different user groups in forest management (Ascher, 1995; Peluso, 1992), and equitable distribution of benefits from the resource among these diverse groups (Lal, 1995). Hence, a number of developing countries are in the process of transforming their 'blueprint' strategies of forest management to people-centered management, commonly known as community-based forest management (CBFM). There are at least two principal stakeholders in this regime – the state, as represented by the functionaries of forestry agencies, and local communities, represented by the members of their collective decision making bodies. Most researchers working on CBFM regimes[33] have tended to focus on issues from the perspective of communities (Baland and Platteau, 1996), and the role of the other partner – state forestry agencies – has received no more than passing reference.

In general, public administration in developing countries, forestry agencies being no exception, is highly bureaucratized and centralized, based on an authoritarian legal system (Haque, 1997). In these countries, state forestry agencies have, for many decades if not centuries, been implementing state-centered forest management policies, which are based on the principle that local people are the enemies of forests. In this process, foresters have developed an attitude of blaming local people for problems in the forestry sector. Now, under the CBFM regime, the same forestry agencies are responsible for the implementation of participatory approaches to forest management. The success of such a system, to a great extent, depends on mutual understanding and a cooperative relationship between state forestry agencies and local communities. For such a relationship to develop, the bureaucratic mindset of the foresters needs to be reoriented to achieve congruence between the working culture of state forestry agencies and the decentralized working ethos of CBFM regime. This process of role transformation requires forest agencies to give up some authority and decision-making powers to local communities. Given the militaristic culture of the organization, this process is a difficult one and bound to face resistance from the members of the state forestry agency. Unfortunately, policymakers and academic researchers have not dealt adequately with this issue of organizational change in forestry agencies, a prerequisite in a CBFM regime.

The transformation of a bureaucratic organization is not an easy task. There is consensus among organizational theorists working on 'organizational change' that organizations often have difficulty devising and executing changes fast enough to meet the demands of an uncertain and changing environment (Baum, 1996), due largely to 'resistance to change' existing in organizations. In this paper, we identify and assess various exogenous and endogenous causes of 'resistance to change', in the forestry agency (Forest Department) of India, with respect to the implementation of a CBFM regime and we provide a framework for understanding how to overcome this resistance. We propose a theoretical model that is based on two dimensions of

[33] Some of these researchers are Arnold, 1990; Ascher, 1995; Bromley, 1992; Chambers, 1994; Kant et al., 1991; Ostrom, 1990; Poffenbeger et al., 1996; and Robinson, 1995.

resistance to change – disapproval of the CBFM regime by members of Forest Department (FD) at the individual level and at the organizational level, and four categories of causal factors of resistance to change – personality traits of the members, organizational factors, external environmental factors, and socialization (demographic) factors. We empirically examine our proposed model using questionnaire survey data, collected from the members of four state FDs in India, and structural equation modeling technique.

A theoretical model, based on two dimensions of resistance to change and four categories of causal factors, is discussed in the next Section. Measures of the concepts of two dimensions of resistance and related causal factors, methods of data collection and data analysis are provided in Section 3. The estimated structural equation models are presented and discussed in Section 4, and finally we conclude with some policy implications.

2.0 A Theoretical Model for Forest Department's Resistance to CBFM Regime

Public participation in policy planning and policy implementation, the essence of democratic civil society, faces many constraints in contemporary public governance systems. Besides poor planning and execution, bureaucratic administrative systems that are based upon expertise, professionalism and rational organizing principles, constrain the participatory processes. The most difficult to change are the structures and processes of administration due to inherent 'resistance to change' in the organizations. Even though adaptation theorists, such as Thompson, 1967; Lawrence and Lorsch, 1967, believe that organizations have an inclination to change, organizational ecologists, such as DiMaggio and Powell, 1983; Hannan and Freeman, 1984; Tushman and Romanelli, 1985, have brought organizational resistance or inertia theory at the forefront of organizational behavior literature. Resistance to change is not merely an objective issue; but being a function of the personalities of organizational members, it also is a subjective issue. Attitudes of individuals in an organization are substantially a function of their in-built personality traits, the organization's culture, and broader societal culture. The resistance to change rooted in the size, complexity, and interdependence of the organization's structures, systems, and formal processes, is termed 'objective resistance'. However, in this study, we address the issue of 'subjective resistance' by which we mean the resistance to change emanating from the organizational members.

In the context of CBFM regimes, subjective resistance, resistance on the part of members of the FD, has two dimensions: the extent to which members of FD resist the implementation of CBFM regime by the FD as an organization, and by themselves as individuals. We incorporate both dimensions in our model denoted by the two constructs of resistance to change, *'resistance-1'* and *'resistance-2'*, respectively, as shown in Figure 1.

Resistance to change is a complex and multi-faceted phenomenon (Waddell and Sohal, 1998), and numerous causal factors have been used to explain it. Broadly, the causal factors for resistance to change can be grouped into endogenous and exogenous factors. A member of the FD is surrounded by three types of environment: (i) an organization's internal environment in which he works all the time; (ii) an external environment which exists outside of the organization; and (iii) a social environment in which he has been brought up and is part of outside office hours. The causal factors from these three environments are respectively called organizational factors, external environmental factors, and socialization factors. The possible interactions between these three categories of exogenous causal factors, two personality traits, and two constructs of subjective resistance are shown in Figure-1. On prima-facie grounds, it also seems reasonable that the members, who have higher resistance to the implementation of

CBFM by themselves, will also have higher resistance to the implementation of CBFM by the FD. Hence, we also hypothesize a positive path from '*resistance-2*' to '*resistance-1*'.

3.1 Personality Factors:

Many organizational theorists argue that the explanation of resistance to organizational change is fundamentally psychological (e.g. Watson, 1969; Kazlow, 1977), and treat resistance to change as a function of the personality traits (including elements such as attitudes, motives, values, needs, and habits) of individuals working in an organization (Durbrin and Ireland, 1993; Griffin, 1993; Hinings and Greenwood, 1988). In the context of public agencies, Downs (1967) and Presthus (1962) argue that organizational members pursue their own ambitions, goals, and interests within the organization. On the basis of degree of change orientation (traditionalism) among organizational members, they have identified different personality types within public agencies.

Classic bureaucracy theory argues that the purpose of rules, regulations, policies, procedures, and precedents is to serve as guidelines to the employees. However, generally these guidelines, in a bureaucratic organization, become habits for the individuals and are relied on for both guidance and protection (Mealiea, 1978) resulting in over-commitment to rules, regulations, and precedents (Saxena, 1996). Such employees do not feel comfortable in a changed environment and therefore, show high resistance to organizational change. The state forest departments of India are examples of a true bureaucratic organization, and hierarchical functioning according to well established rules, regulations, and standardized practices, is a dominant feature of these organizations. Hence, *'traditionalism'* is one of the key personal traits of the members of the FDs, and we hypothesize that this traditionalism not only has a direct positive influence on both kinds of resistance but also channels the influence of other variables discussed later.

Another aspect of personality, related to resistance to change, is the employees' aspirations and expectations from working in a given organization. Individuals within complex organizations, over time, develop vested interests, in addition to or even in conflict with the objectives of the creators of organization (Meyer and Zucker, 1989). Organizational members deriving benefits from the existing organizational arrangements are less likely to tolerate changes (Kaufman, 1971; Meyer and Zucker 1989). In addition, people tend to feel comfortable and secure with that which is familiar, and uncomfortable or insecure with that which is unfamiliar (Williams, 1969). If, in the change scenario, employees perceive a possible threat to their job status, job security, their sense of autonomy or control, or prestige, they respond defensively, with resistance. Fear of failure in changed environment is another factor which makes people resist change. They disapprove of being treated as novices in the organization in which they once have been regarded as experts.

In the present regulatory framework of state FDs, foresters up to the field level, enjoy considerable powers, the discretionary use of which is an important source of prestige and authority. In a CBFM regime, there will be a reduction in these means of control, as the participatory ethos of decentralized forest management envisages clarification and simplification of procedures and stresses greater transparency. This implies that organizational members, afraid of losing prestige, authority, control and promotional avenues in the CBFM regime, will resist its implementation. Hence, the second personality trait and mediating variable in our model is '*fear*' – a concept dealing with the extent of fearfulness among members of the state forestry agencies.

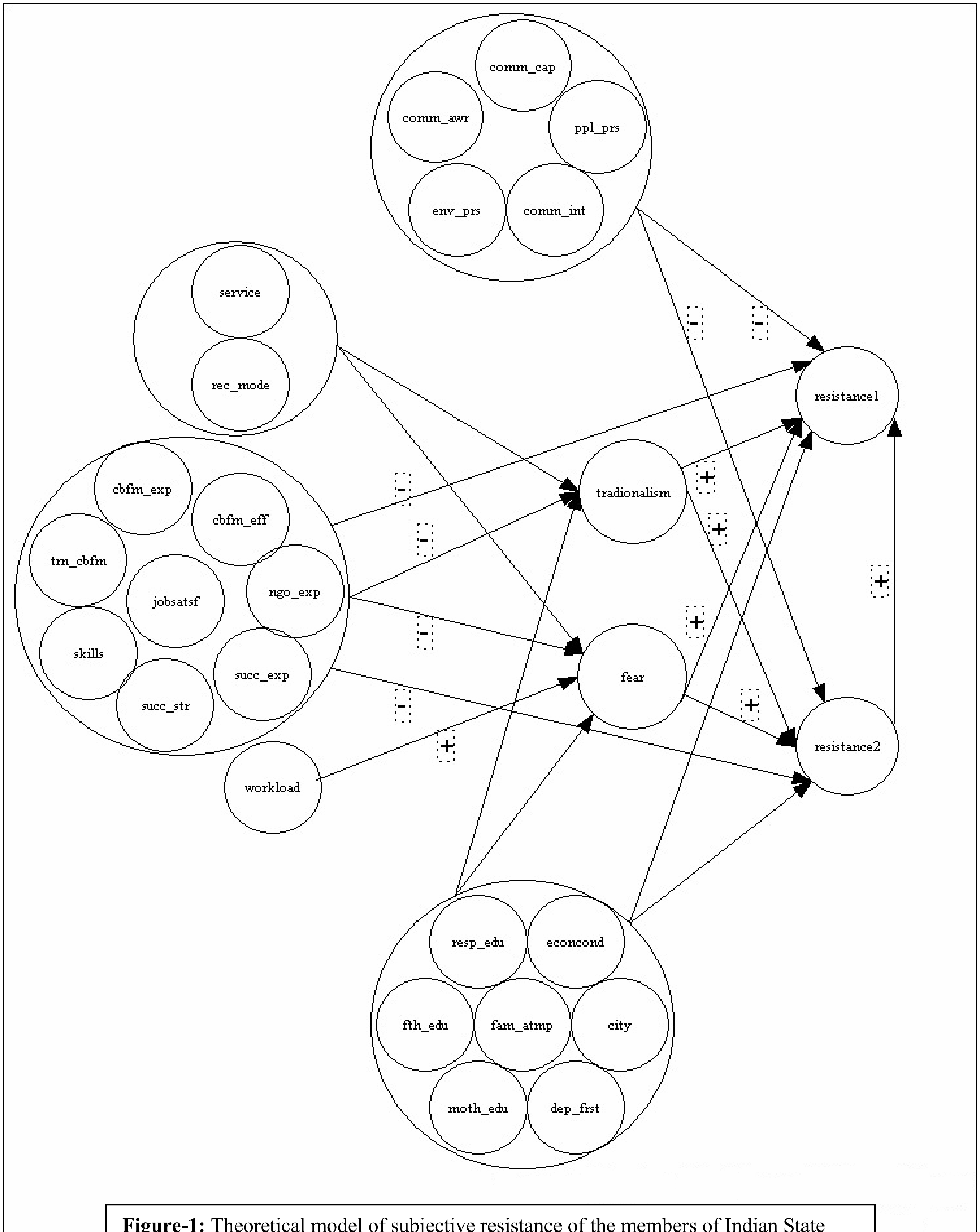


Figure-1: Theoretical model of subjective resistance of the members of Indian State Forest Departments to CBFM regime

3.2 Organizational Factors:

Members of an organization, during their long period of service in the organization, acquire different skills, face diverse situations, and experience success as well as failures, and the degree of all these features as well as individual competence varies among members. Generally, less competent employees resist change while more competent employees welcome change and are more willing to see inefficient procedures altered or eliminated (Blau and Scott, 1962). Employees, who possess the requisite skills and knowledge for success in the changed condition, will be less resistant to change. Further, the ability to evaluate and exploit novel ideas is largely a function of the employees' level of prior related knowledge. If they have successfully worked in similar circumstances earlier, it helps them gain skills and knowledge and also makes them confident of success. Hence, we hypothesize that individual skill levels of members of the FD in peoples' participation (*'skills'*), their prior experience (*'cbfm_exp'*) or voluntary efforts (*'cbfm_eff'*) involving local communities in forest management, the degree of success they achieved in these efforts (*'succ_exp'*), and their awareness of success stories (*'succ_str'*) of CBFM, will help mitigate fear and thus, will reduce both kinds of resistance to CBFM systems.

Some members of the FD also get opportunities of working with non-government organizations. Generally, non-governmental organizations, unlike public bureaucracies, are innovative, adaptable, and socially concerned (Midgley, 1986). Therefore, experience of working with non-governmental organizations (*'ngo_exp'*) will also affect negatively the FD member's resistance to CBFM regime.

In the long run, organizational actors construct around themselves an environment that constrains their ability to change further in later years (DeMaggio & Powell, 1983), and this results in organizations frequently misreading the demands made by the environment, largely due to selective perceptions (Pfeffer & Salancik, 1978). Training is an important strategic tool which helps organizational members to re-enact the environment around them. This implies that the more frequently the members of an organization are imparted training in the area of change, the more receptive they should be to the change process. Hence, we hypothesize that training focused on aspects related to community forestry (*'trn_cbfm'*) should directly decrease resistance among organizational members towards the CBFM regime.

Finally, job satisfaction is an important organizational factor related to resistance to change. Job dissatisfaction induces unwillingness to cooperate and contribute to the organizational goals (Bernard, 1938), and results in feelings of alienation among members who are less willing and less able to promote necessary organizational change (Whetten, 1987). Job dissatisfaction is reported to be strongly correlated to active resistance to change (Mangioni and Quin, 1975; Torenvlied and Velner, 1998). Therefore, we include the level of job satisfaction (*'jobsatsf'*) as one of the causal factors, and expect that it will have a negative effect on resistance to change toward CBFM systems. In addition, we also hypothesize that the respondents' length of service (*'service'*) and mode of recruitment (*'rec_mode'*) will also affect their resistance to CBFM systems.

3.3 External Environmental Factors:

All organizations and organizational members are integral components of a social system, and engage in interactions with the external environment. These interactions play an important part in bringing about change in any organization, especially those which are sesnsitive to external environmental pressures (Armenakis et al., 1993; Miner et al., 1990 Young, 1991). In the case of CBFM regime, the members of forest department interact with the representatives of the people, non-government organizations, and the media, in addition to interacting directly with the member of local communities. Hence, with respect to FD resistance to a CBFM regime, we group external environmental factors into two categories: direct pressure from local community members (*'ppl_prs'*), and other pressures, from representatives of the people, NGOs, and media (*'env_prs'*). In addition to these two factors, interest on the part of communities in forestry activities (*'comm_int'*), their capability to undertake forest management activities (*'comm_cap'*), and level of awareness about CBFM (*'comm_awr'*) will also influence the interactions between local communities and members of the FD. Hence, these variables are also included as causal factors of the resistance to CBFM regime.

3.4 Socialization Factors:

People have differences in their values and assumptions. Thus any change may be 'good' for some and 'bad' for others, based on their value orientations and assumptions (Williams, 1969). The socialization process has a significant impact on the development of general human values, attitudes, and personality (Chackerian and Abcarian, 1984). We focus upon adolescent socialization (i.e. between the ages of 12 to 18 years) as 'adolescence is the first time that the human being consciously tries to conceptualize himself and consciously works to change himself' (Campbell, 1969:825). The variables whose relationships with both kinds of resistance, directly or through two mediator variables, we propose to examine are level of education of respondent's father (*'fath_edu'*) and mother (*'moth_edu'*), size of place where respondent grew up between the ages of 12 and 18 years (*'city'*), economic condition of the respondent's family (*'econ_con'*), the family atmosphere with respect to liberty of expression (*'fam_atmp'*), and the extent to which the respondent's family was dependent on forests (*'dep_frst'*) when the respondent was between the ages of 12 to 18 years. In addition to these factors associated with the family of the respondent, the level of education of the respondent (*'resp_edu'*) is also expected to play an influential role in his/her conceptualization of change.

Given the lack of previous theoretical and empirical studies on relationships among our chosen socialization variables and some inconsistencies reported in the literature, our examination of these variables is heuristic. That is, our examination is aimed at generating hypotheses rather than testing formal hypotheses.

3.0 Data Collection, Measures, and Data Analysis

3.1 Data Collection: A questionnaire survey was used to collect data regarding two types of resistance to CBFM systems as well as different resistance factors. On the basis of social, economic, political variability, and discussion with forest department officials and non-government organizations, four states – Andhra Pradesh (AP), Haryana (HR), Himachal Pradesh (HP), and West Bengal (WB) – were selected for the survey. The universe included forest officers from the apex level i.e., Principal Chief Conservator of Forests, to the junior most field functionary i.e., Forest Guard.

At the senior and middle level management, all officers were included in the sample. At the junior level 10% of the staff working in each cadre (Forest guards, Block Forest Officers, and Range Forest Officers) of each state was included in the sample. A varying number of forest divisions, in each state, were selected randomly so as to ensure the stipulated number of junior-level staff in the sample.

In all, 1641 (response rate- 84%) questionnaires were returned, of which 1524 had complete information. One item in the questionnaire was aimed at testing the respondents' level of knowledge about CBFM regime. Of 1524 responses with complete information, 212 (14%)

indicated a low level of knowledge about CBFM regime. These responses were not included in the analysis; thus, leaving 1312 effective responses for final analysis. Ages of respondents included in the final analysis range from 22 years to 61 years with a mean age of 45.4 years. These respondents have experience of working in the organization ranging from 1 year to 40 years with a mean value of 19.3 years.

3.2 Measures: The questionnaire consisted of a list of structured statements which, according to classical measurement theory, serve as measures of the conceptual components (observed variables or indicators) of the major constructs. The reliability of these items was tested within the framework of test-retest method. Our hypothesized model (Figure-1) consists of 26 latent variables of which four – *'resistance-2'*, *'traditionalism'*, *'fear'*, and *'env_prs'* - have more than one observed variable. The remaining variables are extracted from their respective single observed variables.

Resistance-1: Four items, rated on a 5-point (1 = Strongly agree, 5 = Strongly disagree) Likert type scale were developed to operationalize this construct. The internal consistency estimate (Cronbach's alpha) for the scale is 0.72. The mean of the ratings of the items provided an index of resistance, with higher score indicating greater resistance.

Resistance-2: This resistance was measured using three conceptual components: *'Disapproval of the CBFM'* (extent to which respondent does not agree with the positive outcomes of the CBFM system), *'Support of the CBFM'* (to what extent the respondent supports a CBFM regime as a criterion of performance evaluation in the organization), *'Disapproval of implementation'* (extent to which the respondent disagrees to implement CBFM regime). These three conceptual components were measured using four (Cronbach's alpha =0.83), two (Cronbach's alpha =0.81), and one questionnaire item, respectively. All of these items were rated on five point (1 = Strongly agree, 5 = Strongly disagree) Likert type scale with higher score indicating greater of particular concept.

Personality Factors: Two conceptual components: *'Hierarchical Orientation*' (extent to which respondent believes in working as per rules and regulations) and *'Stability Orientation'* (extent to which respondent tends to rely on standardized practices and precedents), serve as observed variables for the latent construct *'traditionalism'*. Three questionnaire items (Cronbach alpha =0.69) were used to operationalize '*Hierarchical Orientation*' and two items (Cronbach alpha = 0.71) measure *'Stability Orientation'*. All these items were rated on five point (1 = Strongly agree, 5 = Strongly disagree) Likert type scale with higher score connoting greater of a particular concept.

The latent construct *'fear'* was extracted from three observed variables. Of these, two variables – *'Fear of losing Prestige'* and *'Fear of losing Promotions'* – were measured using two questionnaire items each (Cronbach alpha =0.74 and 0.67, respectively), rated on five point (1 = Strongly agree, 5 = Strongly disagree) Likert type scale. The third observed variable – '*Fear of Failure*' – was assessed using one questionnaire item, rated on a similar scale.

Organizational Factors: Three organizational background variables: experience in CBFM (*'cbfm_exp'*), personal efforts in CBFM (*'cbfm_eff'*), and experience in an NGO (*'ngo_exp'*) were coded 1 (*yes*) and 2 (*no*). Number of trainings in CBFM (*'trn_cbfm'*) was coded as 1 (*none*), 2 (*1-3*), 3 (*4-6*), 4 (*7-9*), and 5 (*more than 9*). Recruitment mode (*'rec_mode'*) of the respondent was coded as 1 (*direct recruitment*) and 2 (*by promotion*). The variables *'skill'* and *'workload'* were measured using one and two questionnaire items (Croanbach's alpha = 0.84), respectively. These items were rated on five point (1 = Strongly agree, 5 = Strongly disagree) Likert type scale. Similarly, one questionnaire item, rated on a 5-point (1 = Highly Successful, 5

= Highly unsuccessful) Likert type scale, was used to measure successful experience in CBFM (*'succ_exp'*). Length of service in the FD (*'service'*) was coded as a continuous variable consisting of the number of years the respondent has served in the department.

To measure level of job satisfaction, we followed the procedure used by Torenvlied and Velner (1998). Respondents were asked their opinion regarding ten aspects of their job. For each of these ten aspects, respondents were to indicate the extent of importance they attach to that aspect on a five point scale varying from *'very important'* to *'not important at all'*. They were also asked to indicate their level of satisfaction on each of the ten aspects on a second five point scale varying from *'very satisfied'* to *'not satisfied at all'*. Scores on the two scales were multiplied and aggregated. Mean of the aggregated score serves as job satisfaction index.

External Environmental Factors: *'env_ prs'* construct was assessed using three observed variables: '*Pressure from peoples' representatives'*, *'Pressure from non-governmental organizations',* and *'Pressure from media'*. Each of these observed variables was measured using a single item on the questionnaire. The remaining four external environmental constructs were extracted from their respective single observed variables. Of these, two constructs - *'ppl_prs'* and *'comm_awr'* – were measured with one item each, and the other two – *'comm_int'* and *'comm_cap'* – with two questionnaire items (Croanbach's alpha = 0.81 and 0.76, respectively) each.

Socialization Factors: Level of education of the respondent (*'resp_edu'*) was measured with a categorical questionnaire item ranging from 1 (*High school*) to 6 (*Doctorate degree*). Similarly, the items used to measure the level of education of the respondent's mother (*'moth_edu'*) and father (*'fath_edu'*) were coded 1 (*Illiterate*) to 9 (*Doctorate degree*). The economic condition of the respondent's family (*'econ_cond'*) was assessed using one item rated on seven point scale (1 = Very poor and 7 = Very rich). One questionnaire item with a scale ranging from 1 (*Very strict*) to 7 (*Very free*) was used to measure the respondent's family atmosphere (*'fam_atmp'*). Size of the place (*'city'*) where the respondent grew up from age 12 through 18 years was coded 1 (*Village*) to 5 (*Metropolitan city*). To assess how far respondent's family was dependent on forests (*'dep_frst'*), the questionnaire item was coded 1 (*Not dependent*), 2 (*Somewhat dependent*), and 3 (*Highly dependent*).

3.3 Data Analysis: The data were analyzed with structural equation modeling (SEM) technique using LISREL 8.52 software (Joreskog and Sorbom, 2002). Following the convention in structural equation modeling (Anderson and Gerbing, 1988; Joreskog and Sorbom, 1993), the latent model was analyzed in two separate stages. Stage 1 involves assessment of a measurement model and following acceptance of this, stage 2 provides an estimation and assessment of the hypothesized structural model.

Considering the large sample size in our analysis, we used Root Mean Square Error of Approximation (RMSEA), Goodness of Fit Index (GFI), Adjusted Goodness of Fit Index (AGFI), Comparative Fit Index (CFI), and Normed Fit Index (NFI), in addition to the traditional chi-square test[34] to assess the model-fit. The value of most of these indexes (e.g. GFI, AGFI, CFI, and NFI) can vary between zero and one. A judgment of close fit can be made to the extent that these indexes approach unity.

[34] The value of chi-square is sensitive to variations in sample size. In large samples, the chi-square test detects even trivial differences between the hypothesized model and the data, leading to rejection of the model (Bollen and Long, 1992; Browne and Cudeck, 1993; Hayduk, 1987, 1996; James et al., 1982).

4.0 Structural Equation Models of the FD Members Subjective Resistance

Test-retest reliability coefficients for the questionnaire items used to measure the observed variables range from 0.76 to 0.92, and are statistically significant at a 1% level of significance. Model fit indexes of the measurement model and the structural model are reported in Table 1, and parameter estimates of different paths are given in Table 2.

Overall, the goodness of fit indexes support both the measurement and the structural models. Although chi-square values for both models are significant (p = 0.00), which means that the models fail to pass the exact fit test, the values of all other fit indexes fall within acceptable limits indicating approximate fit between the models and the sample data. The value of RMSEA is well below the cut-off limit of 0.06 and the values of GFI, AGFI, CFI, and NFI are above 0.90[35].

4.1 Measurement Model

In order to examine whether the observed variables are reliable measures of their respective latent variables, a confirmatory measurement model was tested. The initial measurement model had a chi-square value of 623.39 for 192 df (p = 0.00). On the basis of the modification indexes generated by LISREL, three error terms were permitted to co-vary. The modified measurement model fits the data significantly better than the initial model (RMSEA=0.038, SRMR=0.031, NFI=0.96, CFI=0.97, GFI=0.98, AGFI=0.93). Acceptable results of the measurement model confirm that the observed variables are reliable measures of their respective latent variables.

Table 1: Goodness of fit indexes of Measurement Models and Structural Models

		Chi-square	RMSEA	SRMR	GFI	AGFI	NFI	NNFI	CFI
MEASUREMENT MODELS	**M1:** Original model	630.63 (199)	0.041	0.031	0.97	0.92	0.96	0.92	0.97
	M2: Model with three correlated error terms	557.23 (196)	0.037	0.031	0.98	0.93	0.96	0.93	0.98
STRUCTURAL MODELS	**S1:** Original Model	759.21 (217)	0.044	0.034	0.96	0.91	0.95	0.91	0.96
	S2: Model after removing insignificant paths and adding modifications	774.37 (257)	0.039	0.034	0.97	0.93	0.95	0.92	0.96

[35] Hu and Bentler (1999) suggest a value of 0.06 or lower for RMSEA, and a value close to 0.90 for GFI and AGFI for a good model fit.

4.2 Structural Model

Next, following acceptance of the measurement model, we included paths between latent constructs as hypothesized in our theoretical model. The initial model with all the paths as hypothesized resulted in a chi-square value of 759.21 for 217 degrees of freedom (df). All fit indexes, reported in Table-1, indicate good fit between the model and the sample data. However, there were quite a few insignificant paths in this model. Next, we removed these insignificant paths (one at a time) and tested the modified model. The modification indices and standardized residuals of this model suggested the variables *'env_prs'* and *'ppl_prs'* have an indirect effect, instead of a direct effect, on *'resistance-1'* through *'traditionalism'*. In addition, modification indices also suggested a direct path from '*traditionalism*', '*comm_cap*', and '*comm_int*' to *'fear'*. Removal of insignificant paths and acceptance of suggested modifications improved the model substantially as reported in Table-1. Fit indexes (RMSEA=0.039, NFI=0.95, CFI=0.96, GFI=0.97, AGFI=0.93) suggest that model explains the sample data well. Hence, this model is used to explain further results.

The final model has two noticeable features. First, two kinds of resistance – the resistance of the members to the implementation of CBFM by the FD (*'resistance-1'*) and the resistance of members to implementing CBFM by themselves (*'resistance-2'*) – are two independent constructs (correlation coefficient = 0.06). This means that the members of the FD who themselves intend to implement CBFM system in their areas do not support it as an organizational objective of the FD, which is contrary to our hypothesis. Second, of the two personality traits (endogenous variables), only '*traditionalism*' has a direct significant impact on '*resistance-1*', while '*fear*' has a direct significant effect on '*resistance-2*', and '*traditionalism*' affects '*resistance-2*' indirectly through '*fear*'. Hence, a primary causal factor for *'resistance-1'* is *'traditionalism'* and for *'resistance-2'* is *'fear'*.

Direct, indirect, and total effects (un-standardized and standardized estimates) of different causal factors on two kinds of resistance are reported in Table-2. In the next section we discuss the results of *'resistance-1'*, followed by results of *'resistance-2'*.

4.2.1 Subjective Resistance of the FD Members to the implementation of CBFM regime by the FD ('*Resistance-1*') and Causal Factors

The mediator variable (*'traditionalism'*), as expected, has the largest positive influence (0.733). This indicates that the hierarchical working attitude of foresters, combined with their tendency to follow well established practices of forest management, are the major causal factors for FD's members' disapproval of the adoption of CBFM systems by the FDs.

Of four external environmental factors, two (*'comm_int'* and *'comm_awr'*) have significant direct effects (-0.080 and 0.205) on *'resistance-1'*. The remaining two environmental factors (*'env_prs'* and *'ppl_prs'*) influence *'resistance-1'* indirectly through *'traditionalism'* (0.188 and -0.084). This suggests that with an increased interest on the part of communities in forestry activities, members of the FD would tend to favor CBFM regime. In contrast, the level of community awareness has a large positive effect on the degree of *'resistance-1',* i.e. the more aware communities are about CBFM regime, the greater the resistance among foresters to its implementation by the FD. This result, at first glance, seems perplexing. However, the underlying logic becomes clearer if one looks at the implications of the CBFM regime. In the new regime foresters are required to work as 'facilitators', not as 'controllers'. The more the communities are aware of their rights and privileges in a CBFM regime, greater the threat the foresters perceive to their authority and control.

Another external environmental factor which shows sign contrary to our hypothesized model is the pressure from media, non-governmental organizations, and peoples' representatives (*'env_prs'*), which has an indirect positive influence (0.188) on *'resistance-1'*. This indicates that as pressure from these agents increases, respondents tend to more rigidly follow rules, regulations and standardized practices. As *'traditionalism'* has a positive impact on resistance to CBFM regime, increased pressure from these components of the external environment results in greater resistance. On the other hand, direct pressure from local peoples (*'ppl_prs'*) shows an indirect negative impact (-0.106) on resistance by negatively affecting *'traditionalism'*. Again, a deeper understanding of the bureaucratic psyche of foresters, especially in developing countries, is required in order to fully appreciate this result. In general, foresters heed demands raised directly by local people but ignore the same demands if voiced through a mediating body such as the media or a non-government organization. Direct pressure from local people for their involvement in forest planning and management leads to a lessening of hierarchical, standardized working practices of the respondents, which in turn results into lower resistance towards implementation of CBFM regime by the FD.

Three organizational factors: length of service (*'service'*), recruitment mode (*'rec_mode'*), and the number of trainings on CBFM attended by the respondent (*'trn_cbfm'*), are found to have significant effects (-0.111, 0.091, and -0.077) on *'resistance-1'*. Respondents with greater length of service in the FD appear to have a less hierarchical working style, which in turn leads to lower resistance to CBFM regime. However, respondents who are in their ranks by virtue of promotion rather than being directly recruited, show greater tendency to follow rules, regulations, and standardized practices and thus, greater resistance. Training on CBFM systems seems to play a positive role in respondent's acceptance CBFM concept as an organizational goal.

Of the socialization factors, only the respondent's education level (*'resp_edu'*) and family atmosphere during childhood in terms of liberty of expression (*'fam_atmp'*) have significant negative influences on resistance to CBFM regime. These effects are indirect and are channeled through 't*raditionalism'*. Respondents with a higher education level reflect a less hierarchical attitude and thus, less resistance to participatory methods of forest management. These results suggest that liberty of expression in the family during childhood leads to the development of a liberal attitude to working. In sum, the results indicate that inclination of members of the FD to follow hierarchical and standardized working practices ('*traditionalism*') is the single major cause of resistance to adoption of CBFM regime by the FD.

4.2.2 Subjective Resistance of the FD Members to the implementation of CBFM regime by themselves ('*Resistance-2*') and Causal Factors

In the final structural model of '*resistance-2'*, the latent construct – *'fear'*, is an endogenous variable which, in addition to exogenous variables in the model, is influenced by another endogenous variable – *'traditionalism'*. Though the direct path from '*traditionalism*' to '*resistance-2*' is not supported, all exogenous variables affecting it, also affect *'resistance-2'* by having an indirect effect on *'fear'*.

'*Fear*' has the largest positive effect (0.246) on *'resistance-2'*, while knowledge of success stories about CBFM regime (*'succ_str'*) has the largest negative impact (-0.636). *'Fear'* is positively affected by *'traditionalism'* (0.664), *'workload'* (0.240), place where respondent grew up – *'city'* (0.011), and training on CBFM – *'trn_cbfm'* (0.089), and it is negatively affected by knowledge of success stories – *'succ_str'* (-0.440), capacity of local people to manage forests – *'comm_cap'* (-0.139), level of interest of local people in forestry activities – *'comm_cap'* (-0.159), economic condition of respondent's family during socialization – *'econ_cond'* (-0.104), and mode of recruitment – *'rec_mode'* (-0.175).

Inspection of the parameter estimates shows that none of the hypothesized direct negative effects of external environmental factors on *resistance-2* is supported. However, four environmental factors have an indirect effect on *'resistance-2'*; two: *'comm_cap'* (-0.034) and *'comm_int'* (-0.039) through *'fear'*, and two: *'env_prs'* (0.042) and *'ppl_prs'* (-0.010) through *'traditionalism'*. These results suggest that higher capability and increased interest on the part of local communities in forest management mitigates resistance to CBFM systems among foresters. Interpretation of the effects of other two environmental factors in this type of resistance is similar as in the case of *'resistance-1'*.

Table 2: Direct, indirect, and total effects of different causal factors on two kinds of subjective resistance of the members of Indian State Forest Departments to CBFM regime

	Resistance-1						**Resistance-2**							
	Direct effect		**Indirect Effect** TRADITIONALISM		**Total**		**Direct effect**		**Indirect Effect**				**Total**	
									FEAR		TRADITIONALISM			
	Est.†	Std.†	Est.	Std.	Est.	Std.	Est.	Std.	Est.	Std.	Est.	Std.	Est.	Std.
Organizational Factors														
skills							-	-					-	-
workloa									0.02	0.05			**0.02**	**0.05**
succ_str							-	-	-	-			-	-
cbfm_e														
cbfm_e														
suc_exp							-	-					-	-
ngo_ex							-	-					-	-
service			-	-	-	-					-	-	-	-
rec_mo			0.14	0.09	**0.14**	**0.09**			-	-	0.01	0.02	-	-
trn_cbf	-	-			-	-			0.00	0.02			**0.00**	**0.02**
jobsatsf							-	-					-	-
External environmental factors														
env_pr			0.25	0.18	**0.25**	**0.18**					0.03	0.04	**0.03**	**0.04**
ppl_prs			-	-	-	-					-	-	-	-
comm									-	-			-	-
Comm.	-	-			-	-			-	-			-	-
Comm.	0.14	0.20			**0.14**	**0.20**								
Socialization factors														
resp_ed			-	-	-	-					-	-	-	-
fth_edu														
mth_ed														
city									0.01	0.02			**0.01**	**0.02**
fam_at			-	-	-	-					-	-	-	-
econco									-	-			-	-
dep_frs							-	-					-	-

Note:

1. Blank cells in the table denote insignificant paths or paths not included in the model.

† **Est.**: Parameter estimate & **Std.**: Standardized parameter estimate

* Significant at 10% level of significance

** Significant at 5% level of significance

Of the organizational factors, *'skills'* (-0.129), *'succ_str'* (-0.636), *'succ_exp'* (-0.083), and *'ngo_exp'* (-0.114) have a direct effect on resistance; that effect is, as predicted, a negative one. *'succ_str'* also affects *'resistance-2'* indirectly (-0.108), by mitigating fearfulness. Increase in workload in the new regime of forest management (*workload*) positively affects *'resistance-2'* indirectly by increasing fear. Mode of recruitment affects resistance indirectly through fear (-0.043) as well as traditionalism (0.020). Respondents working in their present rank by virtue of promotion show a greater tendency to adhere to rules and regulations, but feel less threatened in CBFM regime. Experience of working in CBFM (*'cbfm_exp'*) or voluntary efforts in adopting a participatory approach (*'cbfm_eff'*) is not found to have any direct or indirect effect on the *resistance-2*. However, if voluntary efforts are successful (*'succ_exp'*), it helps in increasing acceptance of CBFM systems.

Training in CBFM concepts (*'trn_cbfm'*) does not have any direct impact on *'resistance-2*', but it increases resistance indirectly (0.022) by increasing fear of losing authority, control, prestige, and promotional avenues in CBFM regime. The direction of influence of training is contrary to what we hypothesized in the theoretical model. In addition, we also expected a direct path from training to *'resistance-2'* which is not supported by the empirical results. As stated earlier, the most important implications of participatory forest management, from the perspective of the forester are: reduction in authority, control, and sense of autonomy. If training focuses heavily on explaining only these implications, and not the positive outcomes of peoples' participation, it may foster a biased attitude. It seems that trainings, by making respondents aware of the underlying consequences of CBFM regime, are having adverse impact on its acceptability by foresters.

Level of job satisfaction (*'jobsatsf'*) has a direct negative impact (-0.059) on the degree of *'resistance-2*'. This suggests that higher job satisfaction leads to increased acceptance of implementing CBFM regime.

Of the socialization variables, the respondent's family's dependence on forests (*'dep_frst'*) is the only variable which shows a direct negative effect (-0.085) on *'resistance-2*'. This means that people who have grown up in the vicinity of forests and have been dependent on forests in some ways are more in favour of participatory approaches of forest management. The size of place where the respondent grew up ('*city*') shows positive effect on fear, i.e. the larger the place, the more is the fear of losing promotions, authority, prestige, and control, which in turn increases resistance to CBFM systems. The effect of remaining socialization factors (*'resp_edu'* = -0.112; *'fam_atmp'* = -0.004;) on '*resistance-2*' is channeled through *'traditionalism' to 'fear',* and the interpretation of these effects is the same as in the case of '*resistance-1*'.

6.0 Policy Implications and Conclusions

The study confirms the existence of two types of subjective resistances among foresters: members' resistance to implementation of a CBFM regime by the FD and resistance to implementation of a CBFM regime by themselves. Our results indicate that the two types of resistance are independent of each other, i.e. acceptance of CBFM regime at the level of individual member may be insufficient for its successful implementation at the organizational level. Similarly, our results suggest that '*traditionalism*' is a primary causal factor of '*resistance-1*' and '*fear*' of '*resistance-2*', therefore two different approaches are necessary to deal with these two resistances.

'*resistance -1*' is critical for the national-level or state-level success of the CBFM regime. Hence, the Indian forest policy makers should assign high priority to dealing with '*resistance-1*'. The most significant causal factors, in addition to '*traditionalism*', which increase '*resistance-1*' are pressures from media, non-governmental organizations, and representatives of the people (*'env_prs'*), and the level of community awareness about CBFM ('*comm_awr*'), direct pressure from communities ('*ppl_prs*'), the level of the community's interest in forestry activities ('*comm_int*'), and the numbers of trainings ('*trn_cbfm*') received by foresters on CBFM are the most significant factors that reduce '*resistance-1*'. It seems that in the interest of promoting CBFM regimes, the media, non-government organizations, and representatives of the people should change their strategy of directly attacking the Forest Department for its non-participatory approaches, and should instead work through local communities.

In the early stages, traditionalism or hierarchical and conservative attitudes of foresters are influenced by socialization variables and entry-level training, and thereafter are reinforced by organizational structure and culture. The recruitment procedures for foresters should be examined and modified to filter out applicants with undesired conservative attitudes. The entry-level training should focus more on social issues of forestry, and should aim at equipping trainees with skills in two-way communication, eliciting community participation, participatory decision making, analysis and understanding of peoples' values, customs, and traditions etc.

In-service trainings, in addition to exposing trainees to new technical knowledge, provide opportunities for interactions among foresters from different states, academicians, and members from non-government organizations, as well as for sharing experiences of successes and failures from different parts of the country. The results of this study indicate that in-service trainings decrease resistance to CBFM regime at the organizational level but increase resistance to CBFM regime at an individual level. The beneficial effects, at the organization level, of trainings are most likely due to the enhancement of community forestry skills of the foresters, while the negative effects, at the individual level, are likely due to exposure of trainees to underlying implications such as devolution of power, transparency of actions, and accountability of the members to communities, which contribute to fear on the part of participants. Hence, these factors need to be accounted for while designing in-service training programs, and only selected training institutions and trainers with excellent skills in designing and delivering optimal community participation programs should be entrusted to conduct CBFM related in-service training programs.

In CBFM regimes, local communities and FD are equal partners, and training the local communities is as important as training the foresters. Local communities need to be exposed to global forestry issues and basic forest management principles. These communities, once capable of managing forest resources in partnership with forestry agencies, are expected to show an increased interest in forestry activities. This, as shown in this study, will directly mitigate disapproval of the implementation of CBFM by FDs.

The resistance on the part of foresters to implementation of CBFM regime at an individual level ('*resistance-2*'), also requires the attention of policy makers, specifically due to a different primary causal factor - the '*fear*' of losing authority and control. Risk of failures aggravates this fear. Knowledge of cases of successful implementation of participatory approaches is the single most important factor to show a mitigating effect on this resistance. Awareness of the feasibility of CBFM regime and its impact on forest rehabilitation generates confidence among foresters. Success stories are most effective at demonstrating that the participation of the people is attainable and will have positive impact on forest resources. Hence, efforts should be made to disseminate success stories of CBFM systems at every level of hierarchy in the FDs. Experience of working in NGOs has been found to have a positive impact on acceptability of CBFM systems. Hence, foresters at all level should be encouraged to serve some part of their service career in NGOs.

In summary, the present status of CBFM regimes seems to be in a mode of co-optation of local communities into a state dominated forest management regime in which the state is trying to reduce its obligation towards forest management without concomitant transfer of decision making authority and equitable resource sharing arrangements. In Andelson's (2000) terminology, it is 'decentralization without empowerment'. In such a mode, communities may get some benefits which were not available in the strict state regime, but these are not realized through co-operative efforts as per the mandate of CBFM regime; and communities remain dependent on the state with the usual 'top-down' transfer of resources. Hence, appropriate interventions to reduce resistance on the part of foresters have to receive the priority attention from all involved – policy makers, NGOs, and representatives of the people.

Finally, these findings may be highly relevant to a number of other developing countries which have many features of forest management similar to those in India. Adoption of the CBFM paradigm, in most of these countries, has been accompanied by very few organizational reforms (Lindsay, 2000), and foresters in these countries may demonstrate similar patterns of resistance to CBFM regimes. Hence, forest policy makers, in these countries, should initiate similar studies and use the outcomes of these studies to plan and implement organizational reforms and other interventions to reduce resistance to CBFM regime.

Literature Cited:

Andelson, J. (2000). Four considerations for decentralized forest management: subsidiarity, empowerment, pluralism, and social capital. P 11-22 in T. Enters, B. Patrick, P.B. Durst, & M. Victor, (Eds.), Decentralization and Devolution of Forest Management in Asia and the Pacific.

Food and Agriculture Organization of the United Nations and RECOFTC, Bangkok.

Anderson, J., & Gerbing, D. (1988). Structural equation modeling in practice: A review and recommended two-step approach. Psychological Bulletin 103: 411-423.

Armenakis, A., G. Stanley, & W. Kevin (1993). Creating readiness for organizational change. Human Relations 46(6): 681-703.

Arnold, J.E.M. (1990). Social forestry and communal management in India. Social Forestry Network Paper llb, Overseas Development Institute, London.

Ascher, W. (1995). Communities and Sustainable Forestry in Developing Countries. ICS Press, San Francisco.

Baland, J.M., & J.P. Platteau (1996). Halting Degradation of Natural Resources: Is there a Role for Rural Communities? Clarendon Press, Oxford.

Baum, J.A. 1996. Organizational ecology. In S.R. Clegg, C. Hardy, & N.R. Walter (Eds.), Handbook of Organization Studies. Thousand Oaks: Sage Publications, London.

Blau, P., & W. Scott (1962). Formal Organizations: A Comparative Approach. Chandler Pub. Co., San Francisco.

Bollen, K.A., & J.S. Long (1992). Tests for structural equation models: Introduction. Sociological Methods and Research 21(2), 123-131.

Bromley, D.W. (1992). Making the Commons Work: Theory, Practice and Policy. ICS Press, San Francisco.

Browne, M.W., & R. Cudeck. (1993). Alternate ways of assessing model fit. In K.A. Bollen, & J.S. Long (Eds), Testing Structural Equation Models. Sage, Newbury Park, CA.

Chackerian, R., & G. Abcarian (1984). Bureaucratic Power in Society. Nelson-Hall, Chicago.

Chambers, R. (1994). Paradigm shifts and the practice of participatory research and development. Working Paper 2, Institute of Development Studies, University of Sussex.

DiMaggio, P.J., & W.W. Powell. 1983. The iron cage revisited: Institutional isomorphism and collective rationality in organizational fields. American Sociological Review 48: 147-160.

Downs, A. (1967). Inside Bureaucracy. Little Brown, Boston.

Durbrin, A., & R. Ireland (1993). Management and Organization. South-Western Publishing, Cincinneti, OH.

Hannan, M.T., & J.H. Freeman. 1984. Structural inertia and organizational change. American Sociological Review 49: 149-164.

Haque, S. (1997). Incongruity between bureaucracy and society in developing nations: A critique. Peace and Change 22(4), 432-462.

Hayduk, L.A. (1996). LISREL Issues, Debates, and Strategies. John Hopkins University Press, Baltimore.

Hinings, C.R., & R. Greenwood. 1988. The Dynamics of Strategic Change. Basil Blackwell, Oxford.

Hu, L., & P.M Bentler. 1999. Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. Structural Equation Modeling 6(1): 1-55

James, L.R., S.S. Mulaik, & J.M. Brett. 1982. Causal Analysis: Assumptions, Models, and Data. Sage, Beverly Hills, CA.

Jeffery, R., P. Khanna, & N. Sundar. 2001. Joint forest management: A silent revolution among forest staff. In B. Vira, & R. Jeffery (Ed.), Analytical Issues in Participatory Natural Resource Management. Palgrave, New York.

Joreskog, K., & D. Sorbom. 2002. Lisrel 8.52. Scientific Software International Inc.

Joreskog, K., & D. Sorbom. 1993. Lisrel 8: Structural Equation Modeling with the Simplis Command language. Lawrence Erlbaum Associates Publishers, Hillsdale, NJ.

Kant, S., N.M. Singh, K. Singh. 1991. Community Based Forest Management Systems: Case Studies from Orissa. Published by SIDA, ISO/Swedforest, and IIFM Bhopal.

Kaufman, H. 1971. The Limits of Organizational Change. The University of Alabama Press, Alabama.

Kazlow, C. 1977. Faculty receptivity to organizational change: A test of two explanations of resistance to innovation in higher education. Journal of Research and Development in Education 10(2): 87-98.

Lal, J.B. 1995. Community forest management in Southern Asia: A survival issue. P. 73-88 in O.T. Bouman (ed.) Sustainable forests: Global challenges and local solutions. Food Products Press, Binghamton, NY, USA.

Lawrence, P., & J. Lorsch. 1967. Organization and environment. Harvard University Press, Cambridge.

Mangioni, T.W., & R.R. Quin. 1975. Job satisfaction, counterproductive behavior and drug use at work. Journal of Applied Psychology 60: 114-116.

Mealiea, L. 1978. Learned behavior: The key to understanding and preventing employee resistance to change. Group and Organizational Studies 3(2): 211-223

Meyer, M., & L. Zucker. 1989. Permanently Failing Organizations. Sage, Newbury Park.

Miner, A.S., T.L. Amburgey, & T.M. Stearns. 1990. Interorganizational linkages and population dynamics: Buffering and transformational shields. Administrative Science Quarterly 35: 689-713.

Ostrom, E. 1990. Governing the Commons: The Evolution of Institutions for Collective Action. Cambridge University Press, Cambridge.

Peluso, N. 1992. Rich Forests, Poor People: Resource Control and Resistance in Java. University of California, Berkeley.

Pfeffer, J., & G.R. Salancik. 1977. The External Control of Organizations: A Resource Dependence Perspective. Harper and Row, New York.

Poffenberger, M., B. McGean, & A. Khare. 1996. Communities sustaining India's forests in the twenty-first century. In M. Poffenberger, & B. McGean (Eds.), Village Voices, Forest Choices: Joint Forest Management in India. Oxford University Press, New Delhi.

Presthus, R. 1962. The Organizational Society. Random House, New York.

Robinson, M. 1995. Towards a new paradigm of community development. Community Development Journal 30(1): 21-30.

Saxena, K. 1996. Re-engineering public administration in developing countries. Long Range Planning 29(5): 703-711.

Thompson, J.D. 1967. Organization in Action. McGraw Hill, New York.

Torenv lied, R., & G. Velner. 1998. Informal networks and resistance to organizational change: The introduction of quality standards in a Transport Company. Computational & Mathematical Organization Theory 4(2): 165-188.

Tushman, M. L., & E. Romanelli. 1985. Organizational evolution: A metamorphosis model of convergence and reorientation. In L.L. Cummings, & S.M. Barry (Eds.), Research in Organizational Behavior, 7: 171-222. JAI Press, Greenwich, CT.

Waddell, D., & A.S. Sohal. 1998. Resistance: A constructive tool for change management. Management Decision 36(8): 543-548.

Watson, G. 1969. Resistance to change. In W. Bennis (Ed.), The Planning of Change. Holt, Rinehart and Winston, New York.

Whetten, D.A. 1987. Organizational growth and decline processes. Annual Review of Sociology 13: 335-358.

Williams, E. 1969. Changing systems and behavior. Business Horizons 12, 53-58.
Young, M.A. 1991. An Inside Job. Clarendon Press, Oxford.

Socioeconomic factors influencing sustainable forest management stated preference and behavior in rural Nicaragua

Jensen Reitz Montambault[36] and Janaki R.R. Alavalapati[37]

Acknowledgements

Finding presented in this paper are part of a Master of Science thesis in interdisciplinary ecology at the School of Natural Resources and Environment. The primary author extends thanks to Janaki R.R. Alavalapati, chair, as well as Tom Ankerson (University of Florida College of Law) and Tom Hammett (Department of Wood Sciences, Virginia Polytechnic Institute and State University).

This research was made possible by the generous support of the Tropical Conservation and Development Program, Tinker Foundation and School of Natural Resources and Environment. The material is also based upon work supported under a National Science Foundation Graduate Research Fellowship. Any opinions, findings, conclusions or recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of the National Science Foundation, or other supporters.

[36] Graduate Student, School of Natural Resources and Environment, Institute of Food and Agricultural Sciences, University of Florida, P.O. Box 116455, Gainesville, FL 32611-6455, USA.

[37] Associate Professor, School of Forest Resources and Conservation, Institute of Food and Agricultural Sciences, University of Florida, P.O. Box 110410, Gainesville, FL 32611-0410, USA. janaki@ufl.edu (352) 846-0899 (v) (352) 846-1277 (fax).

Socioeconomic factors and policy implications influencing sustainable forest management preference and behavior in rural Nicaragua

Abstract

Forest policy throughout Latin America is undergoing a decentralization process in which more of the responsibilities for managing forest resources are delegated to municipal governments, often with mixed success (Larson, 2003). Considered critical for household needs and as biodiversity reserves, forest fragments on private lands comprise one-quarter of the forest resources in developing countries (Scherr et al., 2004). Household level attitudes and behaviors are, therefore, now more important than ever to the sustainability of these forest areas. This research uses a case study from Santo Tomás, Chontales, Nicaragua to examine the household socioeconomic factors most influential on stated preferences for forest management. Age and rural, as opposed to urban, locations proved to be the most significant factors in this study.

Key Words: Latin America; households; stated preference; private land; attitude

Socioeconomic factors and policy implications influencing sustainable forest management preference and behavior in rural Nicaragua

Introduction

Deforestation and forest degradation due to conversion of forest lands to cattle pasture are the leading cause of biodiversity (Brooks et al., 2002) and ecosystem function (Maass, 1995) loss in Central America and southern Mexico. Nicaragua's forests in particular suffered in the 1990s from the highest rate for deforestation in the region (Larson, 2003). Unlike other countries, such as Brazil, Bolivia and Guatemala where effective decentralization of forest regulation has made an adaptive management approach to government forest policy possible, Nicaragua's well-meaning sustainable management laws are impractical on-the-ground (Ferroukhi et al., 2003; McGinly and Finegan, 2003).

Importance of Forests in Nicaragua

Nicaragua's formal forestry sector, as it has developed since the latter part of the eighteenth century, has been dominated by foreign markets and investors (Ambrogi, 1996; Nuñéz Soto, 1996; Vilas, 1989). After the 1979 Sandinista revolution and ensuing 10-year civil war, lumber mills were made a target of armed conflict (Nietschmann, 1990) and cancellation of industrial forest concessions further weakened the industry (Hammett et al., 1999). Government sponsored settlement of vast expanses for state-owned forested land included marginalized people from Pacific regions in the late 1980's (Nygren, 2004a; Vilas, 1989) followed by a wave of citizens from a variety of backgrounds repatriated after the war (Ortega, 1991). Land tenure conflicts between these groups and pre-revolution cattle ranches ensued (Marin and Pauwels, 2001) and continue to this day. Since the early 1990's the Nicaraguan government has emphasized settlement and progress through agricultural production (Gibson, 1996).

Despite the lack of a developed formal forestry industry, the remaining forests and forest fragments play a critical role in the economy and ecology of the region. Throughout the tropics, natural forests continue to supply more products than plantations (Fredrickson and Putz, 2003). In Belize and Costa Rica, forest fragments have been shown to be effective refuges for dwindling biodiversity (Matlock et al., 2002; Pither and Kellman, 2002). In south-central Nicaragua, the management of non-timber forest products integrated with natural forests has been found to be a viable economic alternative to deforestation (Salick et al., 1995). While these contributions of forests are widely recognized, deforestation and forest degradation are still a serious problem in this area.

The municipality of Santo Tomás, located in the department of Chontales, south-central Nicaragua, for example, recently conducted a participatory rural appraisal that noted uncontrolled deforestation has led to increasingly widespread shortages of fuelwood and water on a household level (PEP, 2001). This case represents a microcosm of Nicaragua's deforestation problem, which is one of the most intense examples in the Central America (Romero and Reyes Flores, 2000). Largely caused by clearing of forest land for cattle ranching (Brooks et al., 2002; Bermúdez Rojas, 1996), this problem has been exacerbated by over 15 years of implementing a combination strict policies for environmental protection and aggressive development plans (Elizondo, 1997; Larson, 2003).

Perverse Effects of Policies

The Nicaraguan government's most recent forest laws (*Ley para el Desarrollo y Fomento del Sector Forestal*) give landowners the right to products and revenue derived from forests on their land provided that they comply with management plan regulations (Articles 23-25, Government of Nicaragua, 2000). This well-meaning language is intended to permit only ecologically sustainable harvesting of timber and non-timber forest products. As with similar laws in other Latin American countries, however, these regulations are too cumbersome to encourage the participation of individual small-landholders, and, compounded by the inefficiencies of under-funded, under-trained management agencies inadvertently encourage illegal forest exploitation (Pool et al., 2001). While some farmers may, out of personal altruism or other goals, elect to maintain untouched forest reserves at little but opportunity cost, the rational choice for many farmers in remote rural regions of Nicaragua is to risk a one-time fine for deforestation to use the land for agricultural production.

In an attempt to make these regulations more practical for compliance and enforcement, many countries in Latin America are experiencing decentralization in the forest sector. Of these, Nicaragua has been the least effective in transferring funds associated with management and enforcement from state to municipal governments (Larson, 2003), although the responsibilities for sustainable forest management have clearly been delegated (Articles 39 and 41, Government of Nicaragua, 2000). While larger-scale companies and private farms may circumvent these regulations all together through bribes and cronyism, when given the choice between illegal exploitation or demolition of forest resources and delicate, often expensive negotiations with potentially corrupt public officials, smaller-scale landowners will often opt for the former (Scherr et al., 2004).

The south-central region of Nicaragua has a strong tradition of cattle ranching (Guerrero and Soriano, 1992). In the Río San Juan department, for example, a household survey indicated that most landowners would respond to increased income by purchasing more cattle and clearing more forested land to accommodate their pasture (Faris, 1999). Institutions have typically portrayed the impoverished, often disenfranchised small-scale landholders on Nicaragua's agricultural frontier as ignorant enemies of the biodiversity and ecosystem services represented by forests, often to the point of excluding their views from policy studies (Nygren, 2004b). Complaints about Nicaragua's environmental and development policies have long asserted that policy failures are partly due to a lack of "on-the-ground" input in the same policy development.

Research Objectives and Rationale

Existing forest laws have failed to curb the high rate of deforestation and forest degradation in Nicaragua. The objective of this study is to investigate household-level preferences and behaviors with respect to sustainable forest management. Socioeconomic correlates to the stated preferences and behaviors in the municipality of Santo Tomás will highlight some of the strengths and weaknesses in the existing institutional arrangements in Santo Tomás. In addition, this information will provide a basis for practical policy making at the decentralized municipal level.

Several well-established theories support the importance of socioeconomic drivers to forest policy. For example, motivation changes as people vacillate on the scale of the ability to satisfy basic or subsistence needs and more amorphous needs such as serenity and self-actualization (Maslow, 1970), therefore access to income, household size, education and environmental training could be a factor in how households perceive forest policy. In addition, since sustainable management of forest resources on private lands is not currently customary in much of rural Nicaragua, it can be viewed as an innovation. The diffusion of innovations as discussed by Rogers (1995) is partially dependent on the interaction of people or groups who are essentially different in ways that include the above-mentioned factors and others such as gender, age and household location. This study will assist in understanding distinctions between groups that have and have not accepted sustainable forest management as an innovation.

Study Area

The municipality of Santo Tomás, in the department of Chontales, is located at approximately 84°50’ W and 11°58’ N and shares a border with the Southern Atlantic Autonomous Region (RAAS) within the Republic of Nicaragua. Once part of the largest tract of contiguous Neotropical forest north of the Amazon (Brooks et al., 2002), Santo Tomás is now comprised of 80% active an abandoned pasture (PEP, 2001) the majority of which is better suited to other vocations (see Figure 1), as is the case with half of Nicaragua’s ranch area (Alves Milho, 1996). The urban center is located 180 km east of the capital city of Managua on Rama Highway. The completion of this highway in 1966 opened access to forest resources and cattle products, accelerating the tendency toward forest fragmentation in the region (Ñurinda Ramírez, 2000).

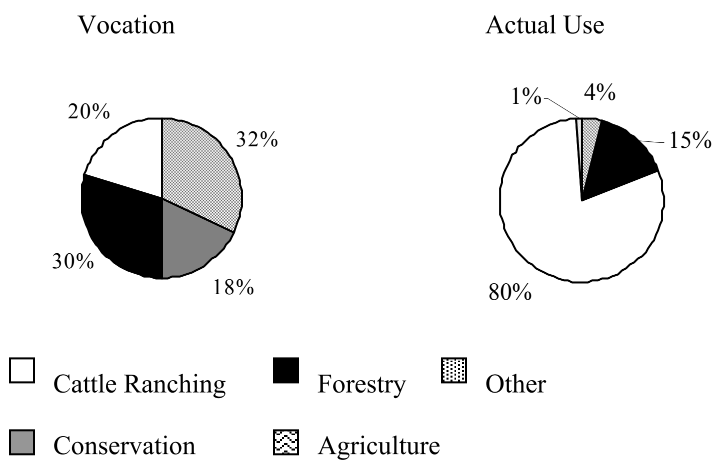


Figure 1. Vocation or appropriate land use as compared to actual land use in Santo Tomás, Chontales, Nicaragua.

Santo Tomás is part of a cultural and ecological transitional zone bridging the drier Pacific region populated almost entirely by *mestizos* or Spanish speakers of mixed and indigenous European descent and the moist lowland of the Atlantic region, home to three indigenous groups, English-speaking descendents of African slaves, the *Creoles*, and *mestizos*, considered to be colonists (Incer, 2000). The high altitude also contributes to three of the four ecological zones in Nicaragua converging in this area (Salas Estradas, 1993).

After the 1979 popular revolution that ended nearly 40 years of repressive dictatorship (Connell, 2001), Santo Tomás suffered from violence related to the civil war between the official government (*Sandinistas*) and armed guerrillas (*contras*). As occurred throughout rural Nicaragua, many farmers in Santo Tomás retreated to the relative safety of urban zones (Nietschmann, 1990) and have experienced land tenure conflicts in the recent years due to the repatriation of previous landowners and government settlement schemes for former combatants on both sides (Ortega, 1991). Because land under agricultural production in Nicaragua generally has greater tenure stability (Deininger and Chamorro, 2004), many households prefer to clear all land despite household, commercial and environmental benefits potentially derived from maintaining forested area.

A goal of the Nicaraguan government is to promote sustainable forest management (Articles 6 and 14.4, Government of Nicaragua, 2000), which is not, however, being achieved on the ground in places such as Santo Tomás (Elizondo, 1997; Faris, 1999; Larson, 2000; Nygren, 2004b). This study investigates the socioeconomic distinctions between groups of respondents professing different preferences and household behaviors related to sustainable forest management, which, according to Maslow's hierarchy of needs and the diffusion of innovations theory, are critical to achieving Nicaragua's stated goals.

Methods

This study uses the results from a survey questionnaire administered to 100 respondents in face-to-face interviews. The survey tool was developed based on concepts presented and field tested by other researchers inquiring about similar themes in Central America (e.g., Albertin, 2002; Harvey and Haber, 1999). Solicited information included socioeconomic details about the household and anecdotal information about the flora and fauna sighted on the property. Self-reported household behavior that might affect the environment such as throwing trash in the river and deforesting riparian zones was requested. Finally, the head of household was asked to rate a series of questions about sustainable management practices on a Likert-scale between strongly agree and strongly disagree or no opinion.

Respondents were stratified into 50% urban and 50% rural to facilitate comparison between these categories. The number of interviews per urban neighborhood (*barrio*) and rural district (*comarca*) were distributed according to population data supplied by the Santo Tomás delegation of the Ministry of Health (MINSA). Urban residents were selected randomly within each neighborhood using a property list from the mayor's office. Rural residents were selected from each district with the aid of key informants from the Santo Tomás delegation of the Ministry of Education, Sports and Culture (MEDC) as the almost entirely undocumented status of households these rural areas prohibited random sampling. Those involved were required to be adult heads-of-household[1]; participation was voluntary and responses kept confidential.

Data from this survey was coded following Fowler (2002) and entered into a MS Excel™ v. 2000 spreadsheet in which the student's t-test for comparing responses from urban and rural households was performed. Selected data was transferred to the statistical package SPSS™ v. 12

to conduct bivariate correlation comparisons. The results of these analyses are presented in the following section.

Results and Discussion

Rural vs. Urban Households

The results of the comparison between rural and urban respondents are presented in Table 4-1 and suggest several important distinctions between these groups. A much lower rate of women were interviewed in rural household reflecting not only the slight predominance of men in the rural population as a whole (PEP, 2001), but also the more conservative culture in rural areas where if both male and female heads of household were available, the wife usually deferred to the husband. Education levels of heads of household in rural respondents tended to be significantly lower than their urban counterparts, while more had received informal environmental education. The discrepancy of education levels is typical in Santo Tomás (PEP, 2001) and in developing countries overall (Handa, 2002). Most people (75%) had received environmental education via the radio, probably due to a nationwide outreach campaign launched by the Ministry of the Environment and Natural Resources (MARENA). Employment is significantly lower in the countryside and household size is higher, again following general statistics, but these results have potential implications for sustainable forest management.

Table 1. Data was sorted by rural (n=50) and urban (n=50) respondents and a student's t-test was used to determine whether the detected variation was significant. Numbers not followed by a percentage symbol are averages.

Socioeconomic Characteristic	Data Type	Rural	Urban	T-Test Probability	Significance
AGE [a]	continuous	42.34	39.92	0.45	
FEMALE [b]	dummy	48%	72%	0.02	**
EDUCAT [c]	continuous	3.38	6.14	0.00	**
ENVIEDU [d]	dummy	92%	72%	0.01	**
INCOME [e]	categorical	0.90	1.25	0.12	
EMPLOY [f]	dummy	28%	58%	0.00	**
TENURE [g]	dummy	84%	82%	0.79	
HHSIZE [h]	continuous	6.52	5.4	0.02	**
Index Value					
Household Behavior				0.55	
Management Preference				0.00	**

* Significant at $\alpha = 0.1$

** Significant at $\alpha = 0.05$

Note: [a] Respondent's age in years; [b] Respondent was female; [c] Years of formal education; [d] Received environmental education; [e] Total household income; [f] Household member with outside employment; [g] Household property neither borrowed or rented; [h] Household size.

The combination of lower education and higher unemployment means that rural people are more likely to seek self- and informal-employment in cattle ranching. Because fuelwood alternatives such as propane and electricity for cooking and other household chores are unavailable in the countryside, these larger families depend more heavily on forest resources for these good at the same time that they depend more heavily on dairy and beef production as a cash crop or informal labor. Without education and additional formal job prospects, the prospect for moving much beyond satisfying basic needs in Maslow's hierarchy of needs is fairly slim. Since decisions made on farms determine to what extent the agricultural system contributes to or mitigates losses of public goods such as biodiversity and ecosystem services (Gerowitt et al., 2003), it is important for policy makers in this area to carefully consider rural peoples' needs in order to accomplish stated policy objectives.

Stated Preference and Self-reported Behavior

Socioeconomic factors were compared to answers provided for stated sustainable management preference and self-reported household behavior questions. Answers to particular questions were also analyzed to see if there were associations. The results showed that those who responded favorably when asked if they approved of clearing currently forested lands for additional cattle pasture also more often preferred cutting timber for export and sale (as opposed to household use). This correlation suggests that there is a set of participants who strongly favor the exploitation of natural resources. Older respondents were significantly correlated with preferring continued conversion of forested land to cattle pasture.

Heads of household who stated a preference for harvesting fuelwood for household use tended to also approve of harvesting timber for household use. This group of participants varied significantly from the general population in a couple ways. They tended to be more rural and have received more environmental education, a strong correlation demonstrated in the previous section. While alternative fuel sources (propane and electricity) and timber substitutes (concrete and iron) are more readily available to urban households, their costs are still prohibitive to rural households, largely because of the cost of transportation from Managua, poor road infrastructure in rural areas and the ineffective local enforcement of timber laws.

Conclusions

This study found that older participants were more likely to state preferences for unsustainable forest management practices, including continued conversion of forest to cattle pasture. Larger rural households usually headed by people with less formal education, tended to favor policies permitting the continued exploitation of forested areas in Santo Tomás for timber and fuelwood for household use. These results are logical given the sociopolitical circumstances existing in this region. Older people were raised in a period of aggressive government settlement of forest areas to convert them to cattle pasture, while younger people received the benefit of an increasing global awareness of the importance of conservation. Rural people have fewer options than urban dwellers, both for wood energy and construction alternatives and for employment other than in cattle ranching.

These research findings suggest that increasing adult education may influence household perspectives and encourage sustainable forest management, as might increasing rural education.

In addition to limited access to alternatives, rural households also tend to be larger and are therefore likely to consume more energy. In this case, family planning might impact the rate of forest degradation for household use and this concept merits further investigation.

As discussed previously, current forest policy in Nicaragua requires management plans for legal exploitation of forest products, which even in a decentralized system are often too cumbersome or prone to corruption to be practical. The results of this study enforce the concept that there is a disconnect between primarily urban policy makers and the rural people who have the majority of the privately held forest resources on their land. Consensus building using a multiple stakeholder approach might address some of these issues at a municipal level, providing a model for better adapting forest management decentralization in Nicaragua.

Endnotes

1. The potential participant was asked whether s/he would be considered the head of household or primary decision-maker. This self-nominating process does leave room for error. Households in which females answered the survey are not necessarily households headed only by a female.

References

Albertin, A.R. 2002. Shade trees for coffee: Farmers' perspectives in the peninsula of Nicoya, Costa Rica M.Sc. thesis, Univ. of Florida, Gainesville, FL. 90 p.

Alves Milho, S.F. (ed.). 1996. Dinámica del sector forestal en Nicaragua 1960-1995: Lineamientos para un desarrollo sustentable. ESECA-UNAN and FARENA-UNA, Managua, Nicaragua. 212 p.

Ambrogi, R. 1996. Impacto de algunas políticas macroeconómicas y sectoriales sobre el sector forestal. P. 199-212 in Dinámica del sector forestal en Nicaragua 1960-1995: Lineamientos para un desarrollo sustentable, Alves Milho, S.F. (ed.). Managua: ESECA-UNAN and FARENA-UNA. 212 p.

Bermúdez Rojas, M.E. (ed.). 1996. Memoria del I congreso forestal de Nicaragua: El recurso forestal y el desarrollo económico. Asociación de Forestales de Nicaragua, Managua, Nicaragua. Unpaged.

Brooks, T.M., R.A. Mittermeier, C.G. Mittermeier, G.A.B. da Fonseca, A.B. Rylands, W.R. Konstant, P. Flick, J. Pilgrim, S. Oldfield, G. Magin, and C. Hilton Taylor. 2002. Habitat loss and extinction in the hotspots of biodiversity. Conservation Biology 16(4):909-923.

Connell, D. 2001. Rethinking revolution: New strategies for democracy and social justice. Red Sea Press, Lawrenceville, NJ. 332 p.

Deininger, K., and J.S. Chamorro. 2004. Investment and equity effects of land regularisation: The case of Nicaragua. Agricultural Economics 30(2):101-116.

Elizondo, D. 1997. The environment. P. 131-145 in Nicaragua Without Illusions: Regime Transition and Structural Adjustment, T.W. Walker (ed.). Scholarly Resources, Wilmington, DE. 332 p.

Faris, R. 1999. Deforestation and land use on the evolving frontier: An empirical assessment. Development Discussion Paper No. 678. Harvard Institute for International Development, Harvard University, Cambridge, MA. 30 p.

Ferroukhi, L., A. Larson, P. Pacheco. 2003. Introduction. P. 7-18 in Municipal Forest Management in Latin America, Ferroukhi, L. (ed). CIFOR, IDRC, Bogor, Indonesia.

Fowler, F.J. (2002). Survey Research Methods (3rd Ed.) Applied Social Research Methods Series Vol. 1. Sage Publications, Thousand Oaks, CA.

Fredericksen, T.S., and, Putz, F.E. 2003. Silvicultural intensification for tropical forest conservation. Biodiversity and Conservation 12(7):1445-1453.

Gerowitt, B., J. Isselstein, and R. Marggraf. 2003. Rewards for ecological goods: requirements and perspectives for agricultural land use. Agriculture, Ecosystems and Environment 98: 541–547.

Gibson, B. 1996. The environmental consequences of stagnation in Nicaragua. World Development 24(2):325-339.

Government of Nicaragua. 2000. Fomento del sector forestal. Asamblea Nacional de la Republica de Nicaragua, Managua, Nicaragua. 32 p.

Guerrero, J.N., and L. Soriano. 1992. Historia de la ganadería de Nicaragua. Editorial Union, Managua, Nicaragua. 175 p.

Hammett, A.L., J.K. McCrary, and G.P. Baur. 1999. Forest products in Nicaragua. Forest Products Journal 49(6):12-20.

Harvey, C.A., and W.A. Haber. 1999. Remnant trees and the conservation of biodiversity in Costa Rican pastures. Agroforestry Systems 44(1):37-68.

Handa, S. 2002. Raising primary school enrolment in developing countries: The relative importance of supply and demand. Journal of Development Economics 69:103– 128.

Incer, J. 2000. Geografía dinámica de Nicaragua. Editorial Hispamer, Managua. 281 p.

Larson, A.M. 2000. Recursos forestales y gobiernos municipales en Nicaragua: Hacia una gestión efectiva. Nitlapán, Universidad Centroamericana, Nicaragua. 174 p.

Larson, A.M. 2003. Municipal forest management in Nicaragua: Decentralized burdens, centralized benefits? P. 113-144 in Municipal Forest Management in Latin America, Ferroukhi, L. (ed.). CIFOR, IDRC, Bogor, Indonesia.

Maass, J.M. 1995. Conversion of tropical dry forest to pasture and agriculture. P. 399-422 in Seasonally Dry Tropical Forests, S.H. Bullock, H. A. Mooney, and E. Medina (eds.). Cambridge University Press, New York. 450 p.

Marin, Y., and S. Pauwels. 2001. El campesino-finquero Vol. 2: Hacia una modernización incluyente de la región central. Nitlapán, Universidad Centroamericana, Managua, Nicaragua. 188 p.

Maslow, A.H. 1970. Motivation and personality, 2nd ed. Harper and Row, New York. 369 p.

Matlock, R.B., D. Rogers, P.J. Edwards, and S.G. Martin. 2002. Avian communities in forest fragments and reforestation areas associated with banana plantations in Costa Rica. Agriculture, Ecosystems and Environment 91:199–215.

McGinly, K., and B. Finegan. 2003. The ecological sustainability of tropical forest management: Evaluation of the national forest management standards of Costa Rica and Nicaragua, with emphasis on the need for adaptive management. Forest Policy and Economics 5:421-431.

Nietschmann, B. 1990. Conservation by conflict in Nicaragua. Natural History 90(11):43-49.

Núñez-Soto, O (ed.). 1996. El sector forestal y la autogestión campesina de los bosques. Centro para la Investigación, la Promoción y el Desarrollo Rural y Social (CIPRES), Managua, Nicaragua. 95 p.

Ñurinda Ramírez, A. 2000. El puente sobre el río Siquia. November 20 Nuevo Darío, Managua, Nicaragua.

Nygren, A. 2004a. Competing claims on disputed lands: The complexity of resource tenure in the Nicaraguan interior. Latin American Research Review 39(1):123-153.

Nygren, A. 2004b. Contested land and incompatible images: The political ecology of struggles over resources in Nicaragua's Indio-Maiz reserve. Society and Natural Resources 17:189-205.

Ortega, M. 1991. Reintegration of Nicaraguan refugees and internally displaced persons. Hemispheric Migration Project, Center for Immigration Policy and Refugee Assistance, Georgetown University, Washington, DC. 41 p.

Pither, R., and M. Kellman. 2002. Tree species diversity in small, tropical riparian forest fragments in Belize, Central America. Biodiversity and Conservation 11:1623–1636.

Planificación Estratégica Participativa [PEP]. 2001. Planificación Estratégica Participativa – Santo Tomás. Proyecto de Fortalecimiento de la Autogestión del Desarrollo Social (FADES – INAFOM), Santo Tomás, Chontales. 213 p.

Pool, D.J., T.M. Catterson, V.A. Molinos, and A.C. Randal. 2001. Review of USAID's natural forest management programs in Latin America and the Caribbean. Contract PCE-I-00-96-00002-00. Document PN-ACR-740 available at www.usaid.org. United States Agency for International Development, Washington, DC. 117 p.

Rogers, E.M. 1995. Diffusion of innovations. 4th Ed. The Free Press, New York.

Romero, L., and F.G. Reyes Flores. 2000. Resúmenes de potencies. IV Congreso Forestal Centroamericano. Montelimar, Nicaragua. Unpaged.

Salas Estada, J.B. 1993. Árboles de Nicaragua. Instituto Nicaragüense de Recursos Naturales, Managua, Nicaragua. 388 p.

Salick, J., A. Mejia, and T. Anderson. 1995. Non-timber forest products integrated with natural forest management, Río San Juan, Nicaragua. Ecological Applications 5(4):878-895.

Scherr, S., A. White, D. Kaimowitz. 2004. A new agenda for forest conservation and poverty reduction, making markets work for low income producers. Forest Trends, CIFOR, IUCN, Washington, DC. 174 p.

Vilas, C.M. 1989. State, class, and ethnicity in Nicaragua: Capitalist modernization and revolutionary change on the Atlantic Coast. Lynne Rienner Publishers, Boulder, CO. 221 p.

Reducing Uncertainty in Forest Management through Improved Knowledge: Private vs. Public Incentives

G. Nilsson, Forest Analyst, The Forestry Corp., Suite 101, 11710 Kingsway Ave. Edmonton, Alberta, Canada T5G 0X5. gunnilla_nilsson@forcorp.com.

G. W. Armstrong, Assistant Professor, Department of Renewable Resources, 751 General Services Building, University of Alberta, Edmonton, Canada, T6G 2H1. glen.w.armstrong@ualberta.ca.

M.K. Luckert, Professor, Department of Rural Economy, 515 General Services Building, University of Alberta, Edmonton, Canada, T6G 2H1. marty.luckert@ualberta.ca. Fax 780-492-0268.

G. K. Hauer, Assistant Professor, Department of Rural Economy, 515 General Services Building, University of Alberta, Edmonton, Canada, T6G 2H1. grant.hauer@ualberta.ca.

M. J. Messmer, Forest Economist, 910 Parklands Drive, Victoria B.C. V9A 4L7. coyne_messmer@telus.net.

Acknowledgements
The authors gratefully acknowledge financial support from Weyerhaeuser Company Ltd., the Natural Sciences and Engineering Research Council of Canada, and the Sustainable Forest Management Network.

Draft May, 2004

Reducing Uncertainty in Forest Management through Improved Knowledge: Private vs. Public Incentives

Abstract

In much of Canada, and in many other jurisdictions worldwide, private companies manage public forestlands through forest management agreements or other forms of forest tenure. In this paper, we investigate the incentives this provides for private firms and public agencies to invest in reducing uncertainty. Using timber supply projection models, we simulate benefits received by industry and the government from reducing uncertainty in growth and yield estimates. The results show that governments, which are assumed to act on behalf of society, and private companies will derive different values from research on growth and yield, and therefore will have different incentives to invest in improved growth and yield estimates. These differing values are driven by: differences in private vs. public discount rates, levels of stumpage fees, tenure security, stringency of sustained yield constraints, whether yields decline rapidly after maturity (i.e. coniferous vs. deciduous species), initial stand structures (i.e. mature, juvenile, or even-age class distributions), and initial harvesting levels (i.e. over-cutting or under-cutting relative to a sustainable level). Optimal investments in research will depend on the eye of the beholder and on the institutional and natural environments within which decisions are made.

Key Words: Research, Funding, Investments, Policy

Introduction

In much of Canada, and in many other jurisdictions worldwide, private companies manage public forestlands through forest management agreements or other forms of forest tenure. As such, the ownership and management of public forests are frequently separate. This separation can lead to two distinct bodies of interest: the government, which is assumed to represent society, and private firms who pursue their own objectives. Ideally, private firms would behave so as to further the objectives of the government. However, private and public objectives may differ. These differences may cause the need for policies that attempt to align private and public objectives.

Past studies investigating separation of management and ownership on forestlands have assessed performance regarding investments and requirements for reforestation (e.g. Luckert, 1998; Pattison Perry *et al*., 1998). The objective of this paper is to examine the incentives for investments in forestry research when private firms manage public land, and to assess how these incentives are affected by institutional structures.

There are two related ways that benefits from forestry research are generally realized. Firstly, research can give rise to innovation resulting in new products or processes (Hyde *et al.*, 1989; Globerman *et al.*, 1999). Secondly, research can cultivate existing science by improving current knowledge or reducing uncertainty (Eid, 2000; Wang and Huang, 2000; van Kooten *et al.*, 1992). This study focuses on private vs. public incentives to invest in the second type of research; benefits derived from reducing uncertainty.

The three major sources of investment funding in forestry research in Canada are the provincial governments, the federal government, and the forest industry. Despite provincial and federal government statements in support of forestry research and development (R&D), expenditure on forestry R&D in Canada is "far less than socially optimal" (Binkley, 1995). The latest review of forestry research in Canada was undertaken by Binkley and Forgacs (1997), and indicated real expenditures on forestry R&D by all three sources is growing more slowly than in other industrial forest nations, including the United States and Sweden. Binkley (1995) cites the following reasons for Canada's relatively poor performance in the forestry R&D sector:

> (i) the specific problems associated with being a net exporter with a large share of many global markets, (ii) the small size of Canadian firms when compared with our global competitors, and (iii) Canada's collective failure to articulate a widely-accepted forest sector strategy which guides the daily policy and management decisions of governments, industry and interest groups.

The third point is a broad indictment that could be interpreted to result from current institutional structures that divide requirements, rights, and responsibilities among private firms and provincial and federal governments. In this paper, we specifically investigate the prospect that institutional structures that separate ownership and management of forest lands could create disincentives to invest in research to reduce uncertainty.

The framework for this analysis uses cost assessments of planning uncertainties to locate possible incentives to invest in research to reduce these uncertainties. Although the principles presented here apply to any forest resource, they are applied here in the context of timber supply. Using timber supply projection models, we simulate differing patterns of available timber supply over time, given current and potentially reduced levels of uncertainty in a planning parameter; for our case study, growth and yield estimates. The values of these timber supply streams are compared to investigate: 1) impacts of a number of factors, including aspects of institutional structures, on incentives to invest in reducing uncertainty and 2) differences in public and private incentives to invest in uncertainty reduction.

Methods

Model Framework

The framework uses timber supply projection models to conduct sensitivity analyses that compare the net present value (NPV) of timber supply streams over time given current and improved levels of precision in estimates of timber yield. The timber supply model maximizes NPV subject to even flow constraints of timber over a 200-year planning horizon.

The modeling procedure used here can be summarized as follows:

1) Because we do not know the "true" timber yields, three initial AACs are calculated based on yields at the mean, the upper limit, and the lower limit of a confidence interval. We assume that current knowledge is such that a 95% confidence interval around yield estimates coincides with limits of +/- 50% of the mean values. The three estimated AACs represent situations of unintentional overcut, the "correct" cut level, and unintentional undercut. We then conduct sensitivity analysis regarding these three starting conditions and a number of factors described below.

2) A company harvests the initial AAC level for 10 years. In the absence of research (i.e. the status quo scenario; "without research"), the company learns through experience and their existing levels of data collection. The confidence interval for yield estimates is assumed to be reduced to +/- 30% after 10 years of experience. In the presence of research (i.e. the enhanced data collection scenario; "with research"), the confidence interval is reduced to +/- 10% after 10 years of research.

3) To generate the associated yield curves for the scenarios with and without research, the mean yield curve is multiplied by a normally distributed random number reflecting the appropriate confidence interval. Using a Monte Carlo approach, 200 AACs are calculated for each state (i.e. with and without research), and for each of the initial AAC levels (i.e. over-, correct-, and under-cutting). The company harvests at one of the new AACs for the remaining 190 years and a corresponding NPV is calculated. Examples of initial cut levels, followed by the correction after 10 years, are illustrated in Fig. 1. The Monte Carlo-generated distribution around the over-cut level is illustrated in Fig 2.

4) We then investigate the impacts of a number of factors on NPVs of yield projections: three starting age class structures; two types of forest; two discount rates; and three sustained yield scenarios.

The true growth rate of the forest will not necessarily support the calculated harvest levels. This situation leads to the possibility of timber supply crashes in instances of over-cutting. The possibility of projected supply crashes is depicted in Figure 3. [i] A crash is deemed to occur when the forest inventory is reduced to a level below the AAC at some point in the planning horizon. [ii]

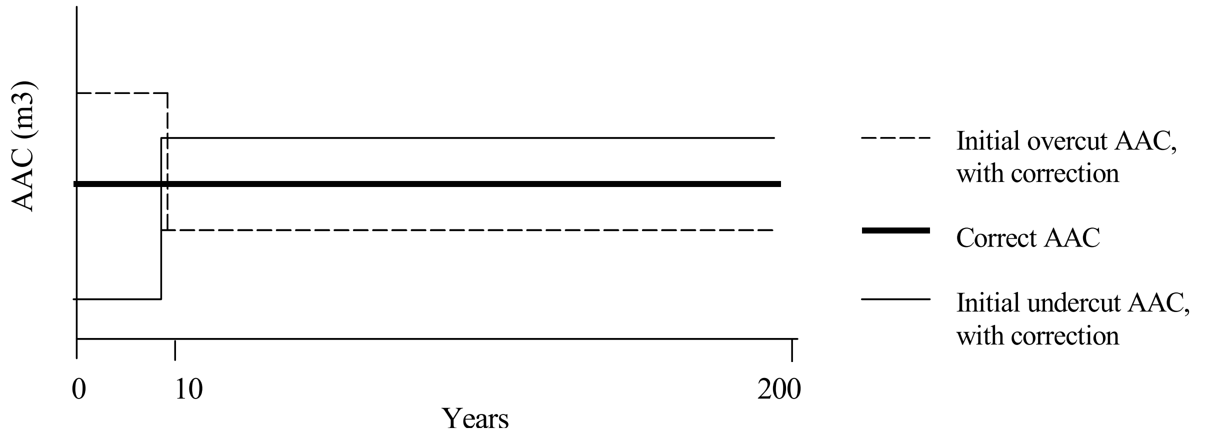


Figure 1. Three initial and subsequently corrected harvest levels.

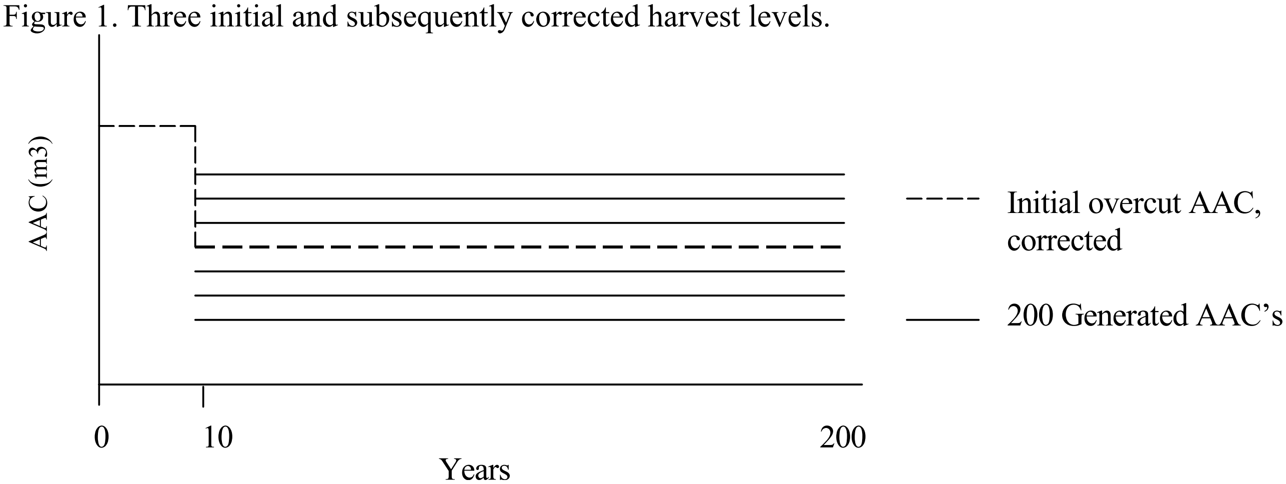


Figure 2. Distribution of erroneous AACs for years 11 through 200

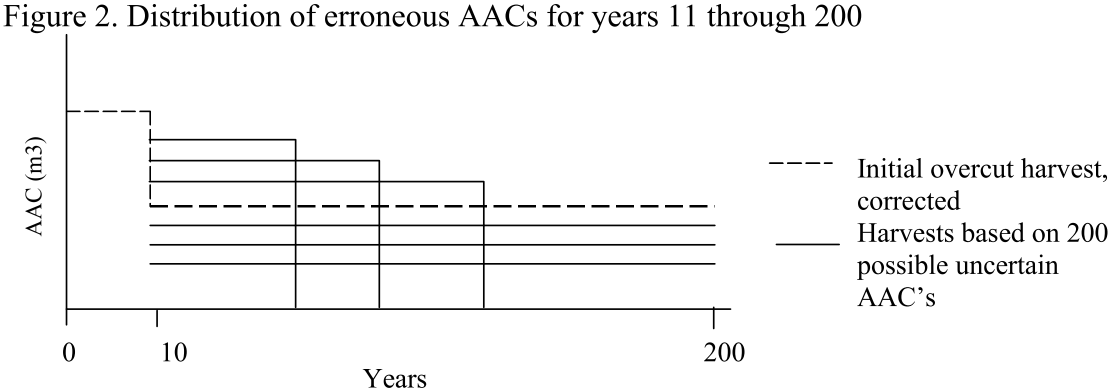


Figure 3. Distribution of harvest levels for years 11 through 200, including unsustainable harvest levels.

Model Specifications

The timber supply projection models are constructed using the Woodstock Forest Modeling System (version 2.5) (Remsoft Inc., 2001) and the linear programming solver XA (Sunset Software Technology). The models are run as Monte Carlo simulations from MATLAB (version 6.1) (The Mathworks Inc., 2001) using the MOSEK optimization toolbox (version 2) (EKA Consulting, 2001). All models have a planning horizon of 40, five-year periods, or 200 years; this is a common planning horizon for Alberta forest products companies (Schneider, 2001).

To begin, the timber supply model optimizes for a maximum NPV using the mean yield curve to calculate the "correct", 200-year AAC. This AAC is subsequently manipulated by plus and minus 50% to obtain the over- and under-cut AACs. [iii] Three sets of timber supply scenarios follow for each one of the three initial AACs. For each set of scenarios, the initial AAC is imposed in the timber supply model for a 10-year period, after which the model optimizes for a corrected AAC. Outside of the model, the corrected AAC number is manipulated 200 times within the bounds of each of the two smaller confidence intervals (i.e. +/- 30% without research, +/- 10% with research). This results in 200 uncertain AACs for the without research scenario, and 200 uncertain AACs for the with research scenario. For each of these 200 manipulations, the timber supply model is re-run with the uncertain harvest level imposed upon it. In instances where the mean yield curve cannot support the imposed harvest level, the model crashes (i.e., a timber supply crash).

There are two hypothetical forests modeled; one is deciduous and the other is conifer. The deciduous yield curve [iv] is subject to a linear decline in volume at age 125 years so that volume is zero by age 180 years (Fig. 4); the conifer yield curve [v] is non-declining (Fig. 5). Both forests are 516,990 hectares [vi] and consist of a single forest type. A clear-cut harvest regime is used with the assumption that the land regenerates naturally and without delay back to the original forest.

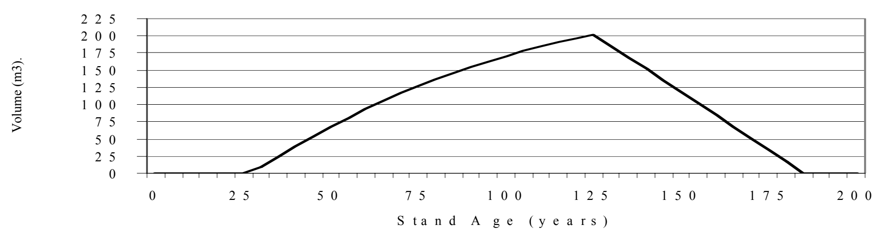


Figure 4. Deciduous yield curve.

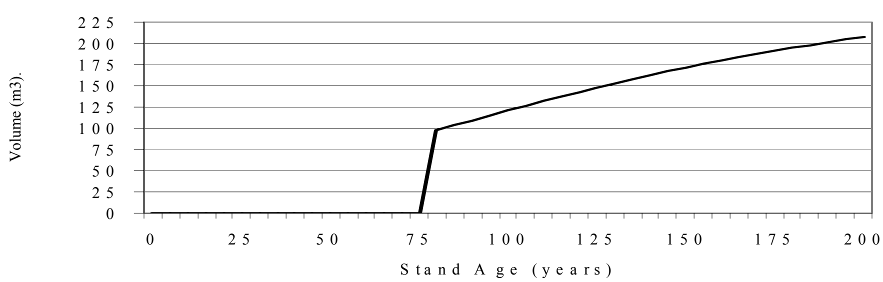


Figure 5. Coniferous yield curve.

Three different starting age-class structures are examined. The “juvenile” (Fig. 7) and “mature” (Fig. 8) distributions are contrived, each serving to demonstrate one of many possible mature and juvenile age-class distributions. A structure with an equal or “even” representation of age-classes across the land base (Fig. 6) is also modeled.

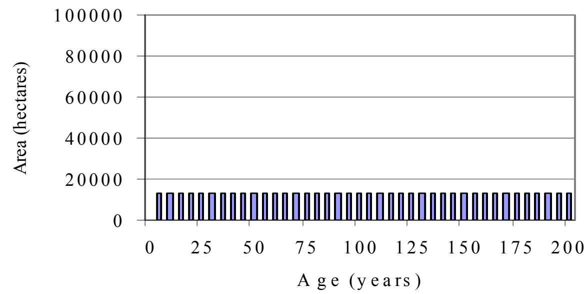


Figure 6. Even age-class distribution.

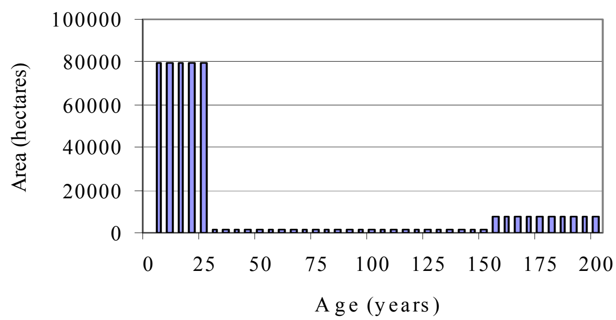


Figure 7. Juvenile age-class distribution.

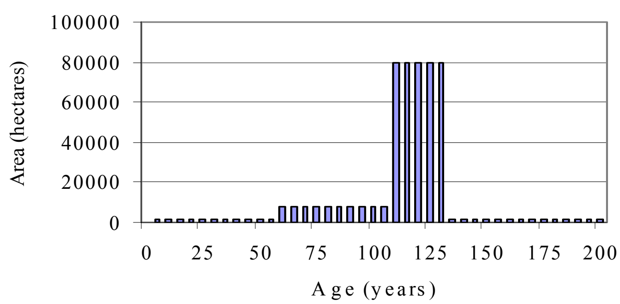


Figure 8. Mature age-class distribution.

Stumpage values of $\$5/m^3$ are used for the deciduous scenarios and $\$15/m^3$ for the conifer scenarios, following Hegan and Luckert (2000). These values represent uncaptured rent; that is, the net return to industry after harvesting costs and timber dues. We consider returns to the public, which includes amounts captured as rent, later in the paper. Interest rates of 0% and 6% are used to explore the differences between private and social perspectives. One perspective comes from the forest industry, which likely faces interest rates of at least 6%. The other is the government, who acts on behalf of society and typically has a discount rate less than industry (see e.g. Luckert and Adamowicz, 1993).

Finally, we examine how different sustained yield constraints affect incentives. These constraints may influence the value of timber supply patterns and the subsequent benefits from reducing uncertainty. Examining this influence may also provide insight into how priorities regarding information collection might change with variations in cut-control policy. This project looks at two of the policy scenarios used by Hegan and Luckert (2000) in their economic assessment of the allowable cut effect in Alberta. The first scenario models current flexibility around the sustainable AAC. Annual harvests are permitted to be within ±25% of the even-flow AAC, [vii] 5-year harvest totals must be within ±10% of the 5-year allowable cut, and 10-year harvest totals must coincide with the total 10-year allowable cut. The second scenario models twice flexibility by doubling the parameters from the current policy scenario and requiring convergence every twenty years.

Results

Within our modeling framework, erroneous yield curves lead to timber supply crashes that lead to losses in value. Research leads to fewer and/or postponed timber crashes which leads to higher values. Therefore, it is useful to begin by discussing the results of Tables 1 and 2, which disclose the frequency and timing of supply crashes without and with research. As discussed below, these crashes depend on the existing age-class structures, interest rates, sustained yield constraints, and whether the yield table is declining or non-declining (i.e. deciduous or coniferous, respectively).

Table 1 shows that the more flexibility allowed in sustained yield constraints, the fewer timber supply crashes occur. Under strict even flow constraints the highest numbers of crashes occur. Without harvesting flexibility, reduced uncertainty cannot affect these numbers. However, as sustained yield constraints are relaxed harvesting may be adjusted to avoid crashes and increased information has the opportunity to reduce crashes further. These patterns start showing up for the deciduous forest in the current flexibility scenario, but only become pronounced in the twice flexibility scenario. Reductions in crashes for the coniferous forest also show up in the twice flexibility scenario. The most pronounced effect of research in the twice flexibility scenario occurs for deciduous volumes in mature forests, where flexibility permits mature and over-mature stands to be harvested before stand break-up, thus avoiding a large number of supply crashes. For coniferous volumes, the most pronounced effect of research also occurs in the twice flexibility scenario with mature forests when under-cutting occurs. Under these conditions, large numbers of supply crashes can also be avoided. Initial cutting levels do not generally make much of a difference to the numbers of crashes, primarily because corrections after 10 years tend to align the harvest levels relative to the first 10 years.

Contrary to patterns in Table 1, in Table 2, returns to research, in the form of delayed crashes, occur across all sustained yield constraint levels with little variation. However, there is considerable variation depending on the age class distribution, species, and the initial harvest scenario. Supply crashes are generally later in forests with more mature trees, coniferous species and harvest scenarios that start with lower cuts. Changes in delays of crashes due to increased research are somewhat constant across initial harvest scenario and across sustained yield scenarios but vary depending on species and age class distribution. With increased information, coniferous forests generally have much larger delays in crashes than deciduous forests. For both species, increased information has the lowest effects in delaying crashes in juvenile forests. However, for even and mature forests, results differ depending on species. For coniferous forests, the delay in timber supply crashes with increased information is similar between even and mature forests, while the delay for deciduous species is less in mature forests than in even forests.

Table 1. Number of scenarios with a projected timber supply crash out of 200 scenarios, without/with research.

Forest Type	Initial Harvest Scenario	Even-flow		Current Flexibility		Twice Flexibility	
		Deciduous	Conifer	Deciduous	Conifer	Deciduous	Conifer
Even	Over-cut	92 / 92	92 / 92	92 / 91	92 / 92	82 / 63	89 / 81
	Middle	92 / 92	92 / 92	92 / 91	92 / 92	81 / 60	88 / 81
	Under-cut	92 / 92	92 / 92	92 / 90	92 / 92	81 / 60	88 / 80
Juvenile	Over-cut	92 / 92	92 / 92	88 / 81	89 / 89	82 / 63	85 / 70
	Middle	92 / 92	92 / 92	88 / 79	89 / 89	81 / 60	85 / 71
	Under-cut	92 / 92	92 / 92	88 / 77	89 / 89	81 / 60	85 / 71
Mature	Over-cut	92 / 92	92 / 92	91 / 85	92 / 92	62 / 23	88 / 81
	Middle	92 / 92	92 / 92	91 / 85	92 / 92	60 / 21	88 / 79
	Under-cut	92 / 92	92 / 92	91 / 85	92 / 92	83 / 65	75 / 41

Table 2. Average year of projected timber supply crash along 200-year timeline without/with research.

Forest Type	Initial Harvest Scenario	Even-flow		Current Flexibility		Twice Flexibility	
		Deciduous	Conifer	Deciduous	Conifer	Deciduous	Conifer
Even	Over-cut	57 / 68	117 / 156	57 / 68	119 / 157	57 / 67	118 / 156
	Middle	58 / 69	121 / 158	59 / 69	122 / 160	59 / 68	123 / 159
	Under-cut	59 / 69	124 / 160	59 / 69	125 / 162	60 / 69	126 / 161
Juvenile	Over-cut	42 / 48	44 / 49	42 / 48	44 / 49	43 / 47	45 / 49
	Middle	42 / 48	44 / 49	43 / 48	44 / 49	44 / 48	45 / 49
	Under-cut	43 / 48	44 / 49	43 / 48	44 / 49	44 / 48	45 / 49
Mature	Over-cut	71 / 75	123 / 161	71 / 75	124 / 162	71 / 75	123 / 161
	Middle	71 / 75	126 / 163	72 / 75	128 / 162	71 / 75	127 / 163
	Under-cut	74 / 79	150 / 185	74 / 79	149 / 184	76 / 82	136 / 170

The results of Tables 1 and 2 combine to influence the average NPV values in Tables 3 and 4 that are calculated, respectively, with 0% and 6% interest rates. Impacts of research on the mean NPVs of timber supply streams in the scenarios are derived by subtracting values of timber streams with research from values of timber streams without research. Many of the differences in results between scenarios may be explained by differences in the timing and frequency of timber supply crashes. The positive values arise from postponed crashes across all Sustained Yield scenarios and because of reduced numbers of crashes, primarily in the twice flexibility scenario. Following results in Table 1, initial cutting levels do not make much of a difference to returns to research, primarily because corrections after 10 years tend to align the harvest levels relative to the first 10 years.

Table 3. Impacts of research on mean NPVs (in millions of dollars) of timber supply streams for deciduous and conifer scenarios under three sustained yield constraints and a 0% interest rate.

Age-class Distribution	Initial Harvest Scenario	Evenflow		Current Flexibility		Twice Flexibility	
		Deciduous	Coniferous	Deciduous	Coniferous	Deciduous	Coniferous
Even	Overcut	$79.4	$352.0	$81.9	$350.0	$124.0	$360.0
	Middle	$82.7	$347.0	$84.8	$352.0	$136.0	$354.0
	Undercut	$84.9	$342.0	$89.8	$345.0	$142.0	$350.0
Juvenile	Overcut	$12.1	$91.8	$15.6	$123.0	$20.8	$139.0
	Middle	$12.8	$104.0	$17.5	$140.0	$23.6	$159.0
	Undercut	$13.3	$109.0	$19.4	$146.0	$24.9	$175.0
Mature	Overcut	$43.6	$359.0	$54.2	$360.0	$117.0	$362.0
	Middle	$43.9	$356.0	$54.8	$355.0	$119.0	$360.0
	Undercut	$43.9	$306.0	$53.6	$310.0	$78.5	$349.0

Table 4. Impacts of research on mean NPVs (in millions of dollars) of timber supply streams for deciduous and conifer scenarios under three sustained yield constraints and a 6% interest rate.

Age-class Distribution	Initial Harvest Scenario	Evenflow		Current Flexibility		Twice Flexibility	
		Deciduous	Coniferous	Deciduous	Coniferous	Deciduous	Coniferous
Even	Overcut	$1.8	$2.7	$1.8	$2.7	$1.9	$2.9
	Middle	$1.8	$2.6	$1.8	$2.6	$1.8	$2.8
	Undercut	$1.8	$2.5	$1.8	$2.5	$1.8	$2.7
Juvenile	Overcut	$0.4	$2.4	$0.4	$2.6	$0.4	$2.4
	Middle	$0.4	$2.8	$0.4	$2.9	$0.4	$2.8
	Undercut	$0.4	$2.9	$0.4	$3.0	$0.4	$3.0
Mature	Overcut	$0.7	$2.7	$0.7	$2.7	$0.8	$2.9
	Middle	$0.7	$2.6	$0.7	$2.6	$0.8	$2.8
	Undercut	$0.6	$2.2	$0.7	$2.2	$0.7	$2.6

In Table 3 it is evident that reducing uncertainty in conifer yields results in much higher returns than reducing uncertainty in deciduous yields. This difference is largely caused by stumpage values, which are three times higher for coniferous species, but also because of the much longer delays in timber crashes, relative to deciduous crashes, which result from improving data on coniferous yields. However, in Table 4, a large portion of these differences between species disappear as benefits from delaying supply crashes far into the future are largely discounted away. A positive discount rate in Table 4 also causes large reductions in the returns to reducing uncertainty across all scenarios.

Despite the fact that all of the mean values in Tables 3 and 4 are positive, there are some individual projections that could lead to negative returns from reducing uncertainty. In order to investigate this possibility, Tables 5 and 6 show, respectively, the probabilities of increases in NPVs for 0% and 6% interest rates. Over all cases, the probability that NPV will increase as a result of research is greater than 50%. With a 0% interest rate, the probabilities are much lower for deciduous species than for coniferous species. With no cost of time, the large returns to increased information for coniferous forests count heavily. Coniferous species have particularly high probabilities for even and mature age class distributions, where increased information delays crashes. However, at 6% interest rates, the probabilities for coniferous and deciduous species are much more similar, with deciduous probabilities frequently higher than coniferous. In particular, deciduous and coniferous species in juvenile age classes tend to have large probabilities of being positive as increased information postpones and reduces more immediate timber supply problems.

Table 5. Probability of an increase in NPV for deciduous and conifer scenarios under three sustained yield constraints and a 0% interest rate.

Forest Type	Initial Harvest Scenario	Even-flow		Current Flexibility		Twice Flexibility	
		Deciduous	Conifer	Deciduous	Conifer	Deciduous	Conifer
Even	Over-cut	0.535	0.905	0.540	0.890	0.680	0.890
	Middle	0.535	0.900	0.540	0.910	0.695	0.915
	Under-cut	0.535	0.915	0.540	0.930	0.695	0.925
Juvenile	Over-cut	0.535	0.535	0.590	0.590	0.680	0.645
	Middle	0.535	0.535	0.600	0.590	0.695	0.640
	Under-cut	0.535	0.535	0.610	0.590	0.695	0.640
Mature	Over-cut	0.535	0.935	0.570	0.930	0.880	0.930
	Middle	0.535	0.935	0.570	0.940	0.890	0.950
	Under-cut	0.535	0.955	0.570	0.950	0.670	0.955

Table 6. Probability of an increase in NPV for deciduous and conifer scenarios under three sustained yield constraints and a 6% interest rate.

Forest Type	Initial Harvest Scenario	Even-flow		Current Flexibility		Twice Flexibility	
		Deciduous	Conifer	Deciduous	Conifer	Deciduous	Conifer
Even	Over-cut	0.775	0.635	0.755	0.635	0.670	0.640
	Middle	0.765	0.630	0.740	0.625	0.625	0.635
	Under-cut	0.750	0.620	0.740	0.620	0.620	0.620
Juvenile	Over-cut	0.885	0.855	0.760	0.850	0.855	0.835
	Middle	0.870	0.855	0.760	0.850	0.835	0.835
	Under-cut	0.860	0.855	0.760	0.850	0.835	0.835
Mature	Over-cut	0.665	0.635	0.650	0.625	0.765	0.635
	Middle	0.665	0.620	0.650	0.620	0.635	0.620
	Under-cut	0.665	0.610	0.650	0.610	0.635	0.620

The previous discussion assesses a number of different factors that influence incentives to invest in research. However, these factors are not likely to be viewed the same by industry and government. As discussed above, industry is likely to have a higher rate of discount than government. Realizing this difference, a number of results become apparent. First, comparing the results between Tables 3 and 4 suggest that the incentives for industry to invest in research will be much lower than incentives for government. If we consider the returns to research must cover costs of research, then the benefits in Table 3, representative of a public perspective with a lower discount rate, will justify costs of many more research projects than will the benefits in Table 4, which may represent the industrial perspective. Similarly, while the government may view results in Table 3 as indicative that returns to coniferous research are large relative to deciduous research, results in Table 4, from an industrial perspective, suggest that these differences are not very great. Differences between government and industry returns in general, and incentives for governments to favor conifer, are greater as sustained yield constraints are relaxed.

Instead of considering average returns, the government and industry could consider probabilities of receiving a positive NPV from reducing uncertainty. Higher probabilities provide more projects that would have a chance of covering research costs. Table 5 indicates that when considering research to reduce uncertainty in deciduous forests, the probabilities for governments will be lower than they will be for considering coniferous research. Conversely, if Table 6 represents industry's perspective, then probabilities of positive NPVs from investments in research are generally higher for deciduous species than for coniferous.

Another difference between industry and government perspectives is that while governments may be concerned with the returns to society at large (i.e. the stumpage fees collected and the value of the timber to the industry), industry is only concerned with the value of the timber they receive. Until now, we have assumed that the value of the trees was the net value to industry (i.e. net of stumpage fees). However, if the stumpage fee values were considered in Tables 3 and 5 (representing the government perspective) then differences discussed previously would be even more marked. That is, the gap between private and public incentives is widened because stumpage fees cause tenure holders to capture only a portion of the benefits from reducing uncertainty (i.e. those benefits not collected with stumpage fees). [viii] If tenure insecurity further erodes expectations of future private benefit streams, the gap between private incentives and public interests may widen even further.

Summary and Conclusions

This paper investigates incentives for improving information for forest management under conditions where private companies manage public forestland. Timber supply projections are used to conduct sensitivity analyses and compare the values of timber supply streams over time according to current and improved growth and yield estimates.

Returns to research from reducing uncertainty may be influenced by many factors. There are physical factors, including differences in yield patterns of coniferous and deciduous species and age distributions defining the starting conditions of forests. Physical factors that define starting conditions of the forest also define the context within which choice variables, regarding policy and value factors, may be exercised. Policy and value factors include whether current harvests are over- or under-cutting relative to sustainable levels, the stringency of sustained yield constraints, the level of stumpage fees being collected, tenure security, and the discount rate that is chosen to calculate returns to research.

Some policy and value factors can cause private incentives for research investment to be less than social levels. Lower social than private discount rates could cause private levels of investment to be far less than would be undertaken if a social discount rate were used. This difference between private and public incentives is particularly large when considering coniferous and deciduous species. Coniferous species, with continued increases in yield over long periods, yield much higher returns at public levels of discounts rates than at higher private levels. The presence of stumpage fees and tenure insecurity also reduce private returns to reducing uncertainty, thereby widening the gap between private and social returns. These differences suggest that research spending by private industry will be less than is derived from a social perspective, and that public spending will likely have to fill the gap.

Some of the policy factors that influence returns to reducing uncertainty could be changed with new forest policies to increase private incentives to invest in research. For example, lowering stumpage fees, or increasing tenure security, would increase the benefit streams that tenure holders receive, thereby increasing incentives to invest in decreasing uncertainty. However, current countervailing duty negotiations regarding Canadian exports of lumber to the US seem to be creating increased tenure insecurity and the potential for increased stumpage fees. Accordingly, we are more likely to see private incentives to invest diminish, necessitating a larger role for public expenditures.

Another policy factor that we investigate, AAC constraints, has the potential to affect private and public incentives to invest in research. Increases in the flexibility of AAC constraints would make investments in reducing uncertainty more attractive to private firms and governments. [ix] The greatest impacts of these constraints occur in coniferous forests with older age classes where over-cutting has occurred. The importance of sustained yield constraints in influencing the returns to research implies that there is a dynamic shadow cost associated with operating under sustained yield constraints. [x] Other studies (e.g. Alavalapati and Luckert, 1997) have estimated static costs of sustained yield constraints. These are costs based on static knowledge. The costs illustrated in this study are dynamic since the sustained yield constraints influence investment in reducing uncertainty, which in turn influences timber supply streams in the future.

This paper has attempted to elucidate a potentially key reason why Canada, and by extension other countries with similar institutional structures, has lagged behind in forestry research. Results show that given the institutional structure in Canada, industries' incentives to invest in research are less than what the government would perceive them to be on behalf of society. In an era when Canadian governments have become increasingly reliant on industrial investment in research and development, the forest sector seems to be caught in an institutional structure that is not likely to facilitate this strategy. Government's response to such a situation need not be confined to increasing public funding for research. Alternative strategies include altering the policy environments that influence private incentives to invest in research, and to consider re-vamping current policies involving sustained yield constraints that reduce incentives for both industry and government to invest in research.

Endnotes

[1] In reality, it is unlikely that severe supply crashes (as depicted in Fig. 3) would actually occur, since forest practitioners would probably observe a discrepancy between growth rates and harvest levels long before there was a drastic drop in AAC. This is why we model some reduction of uncertainty occurring in the absence of research. Because of learning in the absence of research, we would likely see a multiple stair-step pattern with mini-supply crashes in the AAC over time. Nonetheless, modeling the AAC projections with sharper supply crashes allows us to see how various factors influence benefits from uncertainty reduction.

[1] Crashes are less apt to occur in scenarios where flexibility is allowed around the AAC. Fluctuating harvest levels can mitigate some of the effects of reduced inventory.

[1] Manipulating the AAC as such simulates the effect of using uncertain yield curve information.

[1] The deciduous yield curve represents stands in both upper and lower foothills natural subregion of Alberta with medium site class, C-density canopies and 10% conifer. This yield table has been selected because, according to temporary sample plot data, it represents some of the most commonly occurring deciduous sites on the Weyerhaeuser Edson W6 forest management unit.

[1] The coniferous yield curve represents stands in the lower foothills natural subregion of Alberta with medium site class, C-density canopies and 60% conifer. This yield table has been selected

because, according to temporary sample plot data, it represents some of the most commonly occurring conifer sites on the Weyerhaeuser Edson W6 forest management unit.

[1] This area was selected in order to investigate mill capacity issues not covered here (Nilsson 2003). By working backward from the capacity of the Weyerhaeuser Company Ltd. Edson oriented strand board (OSB) mill, the even-flow harvest from a mature, deciduous forest of 516,990 hectares generates a volume of wood roughly equal to the mill capacity: 600,000m^3/year.

[1] The annual flexibility constraints are implicitly assumed in our models since 5-year periods are used.

[1] Perry *et al.* (1998) provide a discussion of this issue in the context of regeneration commands and controls. We do not explicitly consider the effects of positive stumpage fees in this paper. However, since we use a 0% interest rate to model society's time preferences, positive stumpage fees would simply scale the social values upward, thus driving a larger wedge between the size of private and social benefits.

[1] van Kooten et al (1992) also found that flexible harvest policies are preferable in the face of uncertainty.

[1] Boyd and Hyde (1989) suggest two types of shadow costs associated with sustained yield. Static costs may refer to transaction costs that exceed the benefits of the regulation. Dynamic costs, on the other hand, include "the costs imposed by new regulations as they alter future expectations and the costs imposed by the general inflexibility of regulations once imposed".

Literature Cited

Alavalapati, J.R.R. and Luckert, M.K. 1997. Modeling the effect of institutional constraints on short-run timber supply on public land: A Case study of quota holders in Alberta. Natural Resource Modeling 10(4):263-282.

Binkley, C.S. 1995. Designing an effective forest sector research strategy for Canada. Forestry Chronicle 71 (5):589-595.

Binkley, C.S. and Forgacs, O.L. 1997. Status of Forest Sector Research and Development in Canada. <http://forcast.forest.ca/pdf/binkrp_e.pdf> Accessed 2003 Feb 10.

Boyd, R.G., Hyde, W.F. 1989. Forest Sector Intervention: The Impacts of Regulation on Social Welfare. Iowa State University Press, Ames. 295p.

Eid, T. 2000. Use of uncertain inventory data in forestry scenario models and consequential incorrect harvest decisions. Silva Fennica 34(2):89-100.

EKA Consulting ApS, 2001. The MOSEK optimization tools version 2.0 (Build 19). EKA Consulting ApS, Copenhagen, Denmark.

Globerman, S., Nakamura, M., Ruckman, K., Vertinsky, I., Williamson, T. 1999. Technological Progress and Competitiveness in the Canadian Forest Products Industry. Natural Resources Canada, Ottawa. 55p.

Hammitt, J.K., Shlyakhter, A.I. 1999. The Expected value of information and the probability of surprise. Risk Analysis 19(1):135-153.

Hegan, R.L., Luckert, M.K. 2000. An economic assessment of using the allowable cut effect for enhanced forest management policies: An Alberta case study. Canadian Journal of Forest Research 30(10):1591-1600.

Hyde, W.F., Newman, D.H., Seldon, B.J. 1989. The Benefits of Forestry Research. Forest Economics and Policy Analysis Research. Working Paper 134.

Luckert, M.K. 1998. Efficiency Implications of Silvicultural Expenditures From Separating Ownership and Management on Forest Lands. *Forest Science*. 44(3):365-378.

Luckert, M.K. and Adamowicz, W.. 1993. Empirical Measures of Factors Affecting Social Rates of Discount. Environmental and Resource Economics 3(1):1-22. Also appears in Forestry and the Environment: Economic Perspectives. Adamowicz, W.L., White, W. and Phillips, W.E., eds. pp. 262-281. Oxon: CAB International.

The Mathworks Inc., 2001. Matlab 6.1. The Mathworks Inc., Natick, Massachusetts.

Pattison, Perry, M., Luckert, M.K., White, W. and V Adamowicz. 1998. Combining Sharecropping and Command and Control Incentives in Principal Agent Analysis: A Forestry Example. *Journal of Forest Economics*. (4)3: 267-279.

Impact of U.S.-Canada Softwood Lumber Trade Dispute on Forest Products Companies: A Stock Market Perspective

Daowei Zhang and Anwar Hussain*
*Respectively, Professor and Research Associate, School of Forestry and Wildlife Sciences, Auburn University, Alabama 36849, USA.

INTRODUCTION

The softwood lumber trade dispute between the United States and Canada is the longest and largest trade dispute between the two countries. The modern version of the dispute started in 1982 when a group of U.S. lumber producers filed a complaint to the U.S. Department of Commerce, alleging that Canadian lumber producers which obtain most of their timber from Crown (public) lands are subsidized by provincial governments in Canada through low stumpage fees. The two countries have since experienced 5 rounds of trade dispute. The stake is high as U.S.$6 to 7 billion worth of Canadian softwood lumber goes to the U.S. annually. The current tariff revenue alone, imposed by the U.S. in May 2002 at 27.2 percent, is worth billions of dollar each year. Some insiders call the dispute a "softwood lumber war." How much do all of these companies gain or lose due to various trade actions? More importantly, who gains, and who loses? Finally, why do companies assume different positions in the trade dispute?

This study examines the stock price reactions, for both U.S. and Canadian softwood lumber producers, to a series of trade actions related to the dispute. While this study does not cover the economic welfare of consumers in either country, it provides a more direct measure of the economic impacts of trade actions on major lumber producers in both countries. The results explain the motivation of trade actions demanded and supported by U.S. companies and the responses of Canadian companies and may have implications on U.S.-Canada trade policy. This study covers the following major events: a) Canadian withdrawal from the MOU on September 4, 1991, b) Agreement-in-principle reached for the SLA on February 16, 1996, c) Expiration of the SLA on April 1, 2001, and d) Imposition of a 19.67 percent preliminary countervailing duty on Canadian lumber imports by U.S. Department of Commerce on August 10, 2001. The next section describes major events, followed by methodology, data, and results. The final section concludes.

METHODOLOGY

This study uses the event-study methodology to examine the reaction of investors to major news or events associated with the softwood lumber trade dispute. The CAPM specifies a linear relationship between the returns of an individual asset and the returns to a value-weighted portfolio of all assets:

(1) $$R_{it} = \alpha_i + ß_i R_{mt} + \mu_{it}$$

where R_{it} = the rate of return for stock i on day t;

R_{mt} = the rate of return on the market portfolio on day t;

α_i, $ß_i$ = regression parameters;

μ_{it} = a random disturbance term, assumed to be normally distributed as N(0,1), independent of the explanatory variable R_{mt}.

In its multiple regression analysis form, the methodology begins by parameterizing the abnormal return γ_i due to the event in an asset-pricing model using the dummy variable D_t that takes the value of 0 prior to the beginning of the event, and 1 afterwards:

(2) $$R_{it} = \alpha_i + \beta_i R_{mt} + \gamma_i D_t + \mu_{it}$$

where γ_i is a regression parameter for stock i. When the explanatory variables in the return-generating process are the same for each of the N firms, the multiple equations below can be estimated jointly as a seemingly unrelated regression equation (SURE) model (Zellner 1962; Theil 1971):

(3) $$\begin{aligned} R_{1t} &= \alpha_1 + \beta_1 R_{mt} + \gamma_1 D_t + \mu_{1t} \\ R_{2t} &= \alpha_2 + \beta_2 R_{mt} + \gamma_2 D_t + \mu_{2t} \\ &\;\;. \\ R_{Nt} &= \alpha_N + \beta_N R_{mt} + \gamma_N D_t + \mu_{Nt} \end{aligned}$$

This approach incorporates the cases where the contemporaneous $E(\mu_{it}, \mu_{jt})$ and non-contemporaneous $E(\mu_{it}, \mu_{j,t-k})$ covariance of the disturbances across equations are non-zero. Note that estimating (3) as a system gains no efficiency in either the coefficients or the residual variances, and produces estimates which are identical to those obtained from OLS estimation of the individual equations (Theil 1971, Chapter 7). The advantage of this approach over residual analysis comes in testing the joint hypotheses since the heteroscedasticity across equations and contemporaneous dependence of the disturbances are explicitly incorporated in the statistical tests (Binder 1985; Collins and Dent 1984). The null hypothesis of no contemporaneous correlation (H_0: $\sigma_{ij}=0$, for $i \neq j$) can be tested by the Breusch and Pagan test statistic (λ), given as:

$$\lambda = T\sum_{i=2}^{N} \sum_{j=1}^{N-1} r_{ij}^2$$

which is asymptotically distributed as chi-squared (χ^2) with N (N-1)/2 degrees of freedom, and r_{ij} is the correlation coefficient of residuals estimated by using the OLS. Given that the stock market data used in this study was time series, serial correlation across observations on each security might exist. We tested the null hypothesis of no autocorrelation, and in some cases, the null hypothesis was rejected. Therefore, we used a formulation of SURE allowing for autocorrelation of order one, $\mu_{it} = \rho_i \mu_{i,\,t-1} + \varepsilon_{it}$, where ρ_i is the autocorrelation coefficient.

Three null hypotheses are of interest. The first (H_1) is that the *sum* of the abnormal returns (*aggregate abnormal return*) across the N equations equals zero (i.e., $\sum\gamma_i = 0$). This test measures the impact on Canadian or U.S. forest products companies as a whole. The second (H_2) is that *some* of the abnormal returns equal zero (i.e., $\gamma_i = 0$, for some i), with the impact being systematically related to the characteristics of individual firms. Tests of H_2 are more informative than tests of H_1 if an event affects the sample firms but the effects differ in sign and magnitude. A rejection of H_2 would mean that shareholders of some Canadian and/or U.S. firms suffered or gained from the trade actions. The third hypothesis (H_3) is that the abnormal returns—whether significant or not—are equal across equations ($\gamma_i = \gamma_j$ for $i \neq j$). This hypothesis builds on the previous ones and relates to inter-company differential impacts. Its rejection would mean that abnormal returns are not uniform across firms.

DATA

The Canadian and U.S. forest products companies included in this study are listed in Table 1. These companies were selected because they are large softwood lumber producers in each country and their stocks are publicly traded. Collectively they accounted for 32 to 47 percent of softwood lumber production in each country in 1991, 1996, and 2001. To avoid double counting, forest products companies operating in both countries were assigned to one or the other country group based on the headquarter of the company. We could not, however, maintain the same number of companies in the analysis of all four events because of corporate merge and acquisition in the study period. Data for U.S. firms included in this study are from CSI (http://www.csi.com for stock prices) and EDGAR (http://www.sec.gov/edgar.shtlm, for no. of common stock shares outstanding). Data for Canadian firms are from the Toronto Stock Exchange (for stock prices) and SEDAR (http://www.sedar.com for no. of common stock shares outstanding). The S&P 500 index and TSE 300 index were used as market return index for U.S. and Canada firms, respectively. The estimation period and event window varies by country and event.

Table 1. Share of softwood lumber production/ capacity in each country

	1991*	1996*	2001[†]
Canadian firms	Share of Canadian softwood lumber production (%)		
Canfor Corporation	6.40	5.20	7.31
West Fraser Timber Co. Ltd.	4.98	5.08	5.66
Weldwood of Canada Ltd.	4.58		
Fletcher Challenge Canada Ltd.	4.00	0.82	
Macmillan Bloedel Ltd.	3.27	3.72	
International Forest Products Ltd.	3.15	2.71	2.36
Domtar Inc.	2.91	2.77	3.54
Slocan Forest Products Ltd.	2.84	4.31	4.01
Doman Industries Ltd.	2.56	2.11	3.07
Donohue Inc.	2.35	4.41	
Avenor Inc. (Can. Pacific For. Prod., Inc.)	1.83	0.96	
Crestbrook Forest Industries Ltd.	1.45	1.44	
Tembec Inc.	1.40	1.56	3.54
Riverside Forest Products Ltd.		1.81	1.77
Ainsworth Lumber Co. Ltd.		0.83	
Primex Forest Products Ltd.		0.75	0.71
Timberwest Forest Ltd.		1.05	
Accumulative share (%)	35.31	36.70	31.97
U.S. Firms	Share of U.S. softwood lumber production (%)		
Weyerhaeuser Co.	8.10	11.46	12.26
Georgia Pacific Corp.	7.32	7.50	6.28
Louisiana-Pacific Corp.	5.49	3.73	2.99
International Paper Co.	2.66	5.58	8.55
Champion International Corp.	2.47	4.22	
Boise Cascade Corp.	2.45	2.19	1.13
Simpson Timber Co.	1.73	2.79	1.75
Pope & Talbot Inc.	1.50	1.70	1.55
Temple-Inland Forest Products Corp.	1.48	1.90	1.65

Plum Creek Manufacturing	1.26	1.28	0.82
Union Camp Corp.	1.25	1.48	
Potlatch Corp.	0.99	1.33	1.55
Willamette Industries Inc.	0.95	1.67	1.96
Bowater Inc.	0.63	0.59	
Accumulative share (%)	38.28	47.42	40.49

*Based on softwood lumber production. Data source: Lumber & Panel North American Fact book 1992-1993, 1998 by Miller Freeman Inc., 600 Harrison Street, San Francisco, CA 94107.

† Based on softwood lumber production capacity. Data source: Paul Jannke, Resource Information Systems, Inc., 4 Alfred Circle, Bedford, MA 01730

EMPIRICAL RESULTS

Tables 2 to 5 presents the results based on joint estimation of parameter estimates of equation (3) using seemingly unrelated regression. For each SURE model corresponding to the 1991, 1996, and two 2001 events, the hypothesis of zero contemporaneous covariance was rejected according to the Breusch-Pagan test statistics, suggesting that SURE framework is appropriate. In addition, using SURE with AR(1) allowing for autocorrelation of order one resulted in improved estimates. Based on Wald test, H_1 was rejected in all 4 events in the case of Canada, suggesting that all these events had statistical significant aggregate impacts on Canadian firms as a whole. In the case of U.S., results were mixed; H_1 was rejected in the two 2001 events but not in other events. However, the hypothesis of no abnormal returns for some companies (H_2) was rejected for all events for both U.S. and Canadian forest products firm groups. Lastly, H_3 was rejected twice in the case of Canada (for the 1996 and August 10, 2001 events) and once in the case of U.S. (August 10, 2001), suggesting that impacts were not uniform in these events. Firm characteristics such as firm size and diversification may explain the difference in company-specific impacts.

Termination of the MOU: September 8, 1991: This is the only event to which the stock prices of both Canadian and U.S. firms reacted negatively (Table 2). The impacts were, however, broader for Canadian firms, and four of which—Canfor, West Fraser Timber, Weldwood, and Slocan—experienced significant negative abnormal returns.

An agreement-in-principle for SLA reached: February 16, 1996: Based on the results presented in Table 3, Canadian companies including Canfor, Donohue, Doman, and Ainsworth experienced a significant decline in stock prices over the event window. In contrast, four of the U.S. companies—Georgia Pacific, Champion International, Union Camp, and Willamette—were better off (Table 3). It seems that Canadians investors did not see the SLA and the 5-year peace brought by it as a positive event even though the SLA was the result of negotiations of all parties—governments of, and various forest products firms in, both countries.

Expiration of the SLA: April 1, 2001: The expiration of the SLA on April 1, 2001 was perceived as a positive event by Canadian investors in six companies—Canfor, West Fraser Timber, Slocan, International Forest Products, Domtar, and Tembec (Table 4). They had positive returns despite that the Coalition filed cases against Canadian lumber producers, demanding for a huge (as high as 78 percent) duty. Mirroring the opposite response, U.S. firms including Louisiana Pacific, Bowater and Simpson Timber had significant negative returns over the event window (Table 4). This suggests that Canadian investors probably thought that the chance of a preventative duty being eventually imposed was low.

Announcement for a 19.67% preliminary countervailing duty: August 10, 2001: Indeed, the U.S. Department of Commerce announced a countervailing duty of 19.67 percent, much lower than the 40 percent (only for the countervailing duty part) requested by the Coalition. Nonetheless, this event seemed to have surprised them as six Canadian companies—Canfor, Slocan, Doman, Riverside, Tembec, and Ainsworth—had negative abnormal returns over the event window (Table 5). As expected, the impacts were positive and broad based on the U.S. side. Only Pope and Talbot which had operations in Canada had negative abnormal returns.

Industry-wide impacts: After controlling for firm specific risk and movement in market index we estimated the impacts of these events on shareholders' wealth of individual companies and of the whole softwood lumber industry in both countries. The industry-wide impacts were calculated as the total impacts for all firms included in the study divided by their softwood lumber production/capacity share in each country. For the U.S. side, the industry-wide impacts were U.S.$-5.6 and 7.4 billion for the two 2001 events. These results are similar to Zhang (2001) who found that the SLA had brought the U.S. lumber producers $7.7 billions in the first four years. The industry-wide impacts for the U.S. were much smaller for the 1991 and 1996 events. On the other hand, industry-wide impacts were pretty even, ranged from CND$ -720 million to -1.2 billion in the three negative events and 1.2 billion in the first 2001 event (Table 6).

Table 2. SURE parameter estimates for the Sep 4, 1991 event (t-statistics in parentheses).

	α	β	γ
Canadian firms [Window: -1, +15]			
Canfor Corporation	0.0005 (0.37)	0.9196** (3.73)	-0.0079* (1.77)
West Fraser Timber	0.0007 (0.65)	0.1897 (0.86)	-0.0050† (1.39)
Weldwood of Canada Ltd.	-0.0010 (1.06)	0.3175 (1.46)	-0.0048† (1.38)
Donohue Inc.	0.0002 (0.18)	0.6607** (3.15)	-0.0031 (0.92)
Fletcher Challenge Canada Ltd.	0.0004 (0.32)	0.5910** (2.47)	-0.0027 (0.75)
Macmillan Bloedel	-0.0003 (0.30)	0.9595** (5.35)	-0.0014 (0.47)
Int'l Forest Products	0.0003 (0.20)	0.8264** (2.25)	-0.0040 (0.73)
Domtar Inc.	-0.0001 (0.13)	0.6546** (2.12)	-0.0090* (1.82)
Slocan Forest Products	0.0017 (0.83)	0.3154 (0.73)	-0.0072 (1.09)
Doman Industries Ltd.	0.0001 (0.08)	1.6331** (4.28)	-0.0040 (0.73)
Avenor	0.0005 (0.40)	0.4429* (1.84)	-0.0040 (1.02)
Crestbrook Forest Industries	-0.0008 (0.46)	1.4255** (3.70)	-0.0058 (1.01)
Tembec	-0.0001 (0.18)	0.3231* (1.88)	0.0008 (0.33)
No. of observation	167		
Wald Test (for H_1) (df=1)	7.64**		
Wald Test (for H_3) (df=12)	6.17		
Breusch-Pagan test (λ_{LM}) (df=78)	188.42		
U.S. Firms [Window: 0, +7]			

Weyerhaeuser Co.	-0.0002 (0.16)	1.1997** (8.74)	0.0057 (0.88)
Georgia Pacific	0.0014 (0.72)	1.0037** (6.35)	0.0012 (0.14)
Louisiana Pacific Corporation	0.0022 (1.12)	0.7839** (4.67)	-0.0054 (0.63)
International Paper	0.0004 (0.36)	0.9920** (9.42)	0.0024 (0.47)
Champion Int'l Corporation	-0.001 (0.69)	0.9896** (7.21)	-0.0029 (0.44)
Boise Cascades	-0.0004 (0.28)	0.8238** (6.04)	-0.0006 (0.11)
Pope and Talbot	-0.0005 (0.28)	0.5548** (3.32)	-0.0056 (0.71)
Temple Inland	0.0012 (0.95)	1.0908** (7.25)	-0.0005 (0.09)
Plum Creek Manufacturing	0.0055** (2.46)	0.6645** (2.68)	-0.0045 (0.44)
Union Camp Corporation	0.0002 (0.18)	1.0244** (9.24)	0.0016 (0.33)
Potlatch	0.0013 (0.73)	0.7085** (3.73)	-0.0027 (0.34)
Willamette Industries Inc.	0.0018 (1.17)	0.6669** (4.26)	-0.0116* (1.66)
Bowater	0.0004 (0.21)	0.9247** (5.84)	-0.0106† (1.31)
No. of observation	167		
Wald Test (for H_1) (df=1)	0.70		
Wald Test (for H_3) (df=12)	8.60		
Breusch-Pagan test (λ_{LM}) (df=78)	405.54		

** Significant at 5 percent; * Significant at 10 percent; † Significant at 20 percent. Estimation period: Feb 1, 1991- Sep 30, 1991.

Table 3. SURE parameter estimates for the Feb. 16, 1996 event (t-statistics in parentheses).

	α	β	γ
Canadian firms [Window: -1, +11			
Canfor Corporation	-0.0008 (0.78)	0.8454** (4.21)	-0.0146** (2.92)
West Fraser Timber	-0.0012 (0.54)	0.5098 (0.97)	-0.0054 (0.51)
Donohue Inc.	-0.0003 (0.28)	1.2065 (5.77)	-0.0070† (1.40)
Slocan Forest Products	-0.0001 (0.09)	0.0891 (0.73)	-0.0008 (0.28)
Macmillan Bloedel	-0.0010† (1.38)	1.5584** (12.01)	0.0023 (0.70)
Int'l Forest Products	-0.0001 (0.13)	0.8298** (4.58)	-0.0019 (0.41)
Domtar Inc.	-0.0016 (1.28)	2.0137** (8.50)	0.0006 (0.10)
Doman Industries Ltd.	-0.0009 (0.88)	1.0013** (4.46)	-0.0094** (1.91)
Riverside Forest Products	-0.0014 (1.31)	0.6000** (2.98)	0.0011 (0.22)
Tembec	-0.0022** (2.23)	1.1000** (5.70)	-0.0025 (0.54)
Crestbrook Forest Industries	-0.0026** (2.38)	1.1210* (5.18)	0.0012 (0.24)
Ainsworth Forest Products	-0.0010 (0.65)	0.5733* (1.72)	-0.0120* (1.65)
Primex Forest Products	-0.0006 (0.38)	0.1909 (0.62)	-0.0025 (0.36)
No. of observation	294		
Wald Test (for H_1) (df=1)	2.36†		
Wald Test (for H_3) (df=12)	18.03†		
Breusch-Pagan test (λ_{LM}) (df=78)	207.35		
U.S. Firms [Window: -1, +15]			
Weyerhaeuser Co.	-0.0006 (0.78)	1.1657** (8.17)	0.0032 (0.94)
Georgia Pacific	-0.0012 (1.22)	0.9983** (6.89)	0.0053† (1.29)

Louisiana Pacific Corporation	-0.0022* (1.78)	1.6465** (8.00)	0.0042 (0.81)
International Paper	-0.0006 (0.74)	0.8549** (6.44)	0.0027 (0.82)
Champion Int'l Corporation	-0.0008 (0.71)	0.8818** (4.87)	0.0063† (1.33)
Boise Cascades	-0.0001 (01.12)	1.2734** (6.50)	0.0052 (1.01)
Pope and Talbot	-0.0007 (0.71)	0.4744** (4.87)	0.0004 (0.11)
Temple Inland	-0.0010 (1.16)	0.9055** (7.23)	0.0036 (1.05)
Plum Creek Manufacturing	0.0006 (0.88)	0.6755** (5.39)	-0.0014 (0.49)
Union Camp Corporation	-0.0013* (1.65)	0.9270** (7.77)	0.0053* (1.70)
Potlatch	-0.0003 (0.57)	0.7596** (8.09)	0.0019 (0.88)
Willamette Industries Inc.	-0.0010 (0.87)	1.1808** (6.68)	0.0063† (1.30)
Bowater	-0.0001 (0.04)	0.9815** (4.75)	0.0034 (0.52)
No. of observation	294		
Wald Test (for H_1) (df=1)	1.56		
Wald Test (for H_3) (df=12)	5.16		
Breusch-Pagan test (λ_{LM}) (df=78)	327.88		

** Significant at 5 percent; * Significant at 10 percent; † Significant at 20 percent. Estimation period: Feb 1, 1995-Mar 29, 1996.

Table 4. SURE parameter estimates for the April 2, 2001 event (t-statistics in parentheses).

	α	β	γ
Canadian firms [Window: -2, +2]			
Canfor Corporation	0.0007 (0.40)	0.9821** (91.69)	0.0179* (1.67)
West Fraser Timber	0.0016 (0.80)	0.9741 (76.37)	0.0160**(2.04)
Slocan Forest Products	0.0031† (1.57)	0.9770** (80.68)	0.0230* (1.90)
Int'l Forest Products	0.0025† (1.38)	0.9793**(90.42)	0.0207* (1.91)
Domtar Inc.	0.0019 (1.18)	0.9853**(102.14)	0.0147† (1.52)
Doman Industries Ltd.	-0.0019 (0.38)	1.0155** (33.22)	-0.0155 (0.51)
Riverside Forest Products	-0.0012* (0.47)	0.9842 (65.84)	0.0158 (1.06)
Tembec	0.0005 (0.29)	0.9762** (88.16)	0.0238** (2.15)
Ainsworth Forest Products	-0.0010 (0.37)	0.9957** (59.40)	0.0043 (0.25)
Timberwest Forest Ltd.	0.0028** (2.52)	0.9975** (144.35)	0.0025 (0.36)
No. of observation	182		
Wald Test (for H_1) (df=1)	5.44**		
Wald Test (for H_3) (df=9)	7.46		
Breusch-Pagan test (λ_{LM}) (df=45)	132.34		
U.S. Firms [Window: -2, +2]			
Weyerhaeuser Co.	0.0013 (0.79)	0.6088**(4.82)	-0.0057 (0.56)
Georgia Pacific	0.0012 (0.43)	-0.1569 (1.03)	-0.0125 (0.93)
Louisiana Pacific Corporation	-0.0008 (0.30)	-0.3243* (1.66)	-0.0217† (1.31)
International Paper	-0.0002 (0.08)	-0.1823 (1.19)	-0.0042 (0.34)
Boise Cascades	0.0009 (0.48)	-0.1458 (1.06)	-0.0110 (0.93)
Pope and Talbot	-0.0016 (0.84)	0.8705** (6.41)	-0.0055 (0.49)
Temple Inland	0.0012 (0.83)	0.6582** (6.06)	-0.0034 (0.40)
Plum Creek Manufacturing	-0.0008 (0.54)	-0.1335 (1.25)	-0.0023 (0.37)

Potlatch	-0.0007 (0.60)	-0.1194† (1.31)	-0.0016 (0.19)
Bowater	-0.0001 (0.10)	-0.0871 (0.74)	-0.0152† (1.62)
Simpson Timber Co.	0.0002 (0.23)	-0.0388 (0.53)	-0.0081† (1.30)
No. of observation	177		
Wald Test (for H_1) (df=1)	2.23†		
Wald Test (for H_3) (df=10)	7.41		
Breusch-Pagan test (λ_{LM}) (df=55)	787.11		

** Significant at 5 percent; * Significant at 10 percent; † Significant at 20 percent. Estimation period: August 1, 2000-April 4, 2

Table 5. SURE parameter estimates for the August 10, 2001 event (t-statistics in parentheses).

	α	β	γ
Canadian firms [Window: -2, +1]			
Canfor Corporation	0.0018 (0.77)	0.1567 (0.50)	-0.0432** (3.72)
West Fraser Timber	0.0008 (0.40)	0.0437 (0.17)	-0.0050 (0.52)
Slocan Forest Products	-0.0006 (0.21)	0.6614* (1.86)	-0.0226† (1.58)
Int'l Forest Products	-0.0010 (0.34)	0.2487 (0.81)	-0.0129 (0.99)
Domtar Inc.	-0.0003 (0.15)	0.5896** (2.46)	0.0066 (0.68)
Doman Industries Ltd.	-0.0036 (0.63)	1.7766** (2.34)	0.0406† (1.45)
Riverside Forest Products	0.0005 (0.20)	0.273 (0.92)	-0.0233** (2.15)
Tembec	-0.0007 (0.26)	0.6089** (2.21)	-0.0165† (1.36)
Ainsworth Forest Products	0.0045 (1.15)	0.2119 (0.42)	-0.0341* (1.79)
No. of observation	91		
Wald Test (for H_1) (df=1)	4.17**		
Wald Test (for H_3) (df=8)	24.97**		
Breusch-Pagan test (λ_{LM}) (df=36)	55.25		
U.S. Firms [Window: -2, +2]			
Weyerhaeuser Co.	0.0014 (1.01)	0.8555** (6.70)	0.0021 (0.38)
Georgia Pacific	0.0022** (2.18)	0.7171** (6.04)	0.0070† (1.61)
Louisiana Pacific Corporation	-0.0022 (1.30)	0.7250** (3.96)	0.0200** (2.80)
International Paper	0.0016 (1.11)	0.8963** (6.31)	0.0037 (0.62)
Boise Cascades	0.0012 (1.04)	0.6070** (5.20)	0.0065† (1.41)
Pope and Talbot	0.0006 (0.28)	0.2474 (1.21)	-0.0136† (1.59)
Temple Inland	0.0024** (2.16)	0.8151** (6.85)	0.0041 (0.88)
Plum Creek Manufacturing	0.0018* (1.72)	0.4095** (3.56)	0.0115** (2.59)
Potlatch	0.0001 (0.06)	0.6515** (5.01)	0.0044 (0.90)
Bowater	0.0002 (0.14)	0.6791** (5.70)	0.0070† (1.38)
Simpson Timber Co.	0.0003 (0.14)	0.0241 (0.17)	0.0180** (2.16)
No. of observation	86		
Wald Test (for H_1) (df=1)	3.84**		
Wald Test (for H_3) (df=10)	14.60†		
Breusch-Pagan test (λ_{LM}) (df=55)	817.99		

** Significant at 5 percent; * Significant at 10 percent; † Significant at 20 percent. Estimation period: April 20, 2001-August 15,

Table 6. Impacts† of U.S.-Canada softwood lumber trade controversy (in US$1,000)

Canadian Firms	Sep. 4, 1991	Feb.16, 1996	Apr. 2, 2001	Aug. 10, 2001
Avenor	NSND	na	na	na
Ainsworth	na	-19,937	-584,763	-2,929
Crestbrook Forest Industries	-69,979	-15,146	Na	na
Canfor Corporation	-24,867	-147,319	74,970	-107,623
Doman	-2,019	-51,697	-3,256	703,200
Domtar, Inc	-105,127	14,472	27,329	-117,435
Donahue	-18,679	-65,125	na	na
Fletcher Challenge Canada	NSND	na	na	na
Int'l Forest Products	-17,944	-916	23,805	-9,716
Primex Forest Products	na	-908,160	na	na
Riverside Forest Products	na	-902	443,233	-20,490
Slocan Forest Products	-4,353	-21,431	38,824	-39,339
Tembec	3,930	-16,290	89,882	20,588
TimberWest	na	na	-2,813	NSPD
Weldwood of Canada	-52,919	na	na	na
West Fraser Timber	-123	27,649	129,031	51,936
Macmillan Bloedel	-137,532	-6,705	na	na
TOTAL	-429,615	-304,254	377,630	-224,304
Industry-wide impact	-1,216,696	-829,030	1,208,031	-717,544
U.S. Firms				
Weyerhaeuser	41,137	71,706	-1,538	602,281
Georgia Pacific	-3,895	363	-150,461	526,090
Louisiana Pacific	-44,111	7,023	-99,469	156,682
International Paper	-20,249	-253,376	-1,719,885	918,475
Champion International	-101	195,478	na	na
Boise Cascades	15,437	41,134	-12,780	113,236
Pope and Talbot	-2,584	-9,964	-6,831	-12,027
Temple Inland	6,551	58,680	-3,303	213,944
Plum Creek Manufacturing	-252	13,694	-36,716	360,566
Union Camp	43,155	89,456	na	na
Potlatch	-23,141	25,061	-56,354	44,035
Willamette	-55,520	199,043	na	na
Bowater	-6,435	46,981	-162,764	103,355
Simpson Timber Co.	na	na	-30,548	-14,016
TOTAL	-50,009	485,277	-2,280,650	3,012,621
Industry-wide impact	-130,640	1,023,359	-5,632,625	7,440,408

NSND: No number of common share data; na: Not applicable; NSPD: No share price data.

†Calculated as $n_i(P_i^1 - \hat{P}_i)$ where n_i is the number of common stock shares for firm i, $\hat{P}_i = P_i^0 \exp(\alpha_i + \beta_i \ln(INDEX^1/INDEX^0)$, where P_i^0 is a 10-day average share price, 10 days prior to the test window, P_i^1 and $INDEX^1$ are respectively ith stock price and market index (S&P 500 or TSE 300) on the last day of the test window (post event).

CONCLUSIONS

The findings of this study suggest that event specific impacts associated with the U.S-Canada softwood lumber trade dispute have been large enough to be noticeable in stock prices of forest products firms. In three events (1991, 1996, and August 2001), Canadian forest products firms as a whole were hit hard, but they had substantial gains when free trade returned. This may explain why some Canadian forest products firms—represented by the Free Trade Lumber Council—favor the litigation (to fight the U.S. case in WTO and NAFTA) route rather than negotiation.

Firm specific impacts vary among firms in both countries. Given the relatively higher reliance of Canadian forest products companies on the U.S. market, both medium and large Canadian firms were adversely impacted by restrictive trade actions. In the case of U.S., adverse impacts were confined only to the medium forest products companies while the positive impacts included large companies such as Georgia Pacific Corporation and International Paper (whose market capitalizations were more than U.S.$10 billion). This suggests that company size and possibly diversification might have helped large U.S. firms, but did not insulate large Canadian companies from specific events.

REFERENCES

Theil, H. 1971. *Principles of Econometrics.* NY: John Wiley and Sons.

Zellner, A. 1962. An Efficient method for Estimating Seemingly Unrelated Regressions and Tests for Aggregation Bias, Journal of the American Statistical Association 57:348-368.

Zhang, D. 2001. Welfare impacts of the 1996 United States-Canada softwood lumber (trade) Agreement. *Canadian Journal of Forestry Research* 31:1958-1967.

Estimating the Economic Impacts of Mountain Pine Beetle Disturbance Using a Regional CGE Model

Mike N. Patriquin[38] and William A. White[39]

Acknowledgements: This study was funded under the Morice and Lakes Innovative Forest Practice Agreement and the Government of Canada's six year $40 million Mountain Pine Beetle Initiative.

[38] Natural Resource Economist, Canadian Forest Service Northern Forestry Center, 5320-122 Street, Edmonton, AB, T6H 3S5. mpatriqu@nrcan.gc.ca. (780) 435-7371 (v); (780) 435-7359 (fax).
[39] Senior Economist, Canadian Forest Service Northern Forestry Center, 5320-122 Street, Edmonton, AB, T6H 3S5. bwhite@nrcan.gc.ca. (780) 435-7315 (v); (780) 435-7359 (fax).

Estimating the Economic Impacts of Mountain Pine Beetle Disturbance Using a Regional CGE Model

Abstract

A hybrid data collection method involving primary and secondary data is used to develop a regional computable general equilibrium model. The region-specific computable general equilibrium follows the Johansen solution technique and is used to simulate the potential economic impacts resulting from a Mountain Pine Beetle infestation in the Northern Interior Forest Region of British Columbia, Canada. Under Scenario 1 a 10% reduction of the timber supply in the Morice Timber Supply Area leads to decreased economic activity across all sectors of the economy and has serious implications for the future stability of the small timber dependent region. A 10% increase in visitor activity can partially, but not completely offset the negative impacts of a 10% decrease of the timber supply in the Morice TSA. Increasing agricultural exports by 10% benefits all sectors of the economy, but can only minimally offset any negative impacts associated with a 10% reduction of the timber supply in the Morice TSA. Scenario analysis using alternative mitigation strategies involving all sectors of the economy may help inform decisions regarding future regional development policies.

Keywords: computable general equilibrium, natural disturbance, modeling, tourism, economy-wide impact

Introduction

Mountain Pine Beetle (MPB) infestations are naturally occurring events in the forests of British Columbia. These infestations have been extensively studied since the first recorded outbreaks in the early 1900s. The current outbreak is the largest infestation in recorded history and will have significant impacts on the provincial economy. However, examining the impacts from a provincial accounting stance overlooks what are likely to be dramatic localized impacts on the socio-economic sustainability of natural resource dependent regions. MPB is expected to have dramatic and differential impacts on forestry dependent regions through changes in timber supply allocations. These impacts will not only affect forestry, but all other sectors directly and indirectly linked to forestry.

General equilibrium (GE) economic impact models are standard tools for assessing the economic impacts of proposed industrial projects, major tourist events, issues concerning international trade, and domestic government policy changes (Miller and Blair, 1985; Pyatt and Round, 1985). Every sector of an economy is linked to other sectors, whether directly through transactions (purchases and sales), or indirectly through competition for labor, capital, and land for use in the production process. GE models account for sector linkages and provide a more complete picture that an impact on one sector can have on other sectors and the overall economy of a region.

Region-specific data were collected through a hybrid approach involving both primary and secondary data collection. A region-specific computable general equilibrium (CGE) framework was used to estimate the economic impacts of the potential disruption that the MPB infestation will have on the timber supply in the Morice and Lakes Innovative Forest Practice Agreement (M-L IFPA) Region.

Methodology

A mixed-methods or hybrid data collection approach was adopted in order to overcome the limited availability of regional level data. The hybrid approach involves both primary and secondary data collection techniques. Secondary data exists in the form of a Statistics Canada custom census profile for the M-L IFPA (years 2001, 1996, and 1991), the British Columbia Input-Output Tables (1999), and previous economic development and industry reports. Primary industry data was collected through a survey of businesses in the M-L IFPA study area. Respondents were asked to provide information with respect to their personal employment history, business revenue and expenditures (including an estimate of activity from inside the region and from outside the region), business employment, and the business wage bill. The hybrid data (secondary and survey derived) were used to create a region-specific economic database for the study area.

This hybrid approach involves a series of steps starting with the provincial input-output tables (a set of three tables that detail the annual transactions in, and structure of, a market economy) as a base. The provincial input-output tables are then transformed into a social accounting matrix (SAM - a double entry, square accounting framework that ensures data consistency when using hybrid sources). The provincial database (SAM) is then mathematically regionalized using location quotients (the proportion of regional employment divided by the proportion of provincial employment for each sector). This step results in a preliminary region-specific SAM. Superior (primary) data is then inserted through a process of selective precision. Selective precision involves choosing the major sectors of interest and focusing primary data collection efforts. Data consistency is crosschecked with secondary sources throughout the above steps.

Two theoretical streams exist within the GE approach; fixed price approaches and flexible price approaches (Alavalapati et al., 1996; Alavalapati and Adamowicz, 1999). The difference between the two approaches relates to the specific assumptions inherent to each (Partridge and Rickman, 1998; Schreiner et al., 1999). Methods from both approaches are used in this study. Borrowed from the fixed price framework, a social accounting matrix (SAM - a hybrid regional economic database) constructed from a variety of data sources is used to provide baseline indicator levels and the base on which more flexible tools are constructed. A region-specific CGE model (a flexible price technique) of the M-L IFPA economy is used to simulate the potential impacts and future indicator levels of a variety of scenarios related to forest management. The CGE model framework described in this report was first developed for use in the Foothills Model Forest region in Alberta (Patriquin, 2000).

Although CGE models are fairly uncommon on a regional scale, there is general agreement that they do provide unique insights not available using the more widely applied fixed price techniques (Partridge and Rickman, 1998; Alavalapati et al., 1999). The CGE framework adopted for the M-L IFPA has a solid grounding on economic theory, but is still flexible enough for practical application (Patriquin et al., 2002; Patriquin et al., 2003).

The M-L IFPA CGE uses the Johansen solution technique and contains six sectors and three primary factors of production (land, labor, and capital) (Johansen, 1974). The six producing sectors include: agriculture, forestry, service, public, visitor (tourism), and a composite sector comprised of the 'rest of the economy'. Various assumptions are made with respect to the treatment of these variables in the model. The labor supply is assumed fixed (i.e., the migration of labor between the region and the rest of the world is not considered). The labor market is modeled under the Keynesian assumption of a rigid wage rate. Under this assumption, adjustments in the labor market occur from changes in employment levels. It is assumed that over the long run, unemployed individuals will migrate out of the region to find employment. The other two primary inputs, capital and land, are assumed to be sector specific.

The M-L IFPA Case Study Region

The M-L IFPA consists of a 2.6 million hectare area located within the Northern Interior Forest Region of British Columbia, Canada (M-L IFPA, 2003). The M-L IFPA region is comprised of distinct Timber Supply Areas (TSA) – the Morice TSA and the Lakes TSA. The overall region has an estimated 2001 population of 12,170 distributed among four small towns and the surrounding rural area. The largest communities by population size contained within the region are Houston, Burns Lake, Granisle, and Topley. Adjacent communities include Fraser Lake, Smithers, and Prince George. Figure 1 demonstrates the location of the M-L IFPA region (M-L IFPA, 2003).

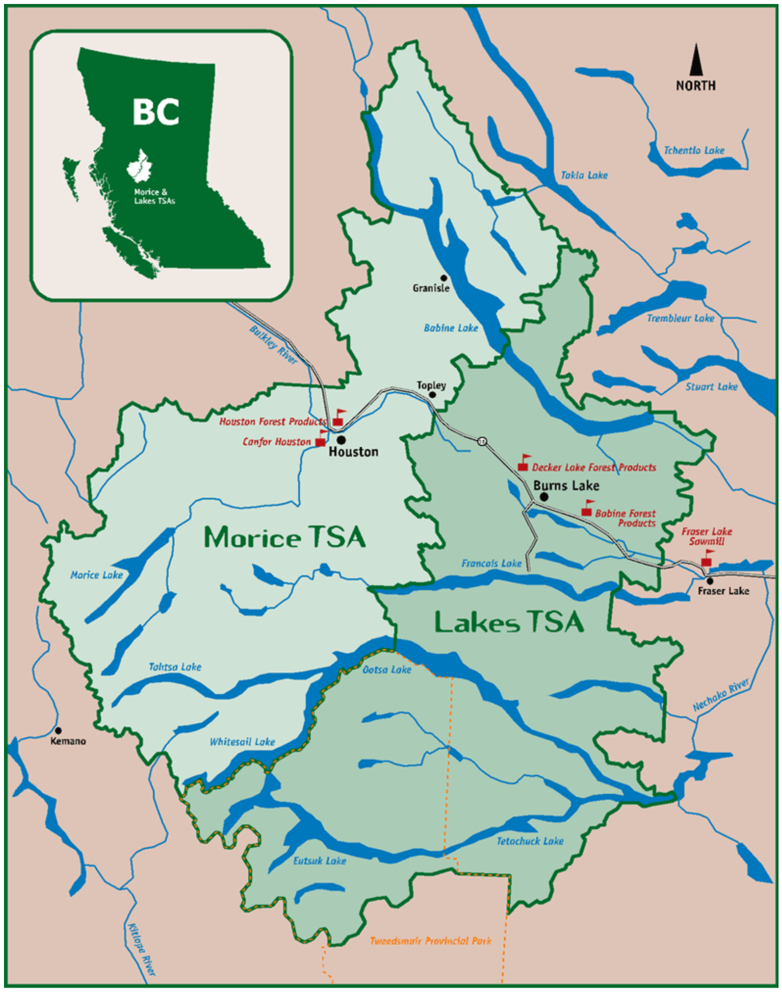


Figure 2: Map of the M-L IFPA

Economic Indicators

There are five categories of economic indicators for which baseline data has been collected and future levels will be simulated. Table 1 displays a general description of each indicator (Patriquin et al., 2004).

Table 1: Economic Indicators Selected for the M-L IFPA

	Indicator	Explanation
1	Revenue	Revenue represents the gross amount of economic activity (in dollars) that takes place in the region on an annual basis. Revenue is the product of quantity and price in an economic market (example, revenue is the total value of sales).
2	Net Regional Product (NRP)	Net regional product is the combination of all dollar payments for labor, capital, resource rents, and indirect taxes (example, net regional product is the amount of "value-added" activity). Unlike revenue, net regional product represents the value of goods and services produced in the region in a year.
3	Royalties & Indirect Taxes	Royalties are the dollar rents paid by firms to the government for use of publicly owned natural resources. Indirect taxes are any taxes other than income or corporate.
4	Labor Income	Labor income is the dollar amount paid by firms to employees (example, salaries, wages, etc.).
5	Employment	Employment is measured as the number of individuals with primary employment in an individual industry.

Simulation Scenarios and Results

Three scenarios were examined involving a change to the timber supply resulting from Mountain Pine Beetle damage in the Morice TSA, increased tourism in the overall M-L IFPA region, and an increase in agricultural exports from the overall region. The purpose of this scenario analysis is to provide an examination of the sensitivity of the economy to various changes in land using sectors. Table 2 provides a brief description of the scenarios that were simulated for the M-L IFPA. These scenarios are hypothetical and were selected in order to provide a preliminary sensitivity analysis.

Table 2: Description of M-L IFPA Scenarios

Scenario	Description
1	10% reduction in Morice timber supply (equivalent to 5.15% of the total M-L IFPA timber supply)
2	10% increase in M-L IFPA visitors
3	10% increase in M-L IFPA agriculture

Scenario Results

The following Tables summarize the simulated changes in the economic indicators for the respective scenarios. The scenario results are expressed in terms of the average annual indicator level after the shock and percent change from the baseline indicator level. Table 3 provides a snapshot of the percent change in each of the overall regional indicators.

Table 3: M-L IFPA Scenario Comparison

	Baseline Level	Scenario 1 -10% Timber Supply	Scenario 2 +10% Visitor Activity	Scenario 3 +10% Agricultural Exports
		% Change	% Change	% Change
Total Revenue ($ Millions)	1,069.3	-2.90	2.05	0.07
Total Net Regional Product ($ Millions)	403.6	-4.55	1.77	0.07
Total Royalties and Indirect Taxes ($ Millions)	105.5	-5.76	1.06	0.08
Total Labor Income ($ Millions)	231.7	-4.02	2.07	0.07
Total Employment	5,345	-2.76	3.27	0.19

Scenario 1

Scenario 1 represents a simulated ten percent reduction in the timber supply of the Morice TSA (equivalent to a 5.15% reduction in the total timber supply of the M-L IFPA region). The ten percent reduction would result in a new timber supply level of 1,782,834 cubic meters (down from 1,961,117 cubic meters) in the Morice TSA and a new timber supply level of 3,382,834 cubic meters (down from 3,461,117 cubic meters) in the overall IFPA region.

The results of Scenario 1 yield a percent reduction in each indicator. Total regional revenue decreases by 2.9% primarily due to a direct negative impact on the forestry sector and net regional product (NRP) is reduced by 4.55%. The ten percent reduction of the timber supply in the Morice TSA results in a 5.76% drop in the total royalties and indirect taxes paid. 4.02% of labor income is lost from the region and the ten percent reduction in the Morice TSA timber supply results in a simulated loss of 2.76% of primary employment positions from the M-L IFPA region.

Scenario 2

Scenario 2 simulates a ten percent increase in visitor sector activity in the M-L IFPA region. In this scenario there is no impact on timber supply. In other words, the total timber supply of the region remains constant at 3,461,117 cubic meters in the overall IFPA region. The strongest linkages of the visitor sector are with the domestic services sector and the rest of the economy (primarily retail).

The results of scenario 2 yield a positive percent change impact on each indicator. Total regional revenue increases by 2.05% and NRP increases by 1.77%. The ten percent increase in visitor activity results in a minimal 1.06% increase in the royalties and indirect taxes paid. Labor income is augmented by 2.07% and there is a simulated gain of 3.27% in the number of primary employment positions in the M-L IFPA region.

Scenario 3

Scenario 3 simulates a ten percent increase in agricultural exports from the M-L IFPA region. Similar to scenario 2, there is no impact on timber supply considered in this scenario. In other words, the total timber supply of the region remains constant at 3,461,117 cubic meters in the overall IFPA region. Visitor sector activity is also held constant at the baseline level. The strongest linkages of the agricultural sector are with the rest of the economy (primarily retail) and to some extent forestry. The agriculture sector also has a weak positive relationship with forestry, agriculture, and the public sector. However, the agricultural linkages are weak overall.

A ten percent increase in agricultural exports yields a simulated 0.07% increase in the overall economy-wide revenue. The increase in agricultural exports also results in an overall increase of 0.07% in NRP and $0.08% in the royalties and indirect taxes paid. The increase in agricultural exports results in a $0.07% increase in labor income primarily derived indirectly through the retail sector. The increase in exports also leads to an increase of 0.19% in the number of primary jobs in the M-L IFPA region.

Discussion

Combining the scenarios reveals that strategies to increase visitor activity in the region by 10% would partially offset (to varying extents) the negative impacts associated with a 10% reduction in the timber supply of the Morice TSA in terms of revenue, NRP, royalties and indirect taxes, and labor income. In terms of the number of primary jobs, the increase in visitor sector activity will fully offset the negative forestry impact, however, the nature of the employment and associated wages will not be what the labor force saw in the forestry sector. For example, visitor sector jobs may be primarily part-time or seasonal and are frequently characterized by lower wages when compared to the forestry sector.

Increasing agricultural exports has a minimal effect in terms of a strategy to mitigate the negative consequences the Mountain Pine Beetle may have on the future timber supply. The agriculture sector may require a structural change to effectively offset downturns in other sectors of the economy.

Literature Cited

Alavalapati, J. and W. Adamowicz. 1999. Economic importance of forestry-related sectors in the provincial and northwestern regional economy of Alberta. For. Chron. 75:111-119.

Alavalapati, J., W. White, P. Jagger, and A. Wellstead. 1996. Effect of land use restrictions on the economy of Alberta: a computable general equilibrium analysis. Can. J. Reg. Sci. 19:349-365.

Alavalapati, J., W. White, and M. Patriquin. 1999. Economic impacts of changes in the forestry sector: a case study of the foothills region in Alberta. For. Chron. 75: 121-127.

Johansen, L. 1974. A multi-sectoral study of economic growth. North-Holland Publishing Company. 274p.

Marcouiller, D., D. Schreiner, and K. Lewis. 1996. The impact of forest land use on regional value added. Rev. Reg. Stud. 26:211-233.

Miller, R., and P. Blair. 1985. Input-output analysis: foundations and extensions. Prentice-Hall, Englewood Cliffs, N.J.

M-L IFPA. 2003. http://www.moricelakes-ifpa.com/index.htm. Accessed 06/06/03

Partridge, M. and D. Rickman. 1998. Regional computable general equilibrium modeling: a survey and critical appraisal. Int. Reg. Sci. Rev. 21: 205-248.

Patriquin, M. 2000. Environmentally extended regional economic impact analysis. University of Alberta. Unpublished Masters Thesis.

Patriquin, M., J. Alavalapati, A. Wellstead, and W. White. 2002. A comparison of impact measures from hybrid and synthetic techniques: a case study of the Foothills Model Forest. Ann. Reg. Sci. 36:265-278.

Patriquin, M., J. Alavalapati, A. Wellstead, and W. White. 2003. A computable general equilibrium model of the Foothills Model Forest economy. Can. J. For. Res. 33:147-155.

Patriquin, M., M. Spence, and W. White. 2004. Economic overview of the Morice and Lakes Innovative Forest Practices Study Region. Canadian Forest Service, Information Report.

Pyatt, G. and Round, J. (eds.). 1985. Social accounting matrices: a basis for planning. World Bank, Washington.

Schreiner, D., D. Marcouiller, G. Tembo, and E. Vargas. 1999. http://rri.wvu.edu/webbook/Schreiner. Accessed 07/15/00

Seung, C., T. Harris, and T. MacDiarmid. 1997. Economic impacts of surface water reallocation policies: a comparison of supply-determined SAM and CGE models. Reg. Anal. Pol. 27:55-76.

ECONOMIC IMPACT OF ADOPTING SILVOPASTURE IN FLORIDA: A CGE ANALYSIS

Troy T. Timko and Janaki R.R. Alavalapati

ABSTRACT:

Silvopasture, a type of ranching operation, combines trees with forage alongside livestock and produces many environmental benefits over traditional ranching. These benefits include carbon sequestration, biodiversity from wildlife habitat improvement, and reduction in pollution runoff. However, policies relating to environmentally benign practices often have far-reaching and sometimes unintended economic consequences. It is therefore necessary to analyze the overall impacts of policies influencing silvopasture to give policy makers information on how their actions could affect the economy of Florida.

Our study used a computable general equilibrium model to estimate the economic impacts of policies influencing the adoption of silvopasture by ranchers in Florida. We examined changes in various demands for commodities and factors of production for each of the five modeled sectors. We also examined the impacts of the shocks on macroeconomic variables (such as aggregate household expenditure, wages and unemployment). In addition, a cost-benefit analysis was conducted by comparing the costs to households in Florida and the benefits they receive from the environmental services provided by silvopasture.

KEYWORDS:
Silvopasture, CGE, Cattle-ranching, Florida, Agro-forestry

ECONOMIC IMPACT OF ADOPTING SILVOPASTURE IN FLORIDA: A CGE ANALYSIS

Cattle-ranching in Florida

The Florida cattle-ranching industry, which contributes more than $300 million to the Florida economy annually, is a major agricultural enterprise and has a significant influence on the state's economy. According to USDA census data for Florida for 2002 (USDA 2002), there are approximately 1.74 million cattle in the state on over 19,000 ranches, making Florida the tenth largest cattle producing state in the U.S. Due to the large size and nature of this industry, it can have significant impacts on environmental quality.

Environmental Impacts of Ranching

There are two main ways that the cattle industry adversely affects the environment. First, water pollution problems can result when water in the form of rainfall runoff comes into contact with manure and carries high concentrations of solids, nutrients, and disease organisms into surface waters and ground waters. Nitrogen and Phosphorus are both nutrients often associated with accelerated eutrophication.of surface water. Also, algae blooms of Pfiesteria piscidida and Cytosporidium in drinking water may be associated runoff from animal waste (Baker 1999).

Environmental degradation from cattle-ranching is not, however, limited to water pollution. Cattle-ranching contributes to global warming through the greenhouse effect via the production of the greenhouse gas, methane. Methane is the second most significant greenhouse gas and is expected to contribute to 18% of the global warming from now until the year 2050. The largest source of methane emissions, 30%, is enteric fermentation from livestock, followed closely by methane emissions from rice paddies at 25 %. Also, due to the combination of factors such as their great numbers, large size, and high energy intake; cattle produce 70% of global methane produced by animals, humans included (Milich 1999).

Despite the environmental impacts associated with cattle production, the worldwide consumption of beef is not likely to decrease dramatically in the foreseeable future. It is, therefore, necessary for society to seek solutions to help mitigate the environmental impacts of ranching while allowing producers to continue to provide the goods that people desire. The adoption of silvopasture practices by ranchers has been suggested as a possible means of helping to mitigate these environmental impacts.

Silvopasture

Silvopasture is a form of agroforestry that combines spatial and rotational growth of timber, forage, and livestock, has many associated environmental benefits (Husak and Grado 2000). Silvopasture may be able to mitigate of some of the negative impacts of cattle production while, in addition, providing other environmental services to the public.

Growing trees on farms and ranchlands would improve the quality of water through the reduction of pollution runoff, the replenishment of ground water aquifers, and the maintenance of the long-term water cycle. (Wu et al. 2001, Stednick 1996) Many silvopasture arrangements include tree and grass buffer strips as part of their overall design. Research suggests that tree and grass buffer strips twenty to thirty meters in width control up to 77% of phosphorus and 80% of nitrogen runoff (EPA 1995; Gerrett et al. 2000). Reduction in the quantities and stocking rates of cattle supported by silvopasture cattle ranches as opposed to conventional ranches would also have the effect of mitigating pollution by the reduction of the quantity and the concentration of animal wastes as the number and density of animals is reduced.

Adoption of silvopasture would also help to mitigate the negative effects that cattle-ranching has on the atmosphere through carbon sequestration (Shrestha and Alavalapati 2004). Carbon sequestration has been shown to be a cost effective means for mitigating global climatic change by compensating for greenhouse gas emissions (Albrecht and Kandji 2002, Zhang and Xu 2003).

Use of Computable General Equilibrium Modeling

Policy makers require information concerning the probable effects of implementing policies that would require ranchers in Florida to adopt silvopasture practices since such policies could drastically influence Florida's economy. Analysts often utilize partial equilibrium analysis to determine the possible effects on an industry as a result of policy actions. While partial equilibrium analyses provide highly detailed information on the likely effects of policies to one particular industry, their downside is that they neglect intersectoral interactions within the economy. In order to address the economy-wide impacts of policies in a more comprehensive manner, general equilibrium modeling techniques have been developed and applied to policy analysis. Therefore, we have chosen to utilize a computable general equilibrium(CGE) analysis in this study.

Florida CGE Model Data

The data utilized in the construction of the social accounting matrix, which was used as the input for the CGE model, for this study was obtained from the IMPLAN database of the Minnesota IMPLAN Group. The original 1999 database for Florida consists of 528 individual sectors or industries. Industries were aggregated into five sectors for the final SAM based on the goals of this study and the general industry product categories. The five aggregated sectors are cattle, other agriculture and resources, forestry, manufacturing, and services.

Model Structure

The computable general equilibrium model that has been constructed in this study is a customized version of a Stylized Johansen Model. The development of the theoretical structure of a Johansen model includes formulating several sets of equations. Included in these are equations for: household and final commodity demands, intermediate and primary factor inputs, commodity pricing, and market clearing (Dixon et al. 1999). These equation sets form the framework for the model and determine how the model will react in response to shocks applied to the system of equations. Following the general structure from Dixon et al. (1999), we develiped a customized version of the Stylized Johansen model. The percentagte change form of the model equations are presented in the following table.

Table 1. Specification of the five-sector Florida CGE model

1	$x_{i0} = y - p_i$	i = 1,…,5
2	$x_{ij} = x_j - \left\{ p_i - \left[\left(\sum_{t=1}^{6} \alpha_{tj} p_t \right) + \left(\sum_{f=1}^{2} \alpha_{fj} p_{fj} \right) \right] \right\}$	i = 1,…,8 j = 1,…,5
3	$p_j = \left(\sum_{t=1}^{6} \alpha_{tj} p_t \right) + \left(\sum_{f=1}^{2} \alpha_{fj} p_{fj} \right)$	j = 1,…,5
4	$x_i = \sum_{j=0}^{6} x_{ij} \beta_{ij}$	i = 1,….,5
5	$x_f = \sum_{j=1}^{5} x_{fj} \beta_{fj}$	f = 1,2,3
6	$x_{ie} = -p_i + p_{iw}$	i = 1,…,5
7	$l = \alpha_u u + \alpha_e e$	
8	$p_2 = 0$	

The variables that were selected as exogenous for this CGE model are listed in Table 2. Two of these variables, the aggregate supply of labor, and the wage rate, are utilized to create the two different closures that we utilize in the analyses in this research. Only one of the two will be exogenous at a given time. For the flexible wage scenario, the aggregate supply of labor will be selected as exogenous and the wage rate will be retained endogenous. For the rigid wage scenario, the wage rate will be selected as exogenous and the aggregate supply of labor will become endogenous. This will allow changes in unemployment to occur in the second model closure.

Table 2. Exogenous variables

piw	world price of commodity
l	employable labor force in the economy
pfj f=2; j=1,…,5	price of capital
xfj f=3; j=1,…,5	supply of land to industries
xf f=1	Total supply of labor
pt t = 6	Price of labor (Wage rate)

Shocks Modeled

Planting additional trees on these lands will reduce the land area available to cattle ranchers for production of their livestock. In order to model the effects of the ranchers implementing this operational change, we chose as an exogenous variable the land factor of production for sector one, which represents the quantity of land available to the cattle industry for production. We then impose a twenty-five percent reduction in the cattle sector's available land base by applying a shock of -25% to the supply of the land factor of production for sector. Recently, research has been conducted on the values of trees or forests on ranchlands. That research was modeled such that for silvopasture adoption by ranchers, 20% of land would be taken out of production from ranching with additional lands taken out for the creation of riparian buffer strips (Shrestha and Alavalapati 2004). The level of environmental improvement offered by this size of land use change is similar to the level of improvement on which the willingness to pay data that was utilized in this study was also based. For that reason, a value of 25% was chosen for the negative shock to the land base for ranchers to include the change in land available due to adding trees to the ranchlands as well as to account for additional land for riparian buffers.

The adoption of silvopasture also causes ranchers to expend more in capital costs on items such as tractor and other timber management equipment rental required to practice silvopasture. The actual increase in capital costs for ranchers' adoption of silvopasture could vary greatly depending on factors such as the size of the ranching operations, the method chosen to protect young trees from cattle, and the amount of the necessary equipment already owned by the rancher. Because of the great deal of variation possible in cost increases, a twenty- five percent increase in capital costs was chosen in order to ensure this portion of the total shock would be significant in comparison to the shock to the land base. This is simulated in the model by applying a 25% increase to the cost of capital for the cattle sector. The effects of each shock are analyzed under each of the two closure scenarios wage-flexible, which ensures no change in employment, and wage-rigid, which allows for changes in employment.

Wage-flexible Scenario Simulation Results

Two simultaneous shocks, a 25% decrease in the land base available for cattle production and a 25% increase in capital costs for the ranching sector, are imposed on the CGE model for each of the two closure scenarios. The 25% decrease in land base available for production of cattle represents land that will be taken out of cattle production and instead be utilized for growing trees. The increase in capital costs in sector one represents additional capital costs, such as tractor and other timber management equipment rental required to practice silvopasture. The shocks simulate the effects that adopting silvopasture will have on the cattle-ranching sector directly. The model then simulates, through the CGE framework, how the changes imposed on the cattle sector will affect the rest of the economy of Florida. The results of the wage-flexible scenario are presented in Tables 5-1, 5-2, and 5-3.

Table 5-1. Macro-economic impacts of -25% land base and +25% capital costs

Variable	% Change	Original level	New level	Change
Total household expenditure(millions)	-0.009218	$240,336.56	$240,314.41	-$22.15
Wage rate	-0.006444	1.00	0.99993556	-0.00006
Percent unemployment	0	3.9	3.9	0

Table 5-1 presents some of the macroeconomic impacts of the shocks on the Florida economy. Household demand for goods has dropped, -$22.15million, reflecting the negative effect on the income of Floridians as a result of these environmentally benign policies. Although this is a large change relative to other magnitudes in this simulation, it reflects a drop of just under one one-hundredth of a percent of the total expenditures of Floridians. The wage rate drops only slightly, -0.0006%, to keep employment levels constant at the 1999 level for Florida of 3.9%.

Table 5-2. Commodity market impacts of -25% land base and +25% capital costs

	Sector	% Change	Original level ($)	New level ($)	Change ($)
Price of commodity	1	3.03419	1.00	1.03	0.030
	2	0.00000	1.00	1.00	0.000
	3	-0.00082	1.00	1.00	0.000
	4	0.00060	1.00	1.00	0.000
	5	-0.00436	1.00	1.00	0.000
Total commodity demand	1	-2.94759	188.56	183.00	-5.558
(levels in millions)	2	-0.00286	7,694.74	7,694.52	-0.220
	3	0.00074	405.84	405.84	0.003
	4	-0.00521	54,213.16	54,210.33	-2.825
	5	-0.00232	416,915.56	416,905.89	-9.668
HH commodity demand	1	-2.9540	0.00	0.00	0.000
(levels in millions)	2	-0.0092	1,126.35	1,126.25	-0.104
	3	-0.0084	1.90	1.90	0.000
	4	-0.0098	17,089.29	17,087.62	-1.677
	5	-0.0049	222,119.02	222,108.23	-10.782
Export demand	1	-2.94507	61.00	59.20	-1.796
(levels in millions)	2	0.00000	3,969.55	3,969.55	0.000
	3	0.00081	400.36	400.36	0.003
	4	-0.00059	20,293.49	20,293.37	-0.121
	5	0.00436	78,871.04	78,874.48	3.443

Table 5-2 presents the economic impacts to the markets for commodity outputs of sectors one through five for a 25% decrease in land base and 25% increase in capital costs for cattle ranchers in Florida under the flexible wage rate scenario. Changes to commodity prices, total commodity demands, total household demands, and export demands are shown. In addition, the pre-shock levels, post-shock levels, and level deltas are given. The commodity output results show that the price of sector one's output (commodity one) has increased by 3.03%. This increase in the output price of the cattle sector can be attributed to the increases in their input costs that are passed along to consumers through raising the price of their product. The price of commodity two remains unchanged since it has been fixed as the numeraire. The manufacturing sector, sector four, also experiences a small increase of 0.0006% in the price of its output. One reason for this increase is because sector four contains many of the cattle consuming industries, such as meat packing plants as well as sausage and other beef processing industries. The price of their cattle input goes up, so they must adjust their output price as well to maintain zero pure profits.

The shocks to the cattle sector have caused the overall economy of Florida to contract. As a result of this contraction, consumer demand for most of the sector outputs has declined. This drop in demand has the largest impact, in terms of dollar value decrease, to the service sector, sector five, which experiences a drop of $9.67 million. The service sector is the largest sector in the model however, and this drop reflects a change of only -0.0023%. The shocks were applied to the cattle sector directly, thus this sector experienced the largest percentage drop of -2.95% in demand following their relatively high price increase.

As a result of the contracting economy, Floridian households have less income to spend on consumption of goods. Hence the demand for all commodities by households has decreased accordingly. Although the model shows that largest decrease in household demand by percentage is in sector one, households do not actually directly consume output from the cattle sector. Households instead purchase the processed cattle output from the manufacturing sector. This output carries along with it a higher price due to the increase in intermediate costs of the input from sector one. This price increase along with the decrease in household expenditure causes the manufacturing sector to experience the second largest drop in consumer demand of the five industries, a decrease of -.0098%.

Export demand changes are the least complicated changes to analyze with this model since we assume a constant exchange rate and the changes in export demand are therefore functions of only the change world price of the commodity and the change in the price of that sector's commodity. Because our treatment of Florida follows the small country assumption, changes in the production of goods in the Florida economy have no effect on world prices. We have therefore fixed world prices exogenously and export demand changes remain functions only of changes in the goods' prices. Accordingly, there was a rise in net exports for commodities three and five and a decline in net exports for commodities one and four. The demand for net exports for commodity two remains fixed because of the selection of sector two as the numeraire in the model.

Table 5-3. Factor market impacts of -25% land base and +25% capital costs

Variable	Sector	% Change	Original level ($)	New level ($)	Change ($)
Labor Demand	1	0.00386	75.11100	75.11	0.00290
(levels in millions)	2	0.00358	3541.36792	3,541.49	0.12675
	3	0.00636	15.22300	15.22	0.00097
	4	0.00183	21113.47800	21,113.86	0.38574
	5	-0.00024	215591.42200	215,590.90	-0.51742
Capital Demand	1	-20.03132	10.63860	8.50755	-2.13105
(levels in millions)	2	-0.00287	1102.93994	1102.90834	-0.03160
	3	-0.00008	125.98700	125.98690	-0.00010
	4	-0.00462	8250.00000	8249.61910	-0.38090
	5	-0.00668	93277.50000	93271.26626	-6.23374
Land Prices	1	33.32833	1.00000	1.33328	0.33328
	2	-0.00287	1.00000	0.99997	-0.00003
	3	-0.00008	1.00000	1.00000	0.00000
	4	-0.00462	1.00000	0.99995	-0.00005
	5	-0.00668	1.00000	0.99993	-0.00007

Table 5-3 presents the impacts to Florida's factor markets as a result of the shocks simulating the adoption of silvopasture by Florida's ranching sector. Since this scenario is under flexible wage rate assumption, aggregate demand for labor is fixed exogenously and the price of labor varies to maintain full employment of labor in Florida. Although the aggregate supply of labor is fixed in this closure, labor is not sector specific. This allows unrestricted mobility of labor within the economy. Each sector has its own degree of labor intensity. Thus, as demand for output from each of the sectors changes each sector will shift its demand for labor by the amount necessary, relative to its labor intensity, to maintain the desired level of output. This can be observed as the individual sectors adjust their employment levels as a result of the shocks. Sector five, which has a relatively large decrease demand for output, \$9.67million, experiences in a decrease in its demand for labor even with the decrease in the wage rate. Labor from this sector then mobilizes and relocates to the other sectors, keeping the aggregate labor supply constant.

Capital is sector specific in this model and therefore cannot move between sectors. The decrease in the output demand for sector one combined with the higher costs of capital in that sector, have resulted in a large drop in capital demand in sector one. This decrease in demand by sector one does not benefit the other sectors because of the immobility of capital. Therefore, the other sectors do not experience a gain in resources available that might be felt under a mobile capital model specification. The other four sectors each experience a slight reduction in capital utilization as a result of the contracting economy.

Supply of land for all sectors was held exogenous in the model, but the land rental rates were allowed to vary. Land, like capital, is treated as sector specific, and sectors one (cattle-ranching), two (other agriculture) and three (forestry) are the land utilizing sectors of this model. As a result of the reduction to the land available for production of cattle for sector one, the rental rates for ranchlands have increased dramatically, 33.24%. The remaining four sectors each experience a slight decrease in rental rates.

Wage-rigid Scenario Simulation Results

The wage rigid scenario presents a closure that is more likely to represent a shorter time horion than in the wage flexible scenario. Because of the decreased flexibility of the economy, the magnitude of the effects of the shocks are increased for many of the variables. Under the fixed wage closure, we found that the incomes of Floridians would decrease \$330.16 million in contrast to the decrease of \$22.16 million under the wage-flexible closure. In addition, under the wage-rigid closure scenario, we estimated that 5,322 Floridians would lose their employment. The cattle-ranching sector is found to lose approximately 3.0% or \$5.6million as a result of the shocks. This decrease in sector activity is small when compared to the magnitude of the imposed shocks on that sector since ranchers pass on the higher costs of business to the manufacturing sector, which eventually results in higher beef prices for consumers.

Summary and Limitations

In our study, we used a five sector CGE model of Florida to analyze the impacts to the economy of Florida in response to shocks simulating the adoption of silvopasture by all cattle ranchers in the state. We wanted to answer two questions. Primarily, we wanted to know how the modeled policy changes would impact Florida's economy.

We analyzed this question under both a flexible and fixed wage enclosure and found that the incomes of Floridians would decrease by \$22.16 million for the wage-flexible closure and \$330.16 million under the wage-rigid closure. In addition, under the fixed wage enclosure scenario, we estimated that 5,322 Floridians would lose their employment. The cattle-ranching sector is found to lose approximately 3.0% or \$5.6million as a result of the shocks. This decrease in sector activity is small when compared to the magnitude of the imposed shocks on that sector since ranchers pass on the higher costs of business to the manufacturing sector, which eventually results in higher beef prices for consumers.

We also wanted to answer the question of how the welfare of Floridians would change as a result of the policy shocks when the environmental benefits of the policies are taken into account. Utilizing a cost benefit approach, we found that under the wage-flexible closure, households in Florida would come out ahead under the flexible wage scenario by $24.056million. However, under the wage fixed scenario, they would be worse off by $284.004million.

There are several areas where this research could be improved, which may be considered limitations to the model. First, the model is static and, therefore, does not show the responses in the economy with respect to time. Also, the model utilizes simplistic Cobb-Douglas utility and production functions, rather than more sophisticated functional forms that may better reflect the economy of Florida. Additionally, we chose to not use timber revenue from silvopasture as additional income for the ranching sector since it would have given an overly optimistic view of the effects of the shocks on the ranching sector, since revenues may not be received until far in the future.

Literature Cited

Albrecht, A., and S. Kanji. 2003. *Carbon Sequestration in Tropical Agroforestry Systems*. Agric., Ecosystems, and Environ. 99:15-27.

Baker, B. 1999. *New National Plan to Control Pollution of Water by Livestock Waste.* Bioscience 48:996.

Dixon, P., B. Parmenter, A. Powell, and P. Wilcoxen. 1999. *Notes and Problems in Applied General Equilibrium Economics*. Elsevier Science Publishers. 392p.

EPA. 1995. *Water Quality Functions of Riparian Forest Buffer Systems in the Chesapeake Bay Watershed*. Technology Transfer Report prepared by the Nutrient Subcommittee of the Chesapeake Bay Program. United States Environmental Protection Agency. EPA 903-R.95-004.

Garrett, H., W. Rietveld, and R. Fisher. 2000. *North American Agroforestry: An Integrated Science and Practice*. American Society of Agronomy, Madison, WI.

Husak, A., and S. Grado. 2000. *Monetary and Wildlife Benefits in a Silvopastoral System*. Journal Article No. FO144. Forest and Wildlife Research Center, Mississippi State University.

Milich, L. 1999. *The Role of Methane in Global Warming: Where Might Mitigation Strategies Be Focused?* Global Environ. Change 9:179-201.

Shrestha R., and J. Alavalapati. 2004. *Valuing Environmental Benefits of Silvopasture Practice: A Case Study of the Lake Okeechobee Watershed in Florida*. Ecol. Econ. 49:349-359.

Stednick, J. 1996. *Monitoring the Effects of Timber Harvest on Annual Water Yield*. J. Hydrology 176:79-95.

USDA. 2002. *Census of Agriculture: National, State, and County Tables*. United States Department of Agriculture, Washington DC. 2002.

Wu, X., E. Redeker, and T. Thurow. 2001. *Vegetation and Water Yield Dynamics in an Edwards Plateau Watershed*. J. Range Management 54:98-105.

Zhang, X., and D. Xu. 2003. *Potential Carbon Sequestration in China's Forests.* Environ. Sci. Pol. 6:421-432.