OBSERVATIONS ON RECENT FOREST ECONOMICS RESEARCH ON RISK AND UNCERTAINTY

INTRODUCTION

In an annotated bibliography of the optimal rotation literature published in 1988 (Newman, 1988), it was predicted that the deterministic rotation literature would be winding down, and that the evaluation of risk and uncertainty (R&U) was the next fundamental issue for forest economists to address. There were three justifications for this bold prediction. First, it seemed as if most of the topics regarding determining rotation age in a static world were well explored. Second, R&U issues represented important gaps in our understanding of forest management. Finally, the R&U literature was ready to expand as new techniques were being developed or popularized. As even a cursory examination of literature will tell us, the prediction was far off in a general sense. More than 60 articles have been published on the optimal rotation question since 1988 (Newman, 1999), and the upcoming Faustmann Symposium is expected to generate more.[1] However, the specific prediction regarding R&U was well founded. Over half of the articles that have been published since 1988 have dealt with dynamic/stochastic issues in rotation determination and valuation.

This explosion of R&U papers in forestry economics since the late 1980's is noteworthy because before this time there were only a handful of papers addressing a range of R&U issues. An incomplete list of earlier papers includes: Norstrom (1975) and Miller & Voltaire (1980 & 1983), which addressed determination of optimal harvest age with stochastic prices; Routledge (1980) and Reed (1984) which assessed fire risk; Mills & Hoover (1982), which compared the magnitude and timing of forest returns with non-forest assets; and Kao (1982 and 1984), which focused on the computational aspects of finding solutions.[2] The more than 30 R&U papers published since 1988 not only explore the research areas developed in these earlier R&U papers, but develop several new areas.

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[1] 150 Years of the Faustmann Formula: The Consequences for Forestry and Economics in the Past, Present, and Future, October 3–6, 1999 at the Hunting Castle of Kranichstein, Darmstadt, Germany. For details until October 6, 1999, see: http://www.lsu.edu/guests/sjchang/Faustmann.html.

[2] Note that all lists of papers are meant to be illustrative and are assumed to be incomplete. We apologize in advance to authors of relevant papers who were omitted.

A key reason for the increase in papers addressing R&U issues in forestry economics is the importance of these issues to forest management. There are a number of reasons that R&U issues are important in forestry. First, the long period from regeneration to harvest in which biological and economic parameters may shift significantly or during which catastrophe may strike. Second, there is a history of dramatically fluctuating stumpage prices in many regions. Finally, analysts need to compare forest investments with non-forest investments and to determine the optimal timing of forest investments. In following sections, we characterize some continuing and emerging areas of R&U research within forest economics using R&U parameters and different methodological approaches. We also note some of the papers within each area that are presented in this issue.

Forest Decision-making in an Uncertain World Workshop

Although numerous R&U papers were published in the early nineties, the first full board meeting of the *Journal of Forest Economics* in Amsterdam in June 1995 provided the impetus for this special issue. The editorial board decided to devote selected individual issues to specific topics, and we volunteered to put together a special R&U issue. After the meeting we decided to hold a workshop to encourage new research on R&U issues and to focus discussion on R&U within forest economics. However, it was not until early 1998 that we actually held the workshop. Support for the workshop was provided by this Journal, the Southern Research Station of the USDA Forest Service, the Center for Forest Business at the Warnell School of Forest Resources at the University of Georgia, and the Department of Natural Resources and Environmental Sciences of the University of Illinois at Urbana-Champaign. Twenty-six people, representing five countries and nine US states, attended the workshop entitled *Forestry Decision-Making in an Uncertain World*. The eight papers presented in this special issue represent selected and edited papers from the workshop.

RESEARCH AREAS

Optimal Stand Harvest with Fluctuating Prices

The dominant question in the R&U literature deals with a landowner's harvest decision in a dynamic market. Many stumpage price series exhibit large variations over time, often as much as 30%. These variations can be separated into long-term trends, which are generally treated as deterministic, and short-run fluctuations, which are generally assumed random. In the past decade, many papers have addressed the question of when to har-

vest a stand when stumpage prices randomly fluctuate. The methodology of most of these papers has been adapted or developed from optimal stopping theory in mathematics, or more directly from economic search theory. Harvesting corresponds to stopping, or a successful search. Most analyses focus on deriving and/or applying rules to determine optimal harvest rules.

The underlying structure of the fluctuating stumpage prices is the primary basis on which to characterize studies in this area. Most studies either assume stumpage prices to be a random walk (e.g., Clarke & Reed, 1989; Reed & Clarke, 1990; Thomson, 1991) or a random draw (e.g., Brazee & Mendelsohn, 1988; Teeter & Caulfield, 1991; Gong, 1995). Empirical evidence of stumpage price fluctuations is mixed. For some stumpage price series, the hypothesis of a random walk cannot be rejected, while for other series the hypothesis of a random draw cannot be rejected. On the other hand, some stumpage price series are clearly autocorrelated, and in that case the hypotheses of both a random walk and a random draw may be rejected. Since some stumpage price series exhibit autocorrelated prices (Lohmander, 1987; Haight & Holmes, 1991), an important unresolved question is deriving optimal reservation prices with autocorrelated prices. Two papers in this issue, Brazee, Amacher and Conway, and Thorsen, address this specific question. Both use first autoregressive prices to show how random walk and random draw prices can be endpoints on a continuum of autocorrelated prices. Thorsen considers an innovative case in which stumpage is a tax conscious farmer's non-fluctuating asset.

Another under-represented area, related to the harvest question, is the determination of stumpage price expectations. Most authors conveniently assume that landowners have perfect information regarding the stumpage price generation process. While this assumption makes for more tractable models, it is certainly not empirically well founded. Landowners must develop expectations about future stumpage prices. Here Gomez, Love and Burton address the expectations issue by developing and using a model of individual timber producer behavior to analyze several price mechanisms and the impacts of these mechanisms on timber harvesting decisions.

Forest Asset Performance

An important question is the performance of forest investments compared with non-forest investments. Forests have often provided relatively low rates of return on investments such as land devoted to forests and regeneration costs in comparison to other non-forest assets. Previous studies have estimated the risk of forest investments (Redmond & Cubbage, 1988; Washburn &

Binkley, 1990; Zhang & Binkley, 1993) and the role of forestry investments in a diversified portfolio (Thomson, 1991; Zinkhan *et al.*, 1992; Caulfield, 1998). Two papers in this issue address questions regarding the performance of forestry investments. Caulfield and Newman discuss the distance between academic research on forest management with significant R&U activities and the practices used by the timberland investment management companies in the U.S.. Heikkinen presents a portfolio model in which landowners must choose between holding timber and non-forest assets. In contrast to previous work, this model focuses more directly on harvesting decisions. The model is then estimated using Finnish data.

Two Period Models

Concurrent with the explosion of papers on R&U was a dramatic increase in papers using two period models. Although not strictly an optimal rotation model in a Faustmann sense, the two period model is well suited to study a range of traditional and emerging forestry issues. The discrete nature of the two periods makes it relatively easy, in comparison to the Faustmann model, to incorporate risk into the analysis. Previous two period papers that have addressed R&U issues include Koskella (1989), Koskella & Ollikainen (1997 & 1998), and Ollikainen (1990 & 1993). In this issue, a new work by these authors incorporates biodiversity as an amenity into a two period model while accounting for different sources of risk and different management goals.

Risky Forest Investments

Recent advances, most notably Dixit and Pindyck's seminal work, *Investment Under Uncertainty* (1994), offer a new and perhaps more holistic view of investments that directly considers the options associated with uncertainty and irreversibility in an investment context. As questions of when to make an investment in forestry operations have been and will always be important, this view potentially has wide applicability in managing large forest operations. Unfortunately, Dixit and Pindyck also presented some advanced mathematical techniques that place new demands on forest economists hoping to analyze these questions. Thus while general techniques have been developed, the application of those techniques to forestry questions and the resulting insights is turning out to be a slow process. Previous papers in the area include Yin & Newman (1995) and Plantinga (1998). In this issue, Yin and Newman adapt Dixit and Pindyck's analysis to cover questions of firm decision making for a forestry operation. In particular, they focus on the options that firms have in managing their total forest investment portfolio.

Computable General Equilibrium

The examination of broad market forces and the impacts of government policies on the forest sector as a whole represents an important evolving area of forest research in which the incorporation of R&U has been sadly lacking. An important tool that has been used to assess a variety of issues is the computable general equilibrium (CGE) model. A few examples of CGE models examining forest policy issues include: Boyd & Newman (1991), Binkley *et al.*, (1994), and Alavalapati *et al.*, (1997). However, none of the studies have satisfactorily addressed the problem of uncertain parameters, which has limited the usefulness of many model results. The final paper included in this issue, by Alavalapati, Adamowicz and White, attempts to address this issue. In it, they use a systematic process to analyze uncertain parameter values within a computable general equilibrium model applied to Canada-U.S. forestry trade policies.

Future Directions

During the final session of the Athens Workshop, the participants discussed possible future directions for R&U research in forest economics and management. Since many previous studies have focused on stand or firm analyses using a point-input-point-output framework, it perhaps was not too surprising that three directions emerged from the conference as being likely areas of development. They were:

(i) A movement from point-input-point-output research to research on continuous forest management operations.

(ii) A movement from stand-level studies to forest-level studies.

(iii) A movement from firm-level analyses to market-level analyses including deriving and characterizing market equilibria.

The papers presented in this issue illustrate a wide range of issues covered under the R&U theme. Together, we hope that they add to our understanding of the ways in which R&U can be analyzed, and encourage future research in the area.

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Associate editors

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