FORESTS IN A MARKET ECONOMY

Edited by

Erin O. Sills and Karen Lee Abt
North Carolina State University and USDA Forest Service

Kluwer Academic Publishers
Boston/Dordrecht/London

Contents

Contributors

Karen Lee Abt, USDA Forest Service
Research Economist, Southern Research Station
Research Triangle Park, North Carolina
Robert C. Abt, North Carolina State University
Professor, Department of Forestry
Raleigh, North Carolina
SoEun Ahn, North Carolina State University
Research Assistant Professor, Department of Forestry
Raleigh, North Carolina
Kevin J. Boyle, University of Maine
Professor, Department of Resource Economics and Policy
Orono, Maine
Joseph Buongiorno, University of Wisconsin
Professor, Department of Forest Ecology and Management
Madison, Wisconsin
David T. Butry, USDA Forest Service
Research Economist, Southern Research Station
Research Triangle Park, North Carolina
Douglas R. Carter, University of Florida
Associate Professor, School of Forest Resources and Conservation
Gainesville, Florida
Frederick W. Cubbage, North Carolina State University
Professor and Head, Department of Forestry
Raleigh, North Carolina

Jeffrey E. Englin, University of Nevada
Professor and Chair, Department of Applied Economics and Statistics
Reno, Nevada
Michele A. Haefele, Colorado State University
Post Doctoral Research Associate, Department of Economics
Fort Collins, Colorado
Thomas P. Holmes, USDA Forest Service
Research Forester, Southern Research Station
Research Triangle Park, North Carolina
Randall A. Kramer, Duke University
Professor, Nicholas School of the Environment and Earth Sciences
Durham, North Carolina
Sharachchandra Lélé, Centre for Interdisciplinary Studies in Environment and Development
Senior Fellow and Coordinator
Bangalore, India
D. Evan Mercer, USDA Forest Service
Research Economist, Southern Research Station
Research Triangle Park, North Carolina
Robert J. Moulton, USDA Forest Service
Retired, State and Private Forestry
Research Triangle Park, North Carolina
Brian C. Murray, Research Triangle Institute
Director, Environment and Natural Resource Economics Program
Research Triangle Park, North Carolina
Subhrendu K. Pattanayak, Research Triangle Institute
Senior Economist,
Environment and Natural Resource Economics Program
Research Triangle Park, North Carolina
And
North Carolina State University
Visiting Assistant Professor, Department of Forestry
Raleigh, North Carolina
Jeffrey P. Prestemon, USDA Forest Service
Research Forester, Southern Research Station
Research Triangle Park, North Carolina
Erin O. Sills, North Carolina State University
Assistant Professor, Department of Forestry
Raleigh, North Carolina

Jacek P. Siry, University of Georgia
Assistant Professor, Warnell School of Forest Resources
Athens, Georgia
*At North Carolina State University during work on this book
Anthony G. Snider, University of Minnesota
Assistant Professor, Department of Forest Resources
St. Paul, Minnesota
*At North Carolina State University during work on this book
David N. Wear, USDA Forest Service
Project Leader, Southern Research Station
Research Triangle Park, North Carolina
F. Christian Zinkhan, The Forestland Group, LLC
Managing Director
Chapel Hill, North Carolina
And
Campbell University
Professor, Lundy-Fetterman School of Business
Buies Creek, North Carolina

Preface

This book draws together contributions from forest economists in the Research Triangle of North Carolina, with co-authors from institutions around the world. It represents our common belief that rigorous empirical analysis in an economic framework can inform forest policy. We intend the book as a guide to the empirical methods that we have found most useful for addressing both traditional and modern areas of concern in forest policy, including timber production and markets, multiple use forestry, and valuation of non-market benefits.

The book editors and most chapter authors are affiliated with three institutions in the Research Triangle: the Southern Research Station of the USDA Forest Service (K. Abt, Butry, Holmes, Mercer, Moulton, Prestemon, Wear), the Department of Forestry at North Carolina State University (R. Abt, Ahn, Cubbage, Sills), and the Environmental and Natural Resource Economics Program of Research Triangle Institute (Murray, Pattanayak). Two other Triangle institutions are also represented among the book authors: Duke University (Kramer) and the Forestland Group (Zinkhan). In addition to our primary affiliations, many of us are adjunct faculty and/or graduates of Triangle universities. Many of our co-authors also graduated from or were previously affiliated with Triangle institutions. Thus, the selection of topics, methods, and case studies reflects the work of this particular network of economists, and to some degree, our location in the southeastern United States. However, our work and the chapters encompass other regions of the United States and the world, including Latin America and Asia.

All of the chapters in this volume were subject to rigorous peer review by at least one other contributing author and at least one external reviewer. We held two workshops to discuss the internal reviews and share suggestions for improvements. Additional feedback on draft chapters and coordination among authors were faciliated by the section editors (Holmes, Murray,

Pattanayak, and Prestemon). External reviews were coordinated by the book editors or by Kluwer. We greatly appreciate the careful reviews provided by Vic Adamowicz, Janaki Alavalapati, Ralph Alig, Greg Amacher, Peter Boxall, Diane Burton, Don Dennis, George Dutrow, Donald Grebner, Peter Holmgren, Bill Hyde, Hunter Jenkins, Jan Laarman, Ian Munn, David Newman, Peter Parks, Matthew Pelkki, Daniel Phaneuf, Dixie Reaves, Kim Rollins, Roger Sedjo, R. David Simpson, Jeffrey C. Stier, Steve Swallow, and Roger H. von Haefen.

We owe thanks to our respective institutions for in-kind and direct support of this project including the USDA Forest Service for contract editing (Sara Jenkins) and technical assistance (Renee Boozer and John Pye), Research Triangle Institute for support of Murray and Pattanayak with a Professional Development Award, and NC State University for technical formatting (Judy Rogers) and graduate student research assistance (Stibniati Atmadja, Nevin Dawson, and Shubhayu Saha). Finally, we have benefited from extremely patient editors at Kluwer Academic Publishers, and we extend our thanks to Noeline Gibson, Helen Buitenkamp, Mary Kelly, and Ursula Hertling.

Chapter 1

Introduction

Erin O. Sills and Karen Lee Abt
North Carolina State University and USDA Forest Service

This book demonstrates how economic principles can be used to analyze forest policy issues across existing and developing market economies. The majority of the chapters address timber production and timber markets, primarily from private forest lands. However, policy makers and forest owners are increasingly concerned with a wide range of forest outputs, including ecosystem services, amenities, recreation, and fuelwood, as well as timber. While many of these outputs are not traded in formal markets, the chapters in this book demonstrate that the market paradigm is a useful framework for examining the behavior and values of forest owners and users. Market concepts can be applied broadly to improve our understanding of public policy in the contentious arena of forest management.

Forest economics addresses the significance of forests to the economy, the impact of the economy on forests, and the means by which government and landowners achieve forest management goals. There are several factors that distinguish forest economics as a separate applied field of economics. First, the diversity of forest landowners, both by groups (public, and private industrial and nonindustrial) and within groups, leads to a diversity of preferences, expectations, and constraints. Second, the long time frames involved in forest production give rise to the classical problem of choosing optimal rotation lengths, capital budgeting, and modern financial analysis. A third complicating factor is that forests jointly produce multiple outputs, some extracted and some valued *in situ*, some traded in the market and some not, and some accruing to forest owners and some to the public. Those not traded in the market, whether consumed by landowners or by the public, have no market price signals to predict behavior or guide allocation. Fourth, the immobility of forests lends greater importance to the issue of market

Sills and Abt (eds.), Forests in a Market Economy, 1–7.

power and to travel costs as necessary inputs to forest use. These and other aspects of forest economics are reviewed in many textbooks, such as Buongiorno and Gilless (2003), Gregory (1987), Johansson and Lofgren (1985), Klemperer (1996), Nautiyal (1988), and Pearse (1990).

1. BACKGROUND AND PURPOSE

This book is designed as a handbook of applied, empirical forest economics for practitioners, policy analysts, and graduate students. The reader of this book is assumed to be familiar with basic market concepts, including marginal analysis of production and consumption decisions under profit and utility maximization. The chapters are designed for readers with a background in quantitative microeconomics (Varian 1999), introductory calculus (partial derivatives), and statistics including multivariate ordinary least squares regression (OLS) and common maximum likelihood estimation techniques such as probit and logit. All of the chapters provide references for the reader wishing to understand the methods in greater depth. Econometric textbooks such as Greene (2002) and Gujarati (1998) are recommended as general references. A more intuitive presentation of many of the methods can be found in Kennedy (1998).

The chapters encompass traditional and modern areas of concern in forest policy, explaining and illustrating how to apply a range of empirical analytical methods (table 1.1). The two chapters following this introduction summarize the status of the world's forests (chapter 2) and the state of research on private forest management (chapter 3). The rest of the book is divided into three sections. The first focuses on timber production, primarily from private US forest lands, and markets. The second addresses multiple use management and considers a diversity of forest owners and outputs. The third section focuses on the valuation of non-market benefits from forests, including stated and revealed preference methods. In each chapter, the goal is to demonstrate rigorous, policy-relevant, empirical analysis in a manner accessible to readers with a background in intermediate microeconomic theory and statistics.

2. ORGANIZATION OF THE BOOK

Traditional forest economics is concerned with producers who are assumed to maximize profits subject to production technology and exogenous prices. The chapters in the first section follow in that tradition, extending the basic theory (chapter 5) in several directions to more

Table 1.1. Chapter themes, data and methods

No.	Theme	Data and Location	Methods
2	Status of the world's forests	Aggregate Worldwide	Summary
3	Private forest management	Aggregate and micro US	Summary
4	Neotraditional optimal rotation	Micro North Carolina	Faustmann (logit)
5	Timber production and harvesting	Micro US South	Cost and production functions (OLS[a])
6	Forests and land as investments	Aggregate US	Modern portfolio theory - CAPM[b], efficient frontier, and option pricing
7	Efficient production frontiers	Micro US South	Stochastic frontier analysis (Math. programming, OLS[a])
8	Modeling aggregate timber supply	Aggregate US South	Timber supply from profit function (3-stage least squares)
9	Modeling aggregate timber demand	Aggregate US South	Derived demand from cost function (Seemingly unrelated regression)
10	Efficiency of timber markets	Aggregate US South	Law of One Price (OLS[a], ARIMA[c], Dickey-Fuller)
11	Trade in forest products	Aggregate Worldwide	Partial equilibrium trade models (simulation)
12	Timber harvests from public lands	Parameters from literature US	Engineering supply (simulation, smoothed by OLS[a])
13	Carbon sequestration	Parameters from literature US	Faustmann, land rent theory (simulation)
14	Timber and amenity as joint outputs	Aggregate and micro North Carolina	Household production (OLS[a] and probit)
15	Nontimber forest products	Household survey India and Brazil	Household production (OLS[a], Tobit, and neg. binomial)
16	Adoption of agroforestry	Household survey Mexico, Philippines	Household production, adoption choice (probit and logit)
17	Demand for forest ecosystem health	Household survey US South	Contingent valuation (bivariate probit)
18	Preferences for forest management	Household survey Maine	Stated preference, attribute based (multinomial logit)
19	Demand for forest recreation	Recreationist survey Brazil	Travel cost (poisson and negative binomial)
20	Ecosystem services as production inputs	Household survey Indonesia	Weak complementarity, derived demand (OLS[a])

[a]OLS=ordinary least squares [b]CAPM = Capital Asset Pricing Model
[c]ARIMA = autoregressive integrated moving average

accurately model forest landowners' objectives and constraints by incorporating risk (chapter 6), the possibility of inefficient production (chapter 7), and market power (chapter 10). The cumulative impacts of individual decisions are observed in markets, and the link between landowner decisions and market analysis is one theme of the first section. The section addresses markets for wood products, including aggregate supply (chapter 8), derived demand from domestic industry (chapter 9), and international trade (chapter 11). Recommended texts for background in production economics are Antle and Capalbo (1988) and Chambers (1988).

One key decision for forest landowners is rotation length, or when to harvest the timber from a given forest stand. The underlying theory of optimal rotations was developed by Faustmann (1849) and extended by Hartman (1976). This theoretical framework is introduced in the first section (chapter 4) and also underlies the first two chapters of the second section (chapters 12 and 13). The Faustmann solution provides the optimal harvest age for the deterministic case with positive financial income from timber harvests. Hartman expanded the analysis to examine tradeoffs between timber returns and other outputs such as amenities and ecosystem services. This and other issues of multiple-use are central to public forest land management in the US, which is addressed in chapter 12 of this book and in references such as Bowes and Krutilla (1989) and Loomis (1993).

The remaining chapters in the second section rely on the household production framework, in which economic agents are modelled as both producers and consumers of forest outputs (chapters 14, 15 and 16). This framework is appropriate for non-industrial private forest landowners in the US and for agricultural households in developing countries. These households use public forests and/or plant trees to obtain a variety of benefits. Where markets are complete, their production decisions can be modelled in the standard profit maximization framework, as demonstrated by the last chapter of the book (chapter 20). Key references on household production theory are Singh et al. (1986) and Sadoulet and deJanvry (1995). The other chapters in section three focus on demands for forest outputs and thus rely on consumer theory, or utility maximization and welfare estimation (chapters 17, 18, and 19). The standard reference for non-market valuation is Freeman (2003), with relevant econometric methods discussed in greater detail in Haab et al. (2002).

3. STUDY SITES AND DATA

Many of the chapters address forestry issues in the US South. Forest land in the South is a market driven, ecologically and culturally significant part of

the regional landscape. It provides an excellent laboratory for examining market influence on a diversity of landowners across a diverse landscape. The South has active markets for timber, and an increasing population with increasing demands for other forest outputs such as recreation and ecosystem services (Wear and Greis 2002). Several chapters consider other regions in the US (e.g., Maine), address the US as a whole, or are not specific to a region. Other chapters focus on developing countries (Brazil, India, Indonesia, Mexico, and the Phillipines). The literature reviewed in the most of the chapters is international, including many examples from Europe. Finally, the international trade chapter addresses the US at a national level in concert with other players in international markets.

The empirical examples in the chapters draw on data from various sources, including secondary data from the US and the South in particular. Examples include the Forest Inventory and Analysis of the USDA Forest Service, the Timber Mart-South price series (Norris Foundation), the Total Timberland Index of NCREIF (National Council of Real Estate Investment Fiduciaries), surveys of logging firms by the American Pulpwood Association, sector-specific producer price indices from the Bureau of Economic Analysis, and US Census of Population and of Manufacturers. Some chapters draw on other literature for parameters to use in simulations. The third type of data is from surveys of households or individuals conducted by the authors. By definition, survey data is required for stated preference valuation methods (chapters 17 and 18). All of the international applications (chapters 15, 16, 19, and 20) analyze household survey data, perhaps in part due to the lower cost of collecting data in developing countries. Deaton (1997) and Mukherjee et al. (1998) are excellent references for analysis of such household survey data.

4. SUMMARY

Most of the chapters present general theory and methodology relevant to a set of forest policy or management questions, review the findings of previous literature, and derive key testable hypotheses. These hypotheses are then tested in the context of case studies, using the variety of data sources and econometric or other quantitative methods described above. Thus, the results are both methodological and policy-related, and both specific to the case studies and generalizable. Table 1.2 lists selected findings from the chapters. Many of the chapters suggest areas for further work, either in testing hypotheses or advancing the methodology to address other issues and other regions of the world.

Table 1.2. Summary of key findings

No.	Theme	Findings
2	Status of the world's forests	The world has 3.9 billion ha of forests, 87% publicly owned, 5% in plantations, 43% with management plans.
3	Private forest management	Landowner and timber characteristics, market and policy variables determine private forest management.
4	Neotraditional optimal rotation	Neotraditional models are consistent with nonindustrial, traditional with industrial. Future rotations matter to both.
5	Timber production and harvesting	Estimated cost and production functions indicate only limited structural change within logging technology class, 1979-1987.
6	Forests and land as investments	Timberland provides portfolio diversification benefits and is attracting new capital from institutional investors.
7	Efficient production frontiers	Average technical efficiency approximately 60%, similar between years, but increasing over time.
8	Modeling aggregate timber supply	Structure and amount of forest inventory capital affect timber supply estimates; pulp & sawtimber supply respond differently.
9	Modeling aggregate timber demand	Heterogeneity of firms, from processing, input definition, or output definition, may drive observed aggregate relationships.
10	Efficiency of timber markets	Timber prices are temporally efficient. Some oligopsony exists in the pulpwood market.
11	Trade in forest products	Rapid growth in trade has been encouraged by trade agreements (NAFTA, WTO), but barriers still exist.
12	Timber harvests from public lands	Public intervention through harvesting increases public supply, reduces private supply, lowers price, increases price volatility.
13	Carbon sequestration	Prices for carbon sequestration influence optimal rotation age and land use allocation.
14	Timber and amenity as joint outputs	Joint production depends on plot, market and landowner factors and affects timber supply elasticities.
15	Nontimber forest products	NTFP collection driven by functional relationship to other household activities, preferences and assets.
16	Adoption of agroforestry	Market incentives, biophysical conditions, preferences, risk/uncertainty and resource endowments influence adoption.
17	Demand for forest ecosystem health	Forest condition is an economic good, and existence value is largest component of public value of spruce-fir forests.
18	Preferences for forest management	Maine general public prefers balance of harvest and protection and is WTP to protect more forest area.
19	Demand for forest recreation	Count data models adjusted to reflect characteristics of the trip decision demonstrate value of infrequent forest recreation.
20	Ecosystem services as production inputs	Micro theory helps identify data-efficient methods that show substantive contributions of forest ecosystem services.

5. LITERATURE CITED

ANTLE, J.M., AND S.M. CAPALBO (EDS). 1988. Agricultural Productivity Measurement and Explanation. Resources for the Future. Washington DC.

BOWES, M. AND J. KRUTILLA. 1989. Multiple Use Management: The Economics Of Public Forestlands. Resources For The Future, Washington DC: 357 p.

BUONGIORNO, J. AND J. K. GILLESS. 2003. Decision methods for Forest Managers. Academic Press, London, UK. 400 p.

CHAMBERS, R. 1988. Applied Production Analysis: A Dual Approach. Cambridge University Press. Cambridge, U.K. 331 p.

DEATON, A. 1997. The analysis of household surveys: A microeconometric approach to development policy. Johns Hopkins University Press, Baltimore, MD. 479 p.

FAUSTMANN, M. 1849. On the determination of the value which forest land and immature stands possess for forestry. Institute Paper 42 (1968), M. Gane, ed. Oxford: Commonwealth Forestry Institute, Oxford University.

FREEMAN, A.M. 2003. The Measurement of Environmental and Resource Values: Theory and Methods. RFF Press, Washington DC. 496 p.

GREENE, W.H. 2002. Econometric Analysis. Prentice Hall, New Jersey. 1056 p.

GREGORY, G.R. 1987. Resources Economics for Foresters. John Wiley & Sons, New York. 477 p.

GUJARATI, D. 1998. Essentials of Econometrics. McGraw Hill, Boston. 534 p.

HAAB, T.C., K.E. MCCONNELL, AND P.E. EARL. 2002. Valuing Environmental and Natural Resources: the Econometrics of NonMarket Values. Edward Elgar Publishing, UK. 326 p.

HARTMAN, R. 1976. The harvesting decision when a standing forest has value. Econ. Inq. 14:52-58.

JOHANSSON, P.O. AND K. LOFGREN. 1985. The Economics of Forestry and Natural Resources. Basil Blackwell, Oxford 292 p.

KENNEDY, P. A. 1998. Guide to Econometrics. The MIT Press, Cambridge, MA. 468 p.

KLEMPERER, W. DAVID. 1996. Forest Resource Economics and Finance. McGraw-Hill Inc., New York. 551 p.

LOOMIS, J.B. 1993. Integrated Public Lands Management: Principles and Applications to National Forests, Parks, Wildlife Refuges, and BLM Lands. Columbia University Press, New York. 544 p.

MUKHERJEE, C., H. WHITE, AND M. WUYTS. 1998. Econometrics and Data Analysis for Developing Countries. Routledge, New York. 496 p.

NAUTIYAL, J.C. 1988. Forest Economics: Principles and Applications. Canadian Scholars' Press Inc., Toronto. 581 p.

NORRIS FOUNDATION. Various Years. Timber Mart-South. The Daniel B. Warnell School of Forest Resources, University of Georgia, Athens.

PEARSE, P.H. 1990. Introduction to Forestry Economics. University of British Columbia Press, Vancouver. 226 p.

SADOULET, E., AND A. DE JANVRY. 1995. Quantitative Development Policy Analysis. Johns Hopkins University Press, Baltimore. 397 p.

SINGH, I., L. SQUIRE, AND J. STRAUSS (EDS). 1986. Agricultural Household Models. Johns Hopkins University Press, Baltimore. 335 p.

VARIAN, H.R. 1999. Intermediate Microeconomics: A Modern Approach. W.W. Norton & Company, New York, NY. 600 p.

WEAR, D.N. AND J.G. GREIS. 2002. The Southern Forest Resource Assessment – Summary Report. Gen Tech. Report SRS-53. Southern Research Station, USDA Forest Service, Asheville, NC. 103 p.