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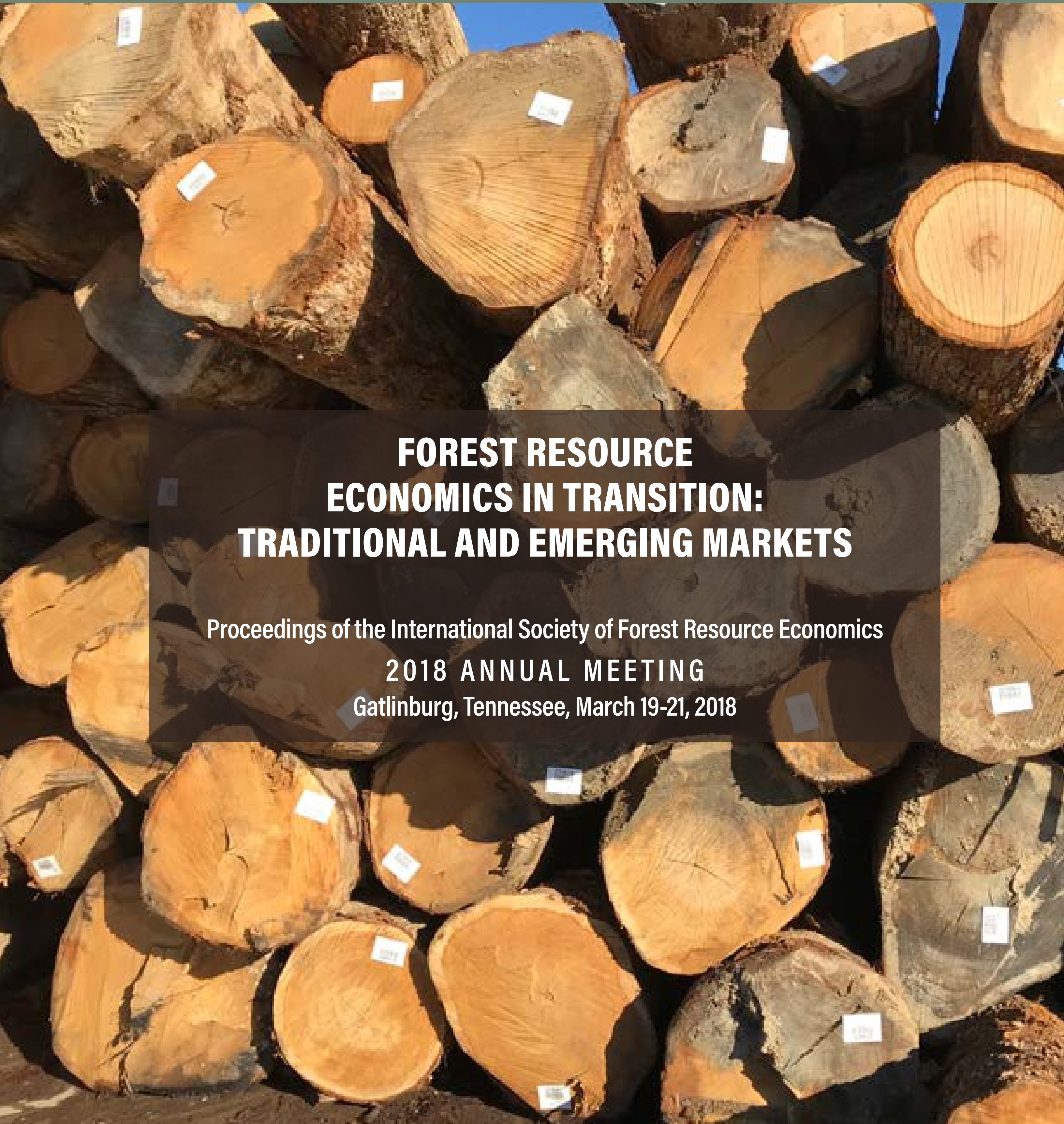

FOREST RESOURCE ECONOMICS IN TRANSITION: TRADITIONAL AND EMERGING MARKETS

Proceedings of the International Society of Forest Resource Economics

2018 ANNUAL MEETING

Gatlinburg, Tennessee, March 19-21, 2018

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Abstract

The International Society of Forest Resource Economics 2018 Annual Meeting was held in Gatlinburg, TN, March 19–21, 2018. The meeting was attended by a range of forest economics professionals to discuss developments in various aspects of forest economics including traditional and emerging markets issues. The 37 talks and 12 poster presentations covered topics on regional economic contribution analysis, finance, management, carbon and greenhouse gases, non-market valuation, prescribed fire, private forest landowner issues, and international policy issues.

Keywords: Forest economics, forest resource policy, resource management, non-market valuation, forest products markets.

Acknowledgments

We thank the ISFRE group at Mississippi State University, led by Jason Gordon with assistance from Karen Brasher, for their help with organizing the meeting and communicating with ISFRE members. Thanks also to Darren Bailey, East Tennessee District Forester, Tennessee Division of Forestry, for leading our field trip to the Chimneys.

We thank our two keynote speakers, Jack Lutz of the Forest Research Group and Jason Jones of RTI International, for their talks on “Timberland Investment Mythbusters” and “Estimating Potential Greenhouse Gas Mitigation Potential of the U.S. Forest, Agriculture, and Land Use Sectors”, respectively. We also extend our thanks to oral and poster presenters as well as all conference attendees whose participation helped make the meeting a success. Thanks to session moderators for their time and effort in conducting the concurrent sessions.

CONTENTS

PLENARY

Timberland Investment Mythbusters

Jack Lutz

Jack Lutz, Forest Economist, Forest Research Group, Hermon, ME 04401.

Abstract—Institutional timberland investment grew rapidly in the United States during the 1990s as large publicly-traded industrial timberland owners began selling off their holdings—a very small handful converted to timberland real estate investment trusts (REITs). Timberland Investment Management Organizations (TIMOs) touted a number of characteristics of privately held timberland and their benefits for an investment portfolio. Market analysts have written that timber REITs are an alternative for investors that cannot afford a private equity investment.

We look at timberland investment characteristics and address the following questions:

- Are timberland returns negatively correlated with financial assets (stocks and bonds)?
- Is timberland an inflation hedge?
- Can timber be stored on the stump?
- Can timberland produce real returns of 8-10 percent in the United States?
- Are timber REITs a substitute for private equity investments in timberland?

PLENARY

Estimating Potential Greenhouse Gas (GHG) Mitigation Potential of the U.S. Forest, Agriculture, and Land Use Sectors

Jason Jones, Yongxia Cai, Justin Baker, Gregory Latta, Christopher Wade, and Lindsay Aramayo Lipa

Jason Jones, Resource Economist, RTI International, Research Triangle Park, NC 27709; Yongxia Cai, Research Economist, RTI International, Research Triangle Park, NC 27709; Justin Baker, Senior Economist, RTI International, Research Triangle Park, NC 27709; Gregory Latta, Assistant Research Professor, University of Idaho, Moscow, ID 83844; Christopher Wade, Research Economist, RTI International Research Triangle Park, NC 27709; and Lindsay Aramayo Lipa, Associate Economist, RTI International, Research Triangle Park, NC 27709.

Abstract—Opportunities to mitigate climate change impacts by decreasing greenhouse gas (GHG) emissions exist in the forestry and agricultural sectors of the economy. Additionally, the interaction of land conversion between these sectors have found to have substantial GHG emissions implications. While significant GHG emission reductions can be achieved within these areas through various policy mechanisms, the socially optimal activity level is ultimately dependent on relative economic and social costs. Economic modelling has traditionally been employed to assess the cost effectiveness of intra-sector abatement strategies through the use of symmetric price incentives, otherwise called, a carbon price.

This study investigates GHG abatement potential and market response of carbon price mechanisms in the U.S. land-use sectors. The forest and agricultural sectors are presented using a partial equilibrium (PE) mathematical model. This allows for the study of physical and economic responses to GHG reduction incentives, while allowing for land and product market interactions between sectors. Detailed PE models also can incorporate specific GHG policy details, allowing for sector or activity-based boundaries, carbon price levels, and alternative carbon price growth rates. GHG emissions reductions across sectors and over time are investigated, in addition to the resulting economic impact on these sectors. Policy design is also evaluated, where mitigation potential is studied across numerous carbon price paths with various eligible activities.

CARBON AND GREENHOUSE GASES

The Environmental Kuznets Curve Model for Greenhouse Gas (GHG) Emissions in Canada

Edward Olale, Thomas Ochuodho, Van Lantz, and Jafar El Armali

Edward Olale, University of New Brunswick, Fredericton, NB E3B 5A3, Canada; Thomas Ochuodho, Assistant Professor, University of Kentucky, Lexington, KY 40546; Van Lantz, Professor, University of New Brunswick, Fredericton, NB E3B 5A3, Canada; and Jafar El Armali, Ph.D. Student, Western University, London, ON N6A 5C2, Canada.

Abstract—This paper tests for the applicability of the Environmental Kuznets Curve (EKC) hypothesis at the Canadian and provincial/territorial levels using greenhouse gas (GHG) emissions as an indicator for environmental degradation. The hypothesis is tested using provincial and territorial panel data from 1990 to 2014. The results vary depending on the econometric estimation method. The pooled regression results are mixed, with the EKC hypothesis confirmed at the Canadian level and in half of the provinces and territories. However, the fixed-effects regression results confirm the EKC hypothesis at the Canadian level and in all provinces and territories. The results also highlight the significance of technological change and province/territory specific characteristics in determining the level of GHG emissions.

CARBON AND GREENHOUSE GASES

Comparing Average Cost and Marginal Cost Assumptions for Regional Afforestation: An Examination of the U.S. Forest and Land Use Sectors

Yongxia Cai, Chris Wade, Justin Baker, Jason Jones, and Gregory Latta

Yongxia Cai, Research Economist, RTI International, Research Triangle Park, NC 27709; Christopher Wade, Research Economist, RTI International Research Triangle Park, NC 27709; Justin Baker, Senior Economist, RTI International, Research Triangle Park, NC 27709; Jason Jones, Resource Economist, RTI International, Research Triangle Park, NC 27709; and Gregory Latta, Assistant Research Professor, University of Idaho, Moscow, ID 83844.

Abstract—The Forestry and Agriculture Sector Optimization Model with Greenhouse Gases (FASOMGHG) has historically relied on regional average costs of land conversion to simulate land use change across cropland, pasture, rangeland, and forestry. This assumption limits the accuracy of the land conversion estimates by not recognizing spatial heterogeneity in land quality and conversion costs. Using data from Nielsen and others (2014), we obtained the average cost of planting forest land per county, then incorporated non-parametric regional marginal cost functions for land converting from marginal agricultural land to forestry into the FASOMGHG framework.

The FASOMGHG model is ran utilizing three different assumptions for land moving into the forest sector: constant average conversion cost, static and dynamic marginal cost. In each period static marginal cost curves will start at the lowest conversion cost for each region. However, in the dynamic marginal cost curves, regional conversion prices begin at the cost of the last acre of land converted in the previous period. Additionally, carbon mitigation price scenarios are applied to GHG emissions to explore how agriculture, forestry, and land conversion respond when carbon sequestration is incentivized. As mitigation prices rise over time, landowners have an incentive to move marginally less productive land into forestry. Rising marginal costs of afforestation could act as an implicit physical upper bound on the amount of land available to be afforested. Results for both sets of scenarios are presented and the benefits of including increasing marginal costs in a structural model to reduce spatial aggregation bias are discussed.

LITERATURE CITATION

Nielsen, A.S.E.; Plantinga, A.J.; Alig, R.J. 2014. New cost estimates for carbon sequestration through afforestation in the United States. Gen. Tech. Rep. PNW-GTR-888. Portland, OR: U.S. Department of Agriculture Forest Service, Pacific Northwest Research Station. 35 p.

CARBON AND GREENHOUSE GASES

Projecting U.S. Forest and Agricultural Land Management Across Shared Socio-Economic Pathways

Jason Jones, Yongxia Cai, Justin Baker, Gregory Latta, and Christopher Wade

Jason Jones, Resource Economist, RTI International, Research Triangle Park, NC 27709; Yongxia Cai, Research Economist, RTI International, Research Triangle Park, NC 27709; Justin Baker, Senior Economist, RTI International, Research Triangle Park, NC 27709; Gregory Latta, Assistant Research Professor, University of Idaho, Moscow, ID 83844; and Christopher Wade, Research Economist, RTI International Research Triangle Park, NC 27709.

Abstract—Robust baseline projections of the forestry sector are necessary for creating informed policy, as such decisions have implications well into the future. Such projections use biophysical and economic relationships to determine long-run activity, dependent on alternative macroeconomic and development pathways. Socio-economic assumptions such as population, GDP, and economic growth directly impact land use, resource availability, and product demand. Projecting forest management under alternate socio-economic pathways is important to inform robust policy and investment decisions.

This research combines the Integrated Climate and Land-Use Scenarios (ICLUS) model, the Agricultural Sector Model (ASM), and the Land Use and Resource Allocation (LURA) forestry sector model to forecast the economic outcomes of long-run land conversion across agriculture and forestry. Previous applications of the LURA model used recursive dynamics, disallowing for endogenous intensive/extensive margin investments. This joint model is solved as a dynamic optimization model, allowing for such forward-looking investment activity.

Inter-sector land and product markets were created to link the models, in conjunction with a compound welfare objective function to interact sectors. As the ICLUS and LURA models are coordinate based, spatial aggregation to ASM regions was required. ICLUS generated land development scenario estimates based on spatially explicit projections of population growth based on socio-economic pathways. The multi-sector modelling framework allowed for these scenario impacts to be assessed across the agriculture and forestry sectors. The resulting land-use, markets, and carbon outcomes will be presented across a range of socio-economic pathways.

CARBON AND GREENHOUSE GASES

Global Forest Carbon Sequestration to 2065 from Forests, Land Use, and Harvested Wood Products

Craig Johnston, Joseph Buongiorno, Prakash Nepal, and Jeff Prestemon

Craig Johnston, Assistant Professor, Department of Forest and Wildlife Ecology, University of Wisconsin-Madison, WI 53706; Joseph Buongiorno, Professor Emeritus, Department of Forest and Wildlife Ecology, University of Wisconsin-Madison, Madison, WI 53706; Prakash Nepal, Research Assistant Professor, Department of Forestry and Environmental Resources, North Carolina State University, Raleigh, NC 27607; and Jeff Prestemon, Project Leader, USDA Forest Service, Research Triangle Park, NC 27709.

Abstract—An economic model of the global forest sector was used to estimate the carbon mitigating potential of the world's forests to 2065 for 180 countries assuming future socio-economic trends that do not change markedly from historical patterns, consistent with the IPCC-SSP2. Forest carbon pools were broken down into four categories; (1) aboveground and belowground biomass, (2) forest soil, (3) dead wood and litter, and (4) harvested wood products. Changes in forest carbon storage were driven by the dynamic relationship between endogenously determined timber harvest, wood product consumption, evolving forest biomass stock, forest area change and exogenous demographic and income changes. The results suggested that the forest sector was a net carbon source of approximately 3.6 GtCO2e yr^{-1} in 1992, decreasing to 2.4 GtCO2e yr^{-1} in 2014 (average rate: -0.05 $GtCO_2e$ yr^{-1}), in general agreement with previous historical assessments. In the projections, the global forest sector achieved a net zero carbon balance by the year 2025, but with large variations by region and country. By 2030, the world's forest sector became a net carbon sink of 1.5 GtCO2e yr^{-1}, and eventually of 6.8 GtCO2e yr^{-1} by 2065.

CARBON AND GREENHOUSE GASES

Is Pellet Production Causing Structural Change in the Pulpwood Market in the U.S. South?

Bruno Kanieski da Silva, Frederick W. Cubbage, and Robert C. Abt

Bruno Kanieski da Silva, Postdoctoral Researcher, Department of Forestry and Environmental Resources, North Carolina State University, Raleigh, NC 27607; Frederick W. Cubbage, Professor, Department of Forestry and Environmental Resources, North Carolina State University, Raleigh, NC 27607; and Robert C. Abt, Professor, Department of Forestry and Environmental Resources, North Carolina State University, Raleigh, NC 27607.

Abstract—The Southern United States is one of the largest wood producers in the World. There are thousands of landowners and timber consumers interacting over time in a complex timber market web. Pulpwood has the most substantial volume share and its consumers were concentrated in pulp and paper industries and composite panel. However, in the last decade, the European energy policies have attracted wood-pellet facilities and increased the competition for wood residuals and pulpwood in the U.S. South. Between 2005 and 2015, the capacity of wood pellet production went from 68,000 to 6.4 million green tons per year. We investigated how pellet mills have impacted pulpwood market structure in the U.S. South. Rather than focusing exclusively on price elasticities, we progress by examining how wood pellet production has impacted spatial transmission of pulpwood prices. Pairwise price ratios were modeled using Smooth Transition Regression (STR) to identify changes in the co-integration (linkage) between markets over time. The market linkage was fitted as a function of market distances, industry concentration, and capacity of pellet wood production. Initial results show that the U.S. South is composed of different market clusters of which its configuration varies over time. Distance was the only factor driving market linkages; the capacity of pellet and pulp and paper industries had no effect. Our research suggests spatial price transmission is not constant over time and pellet mills have not caused structural change in the pulpwood market in the U.S. South.

PRESCRIBED FIRE

Factors Affecting Risk Perception Concerning Prescribed Fire in the United States

Omkar Joshi and Neelam C. Poudyal

Omkar Joshi, Assistant Professor, Department of Natural Resource Ecology and Management, Oklahoma State University, Stillwater, OK 74078; and Neelam C. Poudyal, Associate Professor, Department of Forestry, Wildlife and Fisheries, University of Tennessee, Knoxville, TN 37919.

Abstract—While prescribed fire is an accepted management tool in forest and grasslands, its use has been limited due, in part, to inherent risks to property damage, liability, and injuries. The purpose of this study is to understand the factors that shape landowners and other fire professional's perceptions of risk associated with prescribed burning activities. The requisite data for this study was collected from memberships of Prescribed Burn Associations (PBAs) in 14 southern and mid-western States. Study results suggested that risk perceptions heightened with acres of land being owned or managed. In addition, perceived risk was higher among respondents that indicated to have higher levels of concerns related to safety and weather. In contrast, perceived risk was lower among respondents with longer experiences with burning activities. The socio-demographic variables such as age and education did not have a significant impact on risk perception. Findings will be useful in understanding how landowners and fire professionals perceive risk and offer insight into how perceived risk impacts their burning decisions.

PRESCRIBED FIRE

Perceptions Regarding Longleaf Pine Ecosystem Restoration Using Fire

Samrajya B. Thapa, Jason S. Gordon, Stephen C. Grado, John W. Willis, and Robert K. Grala

Samrajya B. Thapa, Graduate Student, Mississippi State University, Mississippi State, MS, 39762; Jason S. Gordon, Associate Extension Professor, Mississippi State University, Mississippi State, MS 39762; Stephen C. Grado, Professor, Mississippi State University, Mississippi State, MS 39762; John W. Willis, Assistant Professor, Mississippi State University, Mississippi State, MS 39762; and Robert K. Grala, Professor, Mississippi State University, Mississippi State, MS 39762.

Abstract—When restored to full ecological function, longleaf pine (*Pinus palustris*) forests are among the most diverse forest ecosystems in the World. Longleaf pine forests provide unique wildlife habitat and research has shown these forests are highly resistant to insects, disease, fire, wind, and other risks. While a substantial amount of restoration has taken place on public lands, comparably less work has been accomplished on private lands. As part one of a three-phase project, key informant interviews were conducted to explore challenges and opportunities for restoring longleaf pine on private lands. Despite increased planting since Hurricane Katrina, private forest landowners were weary of prescribed fire, a critical element in the management of longleaf pine forests. Interviews examined the interest of landowners in longleaf pine restoration management, including perceptions of risk, liabilities, and economic constraints associated with prescribed fire. Results demonstrated interest in native habitat restoration, particularly for aesthetic and wildlife benefits. Landowners with small parcels expressed some interest in collaborative landscape management activities to take advantage of economies of scale, as well. However, prescribed burning costs, lack of knowledge, and absenteeism, as well as concerns over regulatory issues were key impediments to initiating restoration activities. We conclude with a discussion about ways to increase dialogue among stakeholders to help them understand the risks and benefits of appropriate ecosystem management using fire. Findings can be applied to programs that increase prescribed burning in general and to increasing the range of native longleaf pine—a positive climate change adaptation.

PRESCRIBED FIRE

Likelihood of Implementation of Fuel Reduction Treatment by Nonindustrial Private Forest Landowners

Anusha Shrestha, Robert K. Grala, Stephen C. Grado, Scott D. Roberts, and Jason S. Gordon

Anusha Shrestha, Graduate Student, Mississippi State University, Mississippi State, MS 39762; Robert K. Grala, Professor, Mississippi State University, Mississippi State, MS 39762; Stephen C. Grado, Professor, Mississippi State University, Mississippi State, MS 39762; Scott D. Roberts, Professor, Mississippi State University, Mississippi State, MS 39762; and Jason S. Gordon, Associate Extension Professor, Mississippi State University, Mississippi State, MS 39762.

Abstract—Most of the Mississippi forest land is owned by nonindustrial private forest (NIPF) landowners. Their involvement in fuel management is essential for implementing effective and coordinated fuel reduction treatments at the landscape level. This study quantified the probability that a NIPF landowner will implement a fuel reduction treatment in the next 5 years and determined a relationship between probability and landowner socio-economic characteristics. Data were collected via a mail survey of 2,000 randomly selected NIPF landowners who owned at least 40 acres of forest land in Mississippi. A logistic regression model was developed to quantify the probability of fuel reduction treatment implementation. Only 30 percent of respondents were likely to implement a fuel reduction treatment in the next 5 years. Management of undesired vegetation, promotion of tree growth, improvement of wildlife habitat, and reduction of the likelihood of a wildfire were primary objectives for implementing fuel reduction treatments. Respondents who implemented a fuel reduction treatment, had experience with wildfires, and had a written forest management plan. A similar impact had ownership of forest land for timber production and implementation of fuel reduction treatment by neighboring landowners. However, landowner age was negatively associated with the probability of treatment implementation. This study helps better understand the factors affecting the decision of NIPF landowners to implement fuel reduction treatments and their management objective for implementing these treatments. This information will help develop more effective strategies for facilitating the implementation of fuel reduction treatment and wildfire prevention and mitigation.

INTERNATIONAL POLICY ISSUES

Economic Impact of the World's Forest Sector

Yanshu Li and Bin Mei

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Abstract—Forests and the forest sector provide a range of goods and services that benefit the livelihoods of people and play an important role in local and national economies around the World. In order to help country stakeholders unlock the forest sector's full potential and achieve the goal of sustainable development, it is important to understand the sector's full economic contribution to national economies, looking beyond its direct impacts within the sector and evaluating its far-reaching economic consequence to other industries and the ripple effects through the economy.

The purpose of the study includes: (1) conduct economic contribution analysis of the forest sector using IMPLAN models for studied countries where IMPLAN data are readily available; (2) estimate total economic contribution of the forest sector based on an econometric model for countries where the IMPLAN data are currently not available; and (3) discuss social, economic, and policy factors that may affect a forest industry to reach its potential and suggest ways to enhance/accelerate potentials of the forest sector's contribution to the national economy.

INTERNATIONAL POLICY ISSUES

Investigation Outcome of Antidumping Investigations in Global Forest Products Industry

Xufang Zhang and Changyou Sun

Xufang Zhang, Ph.D. Student, Department of Forestry, Mississippi State University, Mississippi State, MS 39762; and Changyou Sun, Professor, Department of Forestry, Mississippi State University, Mississippi State, MS 39762.

Abstract—The emergence of antidumping (AD) and countervailing (CV) duties as the form of protectionism is one of the most remarkable changes in international trade during past decades. According to the Temporary Trade Barriers Database (TTBD), there are 7,121 AD cases and 923 CV duties from 1995 to 2015. AD investigation comprises petition, initiation, and decision for these three basic events. Throughout the process, different petitions may have different results from preliminary investigations to the final investigations. In this study, the determinants that strongly influence the decision of TTBDs will be analyzed. Since many other industries also feature the same characteristics that apparently lead to settled outcomes, it is likely that two creations would be illustrated in this objective. Initially, the determinants on the results from preliminary injury decision to the final decision will be assessed through both the binary logit model and multinomial logit model. Another highlight is that the impacts on AD investigations will be evaluated based on three different classifications of independent variables. The results reveal that independent variables based on case characteristics like wood products, number of foreign target firms being investigated, domestic petitioners under an association, investigation initiated after 2001 are statistically significant. Additionally, import/export value of forest products before the petition, share of tariff lines for manufactured products with international peaks, GDP per capita, are statistically significant based on the petition country's characteristics and investigated country's characteristics, respectively.

FINANCE

Assessing Risk and Return within a Portfolio of U.S. Timberland and Farmland

Weiyi Zhang and Bin Mei

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Abstract—We apply the modern portfolio theory to optimally construct portfolios of U.S. timberland and farmland, and evaluate risks and returns under different investment scenarios. First, we develop a set of synthetic timberland return series for 22 sub-regions in the U.S. South over a 17-year time horizon (2000-2016) and use the National Council of Real Estate Investment Fiduciaries data to represent returns of various farm crops. A mix of timberland and farmland assets is used to build an efficient frontier, with quarterly risk levels from -0.99 percent to 3.3 percent and expected quarterly return levels from 0.52 percent to 5.02 percent. The optimal tangency portfolio is obtained at a quarterly risk of -0.99 percent and an expected return of 2.62 percent. Recognizing the limited and discontinuous nature of the investable universe of timberland at any given time, we incorporate constraining factors and evaluate their impacts, in two scenarios. Finally, we use Monte Carlo simulation to estimate the value at risk (VaR) and conditional VaR (CVaR) of the optimal portfolios for a 10-year time span for each scenario and find increasing risk levels associated with investment of larger scales.

FINANCE

The Determinants of Transaction Frequency of Institutional Commercial Timberland Properties in the United States

Bin Mei

Bin Mei, Associate Professor, Harley Langdale Jr. Center for Forest Business, Warnell School of Forestry and Natural Resources, University of Georgia, Athens, GA 30602.

Abstract—Using property-level data (1987Q1-2015Q4) from the National Council of Real Estate Investment Fiduciaries, this study examines the determinants of transaction frequency of institutional commercial timberland properties in the United States. Controlling for both macro- and micro-level factors in a logit regression, the overall financial return of the timberland market, the discrepancy between anticipated sale price and last appraisal value, the superior performance of individual timberland properties over the market average, and the geographic locations are found to significantly influence timberland transaction frequency. Aggregate market outlook and growth rate of the national economy are also found to have material impacts on the likelihood of timberland sales.

FINANCE

The Role of Timberland in Mixed-Asset Portfolios

Weiyi Zhang and Bin Mei

Weiyi Zhang, Ph.D. Candidate, Harley Langdale Jr. Center for Forest Business, Warnell School of Forestry and Natural Resources, University of Georgia, Athens, GA 30602; and Bin Mei, Associate Professor, Harley Langdale Jr. Center for Forest Business, Warnell School of Forestry and Natural Resources, University of Georgia, Athens, GA 30602.

Abstract—We investigate the role of timberland in mixed-asset portfolios to measure the financial risk and return of timberland assets in the United States, using both private and public timberland return indices, among other traditional financial assets. This study investigates the effects of lengthening investment horizons, placing constraints on portfolios, and different risk targets. This study uses both geometric mean and arithmetic average as expected return, generalized autoregressive conditional heteroscedasticity models to estimate conditional variance and correlation, and constructs portfolios under the mean-variance framework. The results find that the inclusion of timberland assets can reduce minimum portfolio risk by 5.21 percent while yielding overall portfolio return at 13.47 percent, and private timberland assets' asset prominence in low-risk portfolios. We also conclude that public timberland exhibits lower autocorrelation than private timberland, and higher correlation with other financial assets.

FINANCE

Review of the Effects of Conservation Easements on Surrounding Property Values

Tyler Reeves, Richard Bin Mei, Pete Bettinger, and Jacek Siry

Tyler Reeves, Graduate Research Assistant, Daniel B. Warnell School of Forestry and Natural Resources, University of Georgia, Athens, GA 30602; Richard Bin Mei, Associate Professor, Forest Resource Finance and Economics, Daniel B. Warnell School of Forestry and Natural Resources, University of Georgia, Athens, GA 30602; Pete Bettinger, Professor, Landscape Planning and Harvest Scheduling, Daniel B. Warnell School of Forestry and Natural Resources, University of Georgia, Athens, GA 30602; and Jacek Siry, Professor, Forest Economics, Daniel B. Warnell School of Forestry and Natural Resources, University of Georgia, Athens, GA 30602.

Abstract—This review details the effects of conservation easements (CEs) on surrounding property values. A literature review was conducted, which examined the variable characteristics of CEs that influence property values. Key characteristics of CEs that influence surrounding property value are: permanence, the scale at which CEs are measured, proximity, the land use pattern within CEs, and the effects of agricultural and forest composition. Overall, proximity to CEs was found to increase surrounding property values. The tax implications of CEs were also examined. The effect of municipal services, effect of demand, and the potential for self-financing for additional CEs were discussed. CEs were largely found to increase tax revenue by increasing property values and have the potential for self-financing if designed properly.

NON-MARKET VALUES

Could Ecological Interpretation Improve the Happiness and Emotional Effects of Forest Recreation? Evidences from Taiwan

Wan-Yu Liu and Siang-Hao Jhuang

Wan-Yu Liu, Professor, Department of Forestry, National Chung Hsing University, Taiwan; and Siang-Hao Jhuang, Student, Department of Forestry, National Chung Hsing University, Taiwan.

Abstract—Taiwan has achieved its high economic growth at the cost of the natural environment and forest quality. Enhancing environmental quality is the optimal approach for the creation of an environment that enables people to live healthy. Humans want to live healthy and comfortable lives, and whether this expectation can be realized depends on the extent to which people care for the environment (Yu and others 2016). Since the Declaration of the United Nations Conference on the Human Environment, which called attention to the environment, many countries worldwide have endeavored to develop solutions to environmental problems. Successive sustainable development conferences held in various countries and ongoing advancement in environmental-protection-related thoughts and actions suggest that only through education can human beings become concerned about the environment, acquire appropriate attitudes, adequate knowledge, and a sense of value, and resolve to face the challenges of sustaining Earth (Chankrajang and Muttarak 2017, Kaw 2011, Ünal and Dımışkı 1999).

This study investigated whether the addition of guided tours to forest therapy cause any differences in happiness effects, stress effects, and emotional effects. The results revealed that on average, the visitors to Sheding Nature Park were approximately 38 years old, earned an annual income of NT$45,000, visited the park with 8–9 companions, less than 1 of whom required attentive care, visited the park 2–3 times in the previous year, and rated their satisfaction with the park between "Satisfied" and "Very Satisfied." Furthermore, there were more female visitors than male visitors and more married visitors than unmarried visitors. The occupation of most visitors was student or a position in the service industry, military, or civil service. Most visitors had an academic background unrelated to forestry, ecology, the environment, or natural resources and were university graduates. The type of travel among the visitors was predominately backpacking, and most came from other regions of Taiwan. Regarding the willingness to participate in a guided tour, the female visitors were more inclined to participate than the male visitors, and the unmarried visitors were more inclined to participate than the married visitors. Those who were students, freelancers, or who worked in the service industry, military, civil service, or financial industry were more inclined to participate in guided tours. The visitors with backgrounds unrelated to forestry, ecology, the environment, or natural resources were slightly less inclined to participate, whereas those whose educational level was high school senior, junior college, or master's degree were more inclined to participate. Visitors traveling as backpackers were less inclined to participate, and those who listed the People's Republic of China as their residential location were slightly less inclined to participate. The average admission fee that visitors were willing to pay was NT$61.28. The visitors who had participated in guided tours exhibited a significantly higher level of recreational satisfaction with the park and willingness to pay a significantly higher admission

fee. In addition, visitors who participated in guided tours showed greater satisfaction with the guided tours than with the park itself. Similarly, the price visitors are willing to pay for the guided tours is higher than the price they are willing to pay for admission.

Descriptive statistics of the participants' mental state after forest therapy reveal that in general, their conditions improved. Moreover, the positive influence of forest therapy, which could be manifested as happiness effects, stress effects, and emotional effects, was significantly greater on participants taking guided tours, particularly in improving their sense of happiness and happy mental state. For participants not taking guided tours, although they also experienced an improved sense of happiness, the extent was less noticeable than that of participants who participated in guided tours. This infers that for most visitors, the most noticeable change in their mental states after forest therapy were improvements in the sense of happiness, and generally the improvement was significantly higher among visitors who took guided tours. However, the greatest difference was in the level of excitement.

Multiple linear regression analysis on tourists' travel evaluations revealed the following results. In the "Number of Visits to Sheding Nature Park Last Year" model, the visitors who were younger, earned a lower annual income, gave more positive evaluations of the guided tours, and experienced greater improvements from the emotional effects of forest therapy were more willing to revisit the park and visited the park more frequently. In the "Recreational Satisfaction of Sheding Nature" model, the visitors who were willing to pay a higher admission fee and who exhibited higher satisfaction over the guided tour also exhibited greater recreational satisfaction with the park. In the "Willingness to Pay for Tickets for Sheding Nature Park" model, the visitors who were less willing to pay for admission visited Sheding Nature Park more often, and when visitors' recreational satisfaction over the park increased, the price they were willing to pay for admission was effectively increased. Similarly, when the price visitors were willing to pay for guided tours was higher, the price they were willing to pay for admission was also higher.

Multiple linear regression analysis on the happiness effects, stress effects, and emotional effects of forest therapy revealed the following results. In the "Happiness Effects" model, when visitors' satisfaction with the park was higher, or when visitors experienced favorable stress-relieving effects after forest therapy, the happiness effects were enhanced. In the "Stress Effects" model, the higher the visitors' satisfaction with the guided tours, the lower was the stress-relieving effects after forest therapy. However, when the visitors experienced a greater sense of happiness or greater improvement in mood after forest therapy, they also experienced greater stress-relieving effects. In the "Emotional Effects" model, visitors with a higher annual income or those who visited the park more frequently the previous year experienced greater mood-improving effects after forest therapy. Similarly, visitors who experienced greater stress-relieving effects after forest therapy also experienced greater improvements in their moods.

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NON-MARKET VALUES

Using Conservation Auctions to Improve Cost Effectiveness: The Case for Introducing an Auction into Costa Rica's Existing Payments for Ecosystem Services (PES) Program

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Abstract—Payments for ecosystem services (PES) have been widely advocated for tropical forest conservation. Direct payments for voluntary forest conservation are theoretically more cost effective than indirect incentives. However, there are barriers to creating a cost effective program in practice.

One such barrier is information asymmetries. In theory, a cost effective program would pay landowners an amount equal to their opportunity cost of participation. However, opportunity cost is private information, making it difficult for implementing agencies to determine the opportunity cost of each landowner. This is one reason that many PES programs, including Costa Rica's forest protection program, pay a flat, per-hectare rate. This fixed rate offers rents to landowners whose opportunity costs are low and potentially excludes landowners who could offer high value ecosystem services but have opportunity costs above the fixed rate.

The agency responsible for PES in Costa Rica has been charged with developing mechanisms to increase cost effectiveness. One possible mechanism is a procurement auction. We explore the implications of introducing an auction into the Costa Rican PES program using an agent based model (ABM) reflecting the structure of Costa Rica's PES program and characteristics of program participants. We examine the implications of possible auction mechanisms for the distribution of participation, informational rents captured by participants, and environmental benefits generated per dollar. We find that a first price, discriminatory auction with targeting for both environmental and social benefits has the best combination of outcomes, including greater cost effectiveness and more equitable participation.

Modeling Demand for Lottery Rationed Recreation with Permit Application: Case of Elk Hunting in Tennessee

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Abstract—The Tennessee Wildlife Resource Agency (TWRA) started elk restoration in the five-county region surrounding the North Cumberland Wildlife Management Area in 2000. As the population started to expand, a quota hunting program was established in 2009 to manage the elk population. While the restoration program is well justified from an ecological perspective, continuous public support for the program requires an understanding of the benefit it brings to the region through hunting, wildlife watching, and related activities. This study aims to characterize the economic value of one such service, the opportunity to hunt elk. Due to its nonmarket good nature, the economic benefit of hunting is typically estimated by applying an individual or zonal travel cost model to trip profile data. A trip-based travel cost model is not appropriate in this case, however, because a lottery-rationed hunting permit system dictates hunting opportunities. To address this issue, this study employed a zonal travel cost approach to model the demand for elk hunting permits, in which permit applications by ZIP code numbers were analyzed along with travel cost, and demographics of permit applicants' origins using a count data regression model. The estimated consumer surplus, a monetary measure of expected benefit or the value of opportunity to hunt elk in Tennessee was estimated and then aggregated across ZIP code numbers to derive the total benefit of elk hunting in Tennessee. The estimated consumer surplus under different modeling assumptions suggests a substantial value for elk hunting in Tennessee. The results will inform researchers, recreation managers, and policymakers in understanding the public value of elk restoration in Tennessee and similar regions where elk restoration is being considered.

NON-MARKET VALUES

Understanding Stakeholders' Perceptions about Forestry Best Management Practices in Georgia

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Abstract—The success of forestry Best Management Practices (BMPs) depends heavily on the coordination among primary stakeholder groups. We used the Strengths, Weaknesses, Opportunities, and Threats analysis with the Analytical Hierarchy Process (SWOT-AHP) framework to assess perceptions of three stakeholder groups (loggers, landowners, and agency foresters) about forestry BMPs in Georgia, the largest roundwood producing State in the United States. The agency and logger stakeholder groups gave the highest priority to improved reputation under the strength category, whereas the landowner stakeholder group perceived sustainable forestry as the highest priority under the same category. Lack of landowner education was the highest priority under the weakness category for landowner and agency stakeholder groups, whereas the logger stakeholder group selected lack of trained personnel as the highest priority under the same category. Agency and landowner stakeholder groups gave the highest priority to training and education while loggers indicated maintenance of forest-based environmental benefits as their highest priority under the opportunity category. Finally, landowners and agency stakeholder groups perceived more regulations and restrictions as most significant in the threat category whereas the logger stakeholder group was most concerned about the insufficient accounting of cost sharing under the same category. Overall, selected stakeholder groups recognize the importance of forestry BMPs and had positive perceptions about them. A collaborative approach based on continuous feedback can streamline expectations of stakeholder groups about forestry BMPs in Georgia and several other States that are interested in maintaining a high compliance rate of forestry BMPs for ensuring sustainable forest management.

NON-MARKET VALUES

Big Game Hunting Demand in Georgia: A Travel Cost Analysis

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Abstract—Big game hunting is a popular recreation activity for millions of hunters who hunt on public and private land. Studies in the forest economics literature have not examined hunting demand by comparing price response and value across different land ownership classes. The objective of this study was to estimate and compare the economic value of hunting trips across land ownership types in Georgia. The study employed travel cost modeling (TCM) with data collected from a mail survey of licensed big game hunters. Results indicate that the net economic benefit of hunting access varies across access types, and hunting trips to leased private land sites yield more value than trips to non-leased private land or public land. In addition to travel cost and land ownership type, age, income, retirement status, experience, and presence of food plots were significantly correlated with trip demand. Findings will be useful in understanding the net economic benefit of big game hunting, as well as preferences for and price response to access on hunting lands under different ownership regimes.

REGIONAL ECONOMICS

Historical Contribution of the Forest Products Industry to West Virginia's Economy: A Look at 2006, 2010, and 2015 Data

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Abstract—West Virginia is the third most forested State in the United States and is the second leading hardwood timber producing State in the country. Continuing global competition and the economic recession of 2007-2009 have caused major disruption to the West Virginia forest-related industries. Through the utilization of IMPLAN input-output economic modeling, this research examines the direct, indirect, and induced contributions of the forest products industries to the West Virginia's economy for the years 2006, 2010, and 2015. Initial analysis shows that, though forest product industry employment had already started to decline from peak levels in the late 1990s, from 2006 to 2010 direct employment declined by 35 percent. In the 4 major forest products sectors of solid wood products, logging, pulp and paper, and wood furniture, more than 5,500 jobs were lost during this time period. The industry's direct contribution to the State economy also decreased by 33 percent from 2006 to 2010. While there has been significant recovery since the recession, much of that has taken place in supporting industries, not in the forest-related sectors directly. By 2015, direct employment in the four major sectors had still not recovered to pre-recession levels and only one of the major sectors (the pulp and paper sector) had recovered in terms of the economic contribution to the State's economy. As substantial challenges face the West Virginia economy, understanding the contribution of one of the State's key industries is crucial to meeting them.

Forest Products Industry Contributions to Ohio's Economy: A Comparison of Statewide and Regional Analyses

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Abstract—The forest products sector makes important contributions to Ohio's economy. Impact Analysis for Planning (IMPLAN), a leading economic simulation program, is often used to estimate economic contribution of particular industries or impact of changes in a particular industry (Day and others 2012). In this study, IMPLAN 2015 data was used to analyze forest products industry's contribution to Ohio's economy. IMPLAN results were then further analyzed using forest resource data of the U.S. Forest Service Forest Inventory and Analysis (FIA). In 2015, forest products industries in Ohio generated $9.95 billion in value-added from conversion of forest products. They also had a total impact of 122,000 jobs throughout the State's economy, generating $6.5 billion in wages and benefits. These economic activities generated substantial amounts of Federal, State, and local taxes. However, focusing on statewide results often mask regional differences within a State. For this analysis, six regions within Ohio (Northwestern, Southwestern, South Central, Southeastern, East Central, and Northeastern) were examined (fig. 1). Not surprisingly, these

Figure 1—Six regions within the State of Ohio.

regions had substantial differences in resource base (table 1). However, when separate economic models were run, a rather interesting pattern emerged. Evidently, resource rich regions sometimes did not benefit from their resources (table 1). In Ohio, Southeast, South Central, Northeast, and East Central regions have most of the forest resources. While the Northeast appears to be doing well in capturing economic benefits through value added industries, the other regions are not. On the other hand, Northwest and Southwest, two resource-poor regions, are capturing most of the value added from forest products. A region's ability to capture economic benefit through value added is obviously highly correlated with the region's industrial infrastructure. However, there are important policy and social implications of such a situation. Economic activities generate State and local taxes. Legislators often use tax contributions as a factor in their decision for allocating funds for different economic and social programs. Consequently, some regions may not adequately benefit from these programs, even though their forest resources are helping other regions to do so. This raises serious equity and social justice concerns. As an example, one particular region in Ohio, the Southeast, is a part of rural Appalachia. Despite its natural beauty and lush forests, the region has high levels of poverty and unemployment. This, in turn, gives rise to other social problems. It is, therefore, imperative that Federal, State, and local governments redouble their efforts in these regions through increased education, training, and funding for business development to encourage primary and secondary processing industries. This will enable these regions to maximize economic benefits from their forest resources.

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Table 1—Economic and forest resource data for Ohio regions

Economic and resource indicators	EC	NE	NW	SC	SE	SW
Forest area (MM acres)	1.86	1.52	0.77	1.76	1.43	0.71
Volume (MMBF)	42,770	41,027	20,695	42,638	35,887	17,787
Removals (MMBF)	696	441	249	445	345	168
Growth to drain	1.40	2.12	0.51	1.80	2.03	1.74
Employment	6,221	17,335	11,274	4,207	1,243	13,911
Value added (MM$)	401.94	6,368.22	774.10	16.20	66.24	1,119.38
Percent of State totals	4.60	72.81	8.85	0.19	0.76	12.80
Federal taxes (MM$)	104.84	454.80	219.12	89.79	15.16	368.66
Percent of State totals	7.30	31.68	15.26	6.26	1.06	25.68
State and local taxes	49.97	227.59	108.98	50.96	7.38	196.79
Percent of State totals	6.67	30.40	14.55	6.81	0.99	26.28
Taxes per acre of forest	83.06	448.22	424.12	79.27	15.77	794.12
Taxes per MMBF of removals (MM$)	0.23	1.55	1.32	0.32	0.07	3.37
Employment per MMBF of removals	8.94	39.35	45.34	9.44	3.60	82.80
Value added per MMBF of removals (MM$)	0.58	14.46	3.11	0.04	0.19	6.66

EC = East Central; NE = Northeastern; NW= Northwestern; SC = South Central; SE = Southeastern; SW = Southwestern.

REGIONAL ECONOMICS

Economic Contribution of Forest Products Industry in Michigan: A Comparison of Simple Multiplier Versus Multi-industry Approach

Jagdish Poudel

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Abstract—Twenty million acres of land in Michigan is forested, and timberland accounts for 95 percent of this forest land. These forests have always supported local and State economies and generated employment and income. In 2013, the Michigan Department of Natural Resources (DNR) and the Governor-appointed Timber Advisory Council developed five goals to encourage the growth of the industries by 2018. This study estimates the economic contribution of forest product industries in Michigan using IMPLAN 2016 data. It provides a snapshot of direct economic activity associated with given industries and other economic activities linked to those industries. These contributions were estimated at the State level using a multi-industry approach and simple multiplier approach. The multi-industry approach simplifies commodity production within each sector by eliminating inter-sectoral linkages and modifying trade flows by stopping local purchases from forest products industries beyond the amounts specified as direct outputs. Results show that the simple multiplier approach overestimates the economic contribution. Hence, a multi-industry approach should be used for forest products economic contribution analysis.

INTRODUCTION

Forests in Michigan have been managed not only for timber production but also for wildlife habitat, water protection, biodiversity conservation and forest-based ecosystem services (Pugh and others 2017). Fifty-four percent (20.3 million acres) of land in Michigan is forested, and timberland accounts for 95 percent of this forest land (Michigan Forests 2014). Historically, forests in Michigan have always supported local and State economies and generated employment and income (Leefers 2014). There is an increase in public interest, particularly in the post-recession period, in knowing the economic contribution of forestry and forest product industries (FPI) in Michigan. More specifically, the Governor's Forest Products Summit held on April 23, 2013, was convened to explore ideas and options for growing the State's forest products industries (FPI) (Leefers 2018). Consequently, the Timber Advisory Council was appointed by the Governor and the Michigan Department of Natural Resources (DNR) to fulfill five major goals: to increase the economic impact of the timber industry on State and regional economies from $14 to $20 billion; to increase the export of value-added forest products by 50 percent; to increase forest products-related careers by 10 percent; to support existing industry; and to encourage regionally based industry development.

A trend analysis of the contribution of the forest products industry is necessary to accurately portray the role this industry plays in Michigan. Since 1990, there have been significant declines in employment in the FPI (Leefers 2018). However, according to the Bureau of Economic Analysis (BEA), the forestry and logging industry employment has increased by almost 44 percent since 2010 (table 1). Wood product manufacturing and paper manufacturing employment have increased by 20.6 percent and 3.7 percent, respectively. The annual trend of these forest industries is shown in figure 1. Employment number in these selected forestry industries were decreasing before (pre-recession) or during the recession but are increasing in the post-recession period (fig. 1).

Table 1—Direct employment for seven aggregated forest products industries (2015 and 2016)

Aggregated forest products industries	2015	2016	% change
Forestry	685	1,002	46.33
Logging	4,491	4,145	-7.69
Primary solid wood products and wood-based power	5,096	4,707	-7.63
Secondary solid wood products	7,305	7,078	-3.11
Wood furniture	10,283	10,562	2.72
Pulp, paper and paperboard	3,086	3,096	0.29
Secondary paperboard and other paper products	8,472	8,778	3.62
Total	**39,417**	**39,368**	**-0.13**

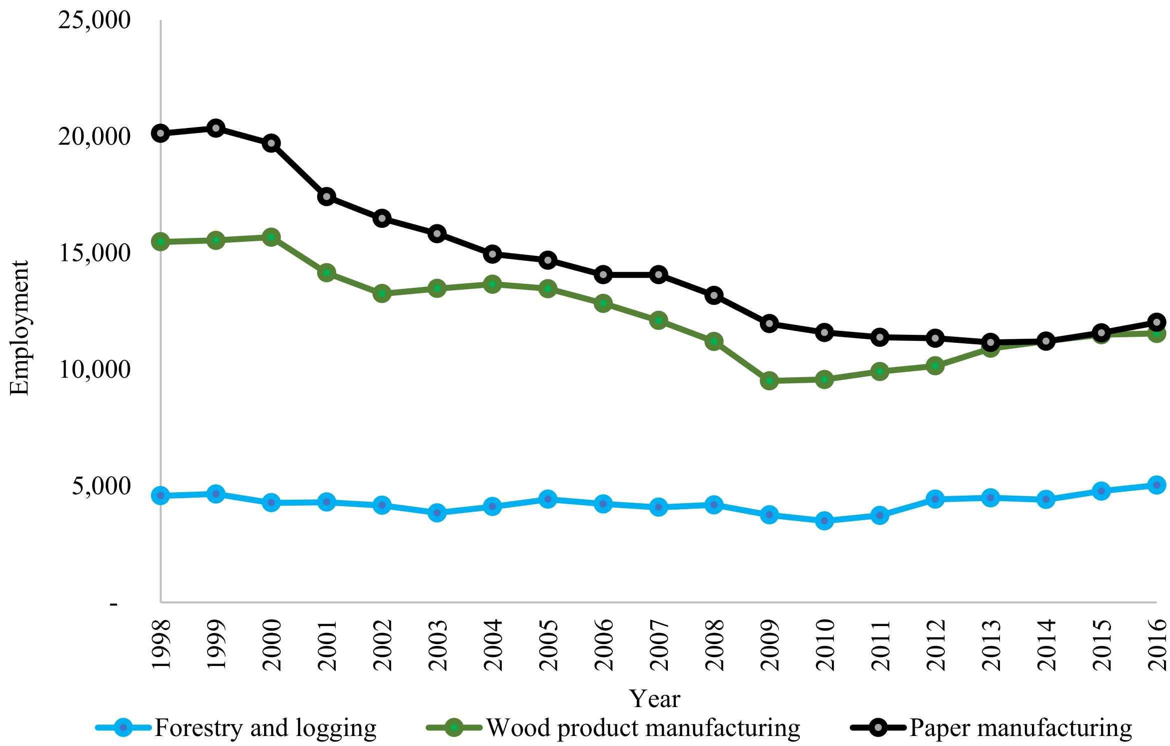

Figure 1—Total full-time and part-time employment in selected forest product industries. (Source: U.S. Bureau of Economic Analysis Regional Economic Accounts, table SA25N, 2018)

Understanding the importance of FPI and their economic contributions have become so important that policymakers, public and private agencies, and academics have conducted numerous studies on the economics of forestry, logging, and forest product industries across the United States. Many researchers use Impact Analysis for Planning (IMPLAN) modeling software and data to estimate the economic contribution of forest product industries (Dahal and others 2015, Khanal and others 2017, Leefers 2018, Parajuli and others 2017, Tilley and Munn 2007) and forest-based outdoor recreation activities (Poudel and others 2016, 2017, 2018). A widely used economic input-output modeling software, IMPLAN is a mathematical model and calculates the estimated economic impact through algorithms that are deterministic rather than stochastic (Poudel and others 2017, 2018). Economic contribution analysis can play a role in the formulation of State and Federal policies and regulations and related management activities pertaining to forestry, as these actions affect revenue, taxes, employment, and income. Hence, periodic assessment of the economic contribution of forestry in Michigan is necessary to provide a consistent perspective over time.

The objective of this paper is to estimate the economic contribution of FPI in Michigan in terms of employment (full- and part-time jobs), labor income, output, and total value added by using 2016 IMPLAN data. In the process, this paper examines the discrepancy of results using simple multiplier approach (economic impact) and multi-industry approach (economic contribution). It is hoped that this assessment will allow us to derive more accurate economic contribution estimates. This paper proceeds as follows: Section 2 provides background; section 3 describes the methods; section 4 reports economic contribution estimates using different approaches; and section 5 close with discussion and conclusions.

BACKGROUND

In light of increasing employment in the forestry and logging, wood product manufacturing, and paper manufacturing industries (fig. 1), there is an increasing interest in how they contribute to Michigan's economy. The future of forests in Michigan depends in large part on the support of policymakers and constituents. An essential element in garnering that support is documenting the magnitude of the contributions of FPI and forest-based recreation activities. Forests in Michigan are the basis for substantial economic activity, and thus, forest-based industries have long been recognized as a significant contributor to Michigan's economies (Leefers 2015, 2016). Recently, forest-based outdoor activities such as hunting, fishing, wildlife watching activities, and wood based energy are also recognized as a significant contributor to economies in the U.S. South (Poudel and others 2016, 2017, 2018; Pokharel and others 2017a, 2017b).

Previous assessments by Leefers (2014), Leefers (2015), and Leefers (2016) have shown that traditional FPI are relatively fluid, with the industry shifting over time. Forests in the United States have a diverse ownership pattern which has changed substantially over the last three decades. In 1981, there were about 66 million acres of timberland owned by industrial forest landowners that contributed 29 percent of the nation's timber supply (Smith and others 2004). In 2005, there was a 60 percent reduction of timberland (Seneca Creek Associates 2005). As such, assessments of economic contributions quickly become dated. Several researchers across the United States have demonstrated the magnitude of contributions to the United States economy by FPI. As pointed out by Abt and others (2002), wood products jobs in the Southern United States increased from 36.5 percent to 39.3 percent during 1987-1997. Furthermore, forest-based jobs increased by 13 percent from 1992 to 2001 in the U.S. South (Aruna and others 1997, Tilley and Munn 2007). However, the Great Recession (2007-2009) severely impacted FPI in the United States. Woodall and others (2011) reported that forestry-related sectors in the United States lost over 1.1 million jobs. In the Northern United States, wood products manufacturing, paper manufacturing, and furniture manufacturing lost 28 percent of jobs during this period (Woodall and others 2011). In the post-recession period, FPI in

Michigan started to grow (fig. 1). In 2015, the total economic contribution of forest industries was $21.2 billion and over 99,000 jobs were supported by this industry (Leefers 2018). In terms of forest-based recreation activities, 4.4 million people in Michigan spent $6.1 billion on activities such as hunting, fishing, and wildlife watching in 2011.

Leefers (2014) first documented the economic contribution of the forest products industry in Michigan using 2012 data. His report established the baseline conditions for studies that followed and, more importantly, illustrated the benefits of evaluating with a standard methodology so that comparisons between States were valid. Leefers (2014, 2015) followed suit in using 2014 and 2015 data to demonstrate the overall forest-based industry contribution. Leefers (2018) replicated his previous studies using 2015 data to detail industry-level changes, and inter-sectoral changes that had occurred over the years between studies. These studies, in aggregate, have demonstrated the benefits of periodic evaluations of the economic contributions of forest-related activities. All of the above-referred studies have relied on an input-output analysis in whole or in part to estimate economic contributions. Input-output analysis is commonly used to document the economic contributions of the forest-products industries and forest-based recreation activities (Leefers 2014, 2015; Poudel and others 2016, 2017, 2018).

Tracking the economic contribution of FPI and forest-based recreation activities is critical for many reasons. First, quantifying the magnitude of these contributions is key to garnering support for forest resources and associated economic activity. Second, documenting changes among these activities over time is a useful method of measuring the economic health of these activities. Third, the economic data can be used to assess if changes in policy, legislation, or tax laws may be affecting forest-based economic activity. Finally, documenting shifts among specific types of forest-based economic activity in Michigan may indicate how responsive the various activities are concerning changes in local supply and demand. Hence, the proposed study will employ an input-output analysis to provide estimates for the FPI using 2016 data and usage both, simple multiplier and multi-industry approach.

METHODS

The forest products industry influences the economy in three ways: direct (when industry responds to demand), indirect (initiated by the directly impacted sectors), and induced effects (household spending by employees in the directly and indirectly impacted industries). The total economic contribution is the value of production required to meet all the needs stemming from the initial activity—in this case, forest product-related purchases. Input-output modeling using IMPLAN is a conventional approach in documenting the economic contribution of FPI. However, these approaches change over time as new methods are developed and implemented. Recently, Henderson and others (2016) and Joshi and others (2017) highlighted similarities and differences in forest industry modeling in the Southern United States. While forestry and agricultural researchers have not settled on standard methods or sectors for defining their industries, it is of great importance to distinguish the results using different modeling approaches. The method for calculating total economic contribution in previous literature relied on the use of sectoral multipliers. This approach, while simple and straightforward, overestimates total contributions due to backward linkages between forest industry sectors and purchase of forest products commodities locally. The magnitude of this overestimation is unknown without more detailed analyses, which is what I do in this paper. I-O models were constructed for Michigan using 2016 IMPLAN State-level data. Models were constructed using a simple multiplier approach and a multi-industry approach. Major economic indicators such as employment (full- and part-time jobs), total income, total output and value-added (in millions of dollars) were estimated. To simplify reporting and facilitate comparisons between studies, economic contribution is computed for seven forest-based industry sectors, consistent with Leefers (2017), and Leefers (2018): forestry; logging; primary solid wood products and wood-based power; secondary solid wood products; wood furniture; pulp, paper and paperboard; and secondary paperboard and other paper products. Results from the models are reported for key economic indicators: employment, total income, value-added, total output, and social accounting matrix (SAM) multipliers. Multi-Industry Contribution Analysis was performed by using the IMPLAN recommended process (https://implanhelp.zendesk.com/hc/en-us/articles/115009542247-Multi-Industry-Contribution-Analysis). This method simplifies commodity production within each sector by eliminating inter-sectoral linkages and modifying trade flows by stopping local purchases from FPI beyond the amounts specified as direct outputs. Multi-industry contribution analysis can also be performed by using the methods described in Henderson and Evans (2017).

RESULTS

Simple Multiplier Approach

The direct employment for seven aggregated forest product industries is reported in table 1. Employment in forestry sector increased by 46 percent in 2016 while logging sector employment decreased by 7.6 percent. Overall, seven aggregated forest products industry sector employment remains fairly constant. The direct contribution of Michigan's FPI industries in 2016 were $11.7 billion in output (2016 dollars), 39,367 jobs and $2.6 billion in labor income (table 2). Total contributions, including direct, indirect and induced effects, were $20.9 billion in output, 99,238 jobs and $5.7 billion in labor income. All of these measures highlight positive growth in aggregate when compared to previous assessments by Leefers (2016), Leefers (2017), and Leefers (2018). On average in the FPI, one new job creates 1.52 additional jobs (multiplier = 2.52).

The 10 IMPLAN sectors that benefited most from the FPI in Michigan, as ranked by employment, are reported in table 3. Employment was highest at 8,091 for commercial logging followed by paperboard container manufacturing at 6,957. Labor income, value-added, and total output associated with respective economic sectors are reported in table 3. Based on labor income to employment ratios, the highest average income was in the paper mills industry sector ($122,161) compared to commercial logging sector ($35,957). Even though commercial logging sectors generated higher total employment, average income in this sector was < $40,000. SAM multipliers for employment, total income, total output and value-added are reported in table 2.

Multi-industry Approach

The direct contributions of Michigan's FPI in 2016 were $11.7 billion in output (2016 dollars), 39,367 jobs and $2.6 billion in labor income (table 4). Direct contribution does not change in either the simple multiplier or multi-industry approach. Total contributions, including direct, indirect and induced effects, were $19.3 billion in output, 87,615 jobs and $5.2 billion in labor income. All of these measures are comparatively less than what we observed in simple multiplier approach. On average in the FPI, multi-industry approach shows that every new job creates 1.23 additional jobs (multiplier = 2.23).

The 10 IMPLAN sectors that benefited the most from the forest product industries in Michigan, as ranked by employment, are reported in table 5. Employment was highest at 6,782 for paperboard container manufacturing followed by wood office furniture manufacturing at 4,336. Labor income, value-added, and total output associated with respective economic sectors are reported in Table 5. Based on labor income to employment ratios, the highest average income was in the paper mills industry sector ($122,161) compared to commercial logging sector ($35,957). Even though paperboard container manufacturing sectors generated higher total employment, average income in this sector was about $68,000. SAM multipliers for employment, total income, total output and value-added are reported in table 4.

As shown earlier, results substantially vary between the simple multiplier and multi-industry approach. The multi-industry approach lowers total output by 8.4 percent compare to the simple multiplier approach in 2016 (table 6). Previous assessment by Leefers (2018) shows that the multi-industry approach lowers total output by 8 to 11 percent when comparing across different years (2012-2015). Table 6 reports the percentage of overestimation of the simple multiplier approach over the multi-industry approach.

Table 2—Economic contribution of forest products industries in Michigan using simple multiplier approach, 2016

Impact type	Employment	Labor income	Total value added	Output
Direct effect	39,367	2,670,650,075	3,338,468,174	11,772,519,490
Indirect effect	30,326	1,792,142,208	2,625,535,301	5,203,880,928
Induced effect	29,545	1,275,267,726	2,282,096,185	3,974,187,437
Total effect	99,238	5,738,060,009	8,246,099,660	20,950,587,855
SAM multiplier	2.52	2.15	2.47	1.78

Table 3—Top 10 industries that benefited from forest product industriesin Michigan ranked by employment, 2016 (simple multiplier approach)

IMPLAN sector	Description	Employment	Labor income	Value added	Output
16	Commercial logging	8,091	$290,935,222	$316,299,600	$637,736,155
149	Paperboard container manufacturing	6,957	$474,791,752	$614,689,629	$3,100,203,888
373	Wood office furniture manufacturing	4,347	$335,975,289	$472,880,773	$1,058,445,073
395	Wholesale trade	4,040	$342,222,279	$648,262,803	$974,019,714
134	Sawmills	3,418	$230,405,848	$216,643,095	$921,347,128
147	Paper mills	2,304	$281,398,732	$522,251,528	$1,897,194,427
142	Wood container and pallet manufacturing	2,213	$144,005,258	$136,060,917	$363,581,990
440	Real estate	2,197	$55,198,226	$276,609,779	$403,155,437
501	Full-service restaurants	1,991	$40,377,415	$44,599,293	$91,213,740
502	Limited-service restaurants	1,988	$35,436,693	$85,795,575	$157,327,662

Table 4—Economic contribution of forest products industries in Michigan using multi-industry approach, 2016

Impact type	Employment	Labor income	Total value added	Output
Direct effect	39,367	2,670,650,075	3,338,468,174	11,772,519,490
Indirect effect	21,486	1,383,168,995	2,129,027,527	3,941,198,149
Induced effect	26,763	1,154,584,970	2,067,942,413	3,597,303,036
Total effect	87,615	5,208,404,039	7,535,438,114	19,311,020,675
SAM multiplier	2.23	1.95	2.26	1.64

Table 5—Top 10 industries that benefited from forest product industries in Michigan ranked by employment, 2016 (multi-industry approach)

IMPLAN sector	Description	Employment	Labor income	Value added	Output
149	Paperboard container manufacturing	6,782	$462,884,315	$599,273,653	$3,022,452,992
373	Wood office furniture manufacturing	4,336	$335,123,857	$471,682,395	$1,055,762,752
16	Commercial logging	4,145	$149,044,055	$162,038,046	$326,707,712
395	Wholesale trade	3,673	$311,180,411	$589,460,994	$885,669,557
134	Sawmills	2,604	$175,551,006	$165,064,878	$701,993,536
147	Paper mills	2,185	$266,927,920	$495,394,962	$1,799,632,000
142	Wood container and pallet manufacturing	2,103	$136,858,642	$129,308,558	$345,538,336
440	Real estate	2,011	$50,521,595	$253,174,211	$368,998,378
501	Full-service restaurants	1,826	$37,028,447	$40,900,155	$83,648,323
502	Limited-service restaurants	1,822	$32,482,404	$78,642,963	$144,211,557

Table 6—Percentage of overestimation of simple multiplier approach results over multi-industry approach results

Impact types	Employment	Labor income	Value added	Output
Direct effect	N/A	N/A	N/A	N/A
Indirect effect	41.15	29.57	23.32	32.04
Induced effect	10.40	10.45	10.36	10.48
Total effect	13.27	10.17	9.43	8.49

N/A = Not applicable.

DISCUSSION AND CONCLUSION

Forestry and FPI have an important role in natural resources management as they provide a source of income and employment across a wide range of economic sectors where forest product industries operate. This paper estimated the economic contribution of forest product industries in Michigan using 2016 IMPLAN data. While the demand for forest products, as indicated by the timber harvest and increasing timber market, is increasing, direct impact in terms of employment is relatively constant. However, different forest products sectors observed changes in employment. Substantial change was observed in sector forestry which includes IMPLAN sector 15 (forestry, forest products, and timber tract production) and IMPLAN sector 19 (support activities for forestry). The number of direct jobs increased by 100 percent in support activities for forestry. This sector is comprised of establishments primarily engaged in performing particular support activities related to timber production, wood technology, forestry economics and marketing, and forest protection. These establishments may provide support activities for forestry, such as estimating timber, forest firefighting, forest pest control, and consulting on wood attributes and reforestation.

Simple multiplier and multi-industry approach results show that the indirect effect resulting from direct employment in the forest products industry is overestimated by almost 41 percent, induced effect overestimated by 10.4 percent and total employment effect is overestimated by 13.2 percent. While the percentage of overestimation for different economic indicators is almost the same in induced effects, substantial variations are observed in indirect and total effect. This suggests that the simple multiplier approach produces economic contribution results by including both indirect and induced impacts of its own industry sectors that overestimate the total value of the sector. This is because of input bias that results when modeling output as a final demand (Henderson and Evans 2017). Such input bias can be corrected by adjusting the direct effect to account for indirect and induced effects a sector can have upon itself (Henderson and Evans 2017). Hence, the model adjustment was necessary in order to avoid indirect and induced impacts from its own industry sectors. The adjustment technique recommended by IMPLAN was used to estimate economic contribution analysis (https://implanhelp.zendesk.com/hc/en-us/articles/115009542247-Multi-Industry-Contribution-Analysis). Recently, Henderson and Evans (2017) suggested the alternative way to adjust the model outside of IMPLAN software. Either way, it is expected that both model adjustment methods, inside the IMPLAN software and outside the IMPLAN software, would produce similar results.

The output to employment ratios considerably vary across different forest products sectors. Higher labor productivity is observed in the paper mill sector. SAM multipliers for key economic indicators were higher in the simple multiplier approach than in the multi-industry approach, indicating own-industry sectors rounding in the economy. In general, a higher multiplier suggests that regional economies are better able to capture spending. Diverse and abundant forest resource availability, harvesting seasons, and associated industry sectors likely capture more rounds of re-spending and thus contribute to overall economic contributions. The simple multiplier approach overestimates the economic contribution by almost 8 percent in terms of industry output, indicating that the impacted economic sectors had double counts for intra-industry linkage. Thus, the differences in economic contributions likely resulted primarily from differences in the modeling technique. From a policy perspective, it may be worthwhile to adopt a multi-industry approach that provides accurate estimates, favoring either type over the other (model adjustment methods) is not warranted without further investigation.

This paper also demonstrated which economic sectors benefited from the forest products industry and to what degree. An understanding of how various sectors of the economy benefit can provide insights into the potential local economic multiplier effects that result from maintaining or expanding pubic investments that are supportive of the forest products industry. The commercial logging sector benefited the most with respect to employment in the simple multiplier approach; however, average income for those jobs were low compared to the paper mills industry. Paperboard container manufacturing generated higher employment when using the multi-industry approach; however, mean wages were substantially higher when compared to commercial logging. This suggests that different modeling approaches do produce different results.

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PRIVATE FORESTS

Determinants of NIPF Landowners' Use of Consulting Foresters in Mississippi

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Abstract—Among other activities, consulting foresters help landowners make critical management decisions and encourage reforestation after final harvest. However, research and anecdotal evidence suggest a large portion of nonindustrial private forest (NIPF) landowners do not utilize the services of consulting foresters. This paper describes the willingness of landowners to hire a consulting forester. In 2010, Mississippi NIPF landowners were selected randomly from a property tax mailing list maintained by Mississippi State University. Participants were surveyed to determine their attitudes and behaviors regarding consulting foresters, and to identify the characteristics of those landowners willing to hire consultants. A binary probit regression model was used for analysis. Results indicated one-fourth of the survey participants were willing to use a consulting forester to manage their forest land. These landowners tended to have larger forest tracts, higher income, and higher education levels than their counterparts. In addition, age was negatively correlated with willingness to hire a consulting forester. The paper concludes by suggesting ways to improve collaboration and communication between consulting foresters and NIPF landowners to increase the quality and quantity of goods and services from NIPF lands.

PRIVATE FORESTS

Landowners' Willingness to Accept Compensation for Managing Open Pine Stands for Ecosystem Services

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Abstract—Pine forests of the Southern United States provide habitat for many threatened wildlife species such as gopher tortoise (*Gopherus polyphemus*), red-cockaded woodpecker (*Picoides borealis*) and Mississippi sandhill crane (*Grus canadensis pulla*). In addition, pine forests in the region contribute the largest share of timber volume of any U.S. timber market. However, these pine dominated forest ecosystems are threatened by land conversion, urbanization, invasive species, and widespread accumulation of hazardous fuels. Increasing rotation age and implementing other conservation practices helps to not only produce quality timber as well as increase the provision of ecosystem services. However, because the majority of forest lands in the region is owned by nonindustrial private forest (NIPF) landowners, their cooperation is necessary to increase the provision of ecosystem services. To investigate NIPF landowners' willingness to participate in a conservation program and quantify monetary budgets necessary to increase the provision of ecosystem services, this study conducted a contingent valuation survey in the East Gulf Coastal Plain of the Southern United States. A binary logit model was constructed to analyze the survey data. Preliminary results indicated that landowners' average willingness to accept (WTA) compensation was $170 per acre per year and WTA compensation was associated with bid amount, owning land for maintaining wildlife habitat, and frequency of contact with local conservation groups. An effective conservation education through mobilization of local conservation groups might help to increase NIPF landowner participation in open pine stand conservation programs.

Segmenting Landowners of Shandong, China, Based on their Attitudes Towards Forest Certification: A Tool for Policy Design and Outreach

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Abstract—Forest certification has been treated as the most important initiative to improve forest management and to achieve sustainable and responsible management in the past decade. In China, the objective of modern forestry development is to sustain ecological and environmental benefits of forests and forest certification provided such a policy instrument. To explore and understand landowners' attitudes, values, and interests in forest certification, we conducted a survey in Shandong, China in the summer of 2016. This study employed cluster analysis to segment landowners into three relevant groups based on their interest level in participating in forest certification under different program requirements: (1) likely landowners, (2) potential landowners, and (3) unlikely landowners. We examined the demographics, forest characteristics and management objectives, and their perceptions for perceived benefits and drawbacks with forest certification of those three segments. The results suggested the necessity of differentiating landowners to formulate and design specific motivation-based incentives and tailor outreach efforts and communication strategies to improve their interests in forest certification. Those findings are useful for forest policymakers to tailor communication, services, and programs to encourage landowners to engage in forest certification.

PRIVATE FORESTS

Total Wood Demand is a Significant Determinant of Forest land Acreage in the Southern United States

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Abstract—Expanding agriculture and rapid urbanization threaten existing forest lands. By modeling changes in acreage of forest lands across 10 States in the Southeastern United States over a 6-year period (2009 to 2014), we examine the effects of demand for hardwoods and softwoods, prices of pulpwood and sawtimber products as well as major agricultural field crops, and demographic factors on forest land acreage. Demand for wood is positively associated with forest land acreage. For both softwood and hardwood forests, the price of sawtimber influences forest cover positively and pulpwood prices negatively. Meanwhile, the positive effect of urbanization suggests that the act of people moving from rural districts and resettling to metropolitan areas may serve to alleviate anthropogenic stressors on forest lands, inducing regrowth and therefore, more land under forest cover. Furthermore, results indicate the positive effect of urbanization on forest cover depends directly on per capita income levels. We hope conclusions reached in this study may aid in designing future policy affecting forests in the Southeastern United States.

PRIVATE FORESTS

The Effect of the 2017 Tax Reform Proposals on Timber Income of Private Noncorporate Forest Landowners in the South

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Abstract—The 2017 Tax Cuts and Jobs Act (TCJA) made changes that may increase/decrease profitability of owning and growing timber for noncoporate forest landowners in the South. Apart from the final bill, a number of proposals had been proposed and discussed during the session. Insights into the effects of these proposals on the financial return of growing timber for noncorporate forest landowners would facilitate policy discussion and formation related to federal income taxation on forests and promote sustainable forestry.

The purpose of the study is to assess the effects of the final 2017 ACJA and major proposals related to timber taxation during the session on financial returns of growing timber for noncorporate forest landowners. After-tax Bare Land Values (BLVs) were estimated for a representative southern pine management plan under various tax situations: before ACJA, under ACJA (with two different interpretations of Section 199A), with immediate expensing of reforestation costs, and the scenario if capital gain tax rate is halved.

The study found that the effects vary by size of timberland holding, nontimber income of forest landowners and their management regimes. Most private forest landowners benefit from the new tax law while some landowners will be worse off. How to interpret Section 199A (Deduction of qualified business income of pass-through entities) will have significant effects on the profitability of growing timber.

PRIVATE FORESTS

Effects of the Sustainable Forestry Initiative (SFI) Fiber Sourcing Standard on the Implementation Rate of Forestry Best Management Practices in Georgia

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Abstract—The role of the Sustainable Forestry Initiative (SFI) Fiber Sourcing Standard is critical in promoting sustainable forest land management on noncertified forest lands. We used an innovative spatial approach to determine the influence of the SFI Fiber Sourcing Standard on Georgia's forest lands over space and time. We also determined the role of the SFI Fiber Sourcing Standard in increasing the implementation rate of forestry Best Management Practices (BMPs) in Georgia. Our results suggest that at least 88 percent of total forest land in Georgia is currently affected by the SFI Fiber Sourcing Standard. We also found that the average forestry BMP implementation rate on harvested sites which are within the sourcing radius of mills certified to the SFI Fiber Sourcing Standard is higher relative to harvested sites which are located outside the sourcing radius of any such mill. On average, the forestry BMP implementation rate goes up by about 3 percent if a harvested site is within the sourcing radius of a mill certified to the SFI Fiber Sourcing Standard. Our results indicate that the majority of forest lands, including noncertified forest lands, are managed sustainably in Georgia to a large extent as forestry BMPs are a strong indicator of forest land sustainability. Additionally, the SFI Fiber Sourcing Standard is helpful in increasing BMP implementation rates across Georgia over time. We hope that our results will bring much needed clarity to the sustainability of noncertified forest lands in Georgia and other forested regions in North America.

MARKETS AND PRICES

Examining the Market Dynamics, Exogenous Impacts, and Structural Break in Softwood Sawtimber Stumpage Market on a Quarterly Basis: Evidences from Louisiana

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Abstract—Modelling of regional timber stumpage market demand and supply has been a well-established research topic in the field of forest economics. Numerous studies have explored such issues for several different regions in the United States and around the World. However, most existing studies are on an annual basis, such that they are not able to reveal the short-run market dynamics precisely. In this study, we have retrieved a quarterly dataset for the demand and supply of softwood sawtimber stumpage in Louisiana between 1984 and 2016 from the State taxation database. Both the long- and short-run dynamics of such markets are assessed by a vector error correction model. In addition, the effect of structural break, seasonality, and impact of several exogenous events were also examined. Compared to the studies utilizing annual data, this study provides more detailed empirical evidences in terms of the short-run market dynamics, which will be very helpful to the decisionmakers in such markets.

Timber Severance and Timber Prices: A Causality Test for Louisiana, Texas, and Mississippi

Rajan Parajuli and Shaun M. Tanger

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Abstract—According to Granger's causality, stumpage price Granger causes timber quantity severed if we can better predict the current timber quantity severed with both past timber quantities severed and stumpage prices than with just past timber quantities severed alone. Conversely, timber quantity Granger causes stumpage price if we can better predict the current stumpage price with both past stumpage prices and timber quantities severed than with just past stumpage prices alone. In theory, these two variables should be simultaneously determined. If they indeed are simultaneously determined, empirically we should find significant results for each product in both directions.

We applied Granger causality tests to annual stumpage and price data for three southeastern States (Louisiana, Texas, and Mississippi) on quantities harvested of pine and hardwood stumpage products and average stumpage prices for those corresponding products.

Results varied among States and products, showing that only in two cases did past timber quantities severed caused the current price and past prices caused the current timber quantity severed, simultaneously. As such, a feedback loop does not exist between quantity severed and price for several products in the three States.

Interestingly, this result implies that the timber markets in the three States are not competitive and efficient (in most cases). While not mutually exclusive, it may indicate misspecification when conducting single State Granger causality for stumpage markets if these markets are co-integrated. This may require more sophisticated specification in causality modeling of stumpage products.

MANAGEMENT

A Network Analysis to Identify Hotspots in which Merchantability May Limit Forest Management Across the United States

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Abstract—The harvesting of trees is one of the primary silvicultural treatments used to accomplish either financial or ecological goals. The ability to which removed material can be merchandized determines either how profitable the enterprise or how far a limited management budget can be stretched. One of the primary limitations to fully utilizing harvested forest commodities is transportation cost. This is affected by the spatial allocation of forest products processing facilities, the array of primary forest commodities they consume, and the transportation infrastructure. Lower levels of forest management in high cost forest areas might be more susceptible to fire, insects and disease, or conversion to other land use. This study conducts a network analysis utilizing the location and consumption characteristics of over 3,300 forest products producers in the continental United States along with a national road dataset to evaluate "hotspots" in which there could be financial limitation to forest harvesting. The products considered are softwood and hardwood saw logs, chips, and biomass for bioenergy such as small trees, breakage, defect, and logging residues. We establish procurement zones around each mill for each forest commodity at varying distances and costs and construct a "hotspot" value utilizing the number of overlapped zones weighted by generalized commodity-specific prices. Maps of individual commodity procurement zones as well as "hotspots" are presented at the national and State level.

Silvopasture and Farm Size Affects Characteristics and Management

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Abstract—Economies and diseconomies of size may impact the profitability of firms and farms. These may be due to various factors such as the fixed costs of operation, inputs that improve productivity but are large and expensive, or limited management capacity. Silvopasture, the intentional and managed combination of trees, forage, and livestock on a single parcel of land, has been advocated as a potential way for small and medium farms to diversify and increase profitability; however, economies of size could limit applicability and profitability for them. Past research on silvopasture in the United States has rarely considered effects of size on profitability, characteristics, and management, implicitly assuming constant returns to scale, and no economies or diseconomies. Because silvopasture is not widely adopted, we used diverse methods to explore the effects of farm and system size on silvopasture in the southeastern States of North Carolina and Virginia, and to create a framework for understanding silvopasture establishment and management. This included mixed-methods interview of key informants, surveys of extension agents and producers, and case studies of silvopasture practitioners. All the case studies established silvopasture by thinning established forests, rather than planting trees in pasture. We found that farm size seemed more inter-related with underlying motivations than silvopasture size, and that both farm size and motivation affected adoption and establishment, management, and product marketing. Key motivations for silvopasture included: expanding the pasture base, animal comfort, joint production, and investment. Key barriers were lower expected forage production, cost and effort, and low sawtimber prices.

MANAGEMENT

Loblolly Pine Mid-rotation Competition Control and Fertilization Value and Rate of Return Estimates

David Dickens, Jacek Siry, Bob Izlar, and Matt Sault

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Abstract—Biological growth and timber product prices are the drivers typically accounting for the majority of timberland returns. Fertilization provides limiting nutrients to improve growth with the peak response occurring on most soils 4 years after treatment and lasts 8 to 10 years. Competition control reduces unwanted woody vegetation increasing site water and nutrient availability to the crop trees. Competition control growth benefits tend to peak at 8 years and lasts 14 years. These two treatments applied after a mid-rotation thinning capitalize on the newly available resources and provide higher growth rates over 6 to 14 years. This research examined the costs of these treatments for loblolly pine (*P. taeda*) as they affect financial returns across different product class price points. Two loblolly pine replicated studies were established up in the Coastal Plain of southern Georgia, the first one with a mid-rotation NPK, herbicide, and NPK + herbicide plot measured against control plot trees, and the second study with a herbicide only (control), NP, NPK, and NPKSCu. Internal rates of return (IRRs) were calculated for each treatment product yield using a range of herbicide, fertilizer, and wood product prices. All but the two lowest product prices showed returns above a 6 percent hurdle rate for the fertilizer + herbicide treatment with fertilizer price being the limiting factor. Other treatments did not yield any positive returns regardless of treatment or product price. These findings are of value to forest landowners who are interested in increasing their land production and enhancing their returns.

Decision Dilemma: Traditional versus Non-Traditional Timber Management Regime

Umesh Chaudhari and Michael Kane

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Abstract—Loblolly pine (*Pinus taeda*) is widely planted in the Southern United States due to its adaptability, growth rate, and suitability for markets of traditional and non-traditional timber products. This study represents results as an average of three installations (sites) of the Plantation Management Research Cooperative (PMRC) Culture Density Study from the Lower Coastal Plain of Georgia and Florida. We examine loblolly pine timber yields and financial returns from traditional and non-traditional (bioenergy feedstock) timber product mixes for combinations of site class, cultural regime, and density management (planting density and thinning). Financial returns were determined using the discounted cash flow approach of net present value (NPV) and soil expectation value (SEV) under different assumptions. Management regimes were ranked using the SEV due to varying optimum rotation ages as influenced by planting density, cultural regime, and thinning scenario. Financial returns for traditional timber products were always greater with and without thinning compared to a dedicated bioenergy regime in a base case scenario; however, the bioenergy regime seemed lucrative if prices were increased compared to a no-thinning scenario. The optimum management regime was 600 trees per acre planting density with intensive culture and two thinnings for the traditional timber product, while the optimum management regime shifted toward higher planting densities when bioenergy was added to the traditional timber product mix.

MANAGEMENT

An Economic Comparison of Loblolly, Longleaf, and Slash Pine with and without Pine Straw Income, Environmental Quality Incentives Program (EQIP) Cost-Share and Conservation Reserve Program (CRP) CP36 Cost-Share and Rental Payments

David Dickens, Yanshu Li, and Dave Moorhead

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Abstract—Bare Land Values (BLV) at 4 and 6 percent discount rates were used to compare a one thin, 24-year loblolly rotation to a two thin 33-year slash pine rotation and a two thin 45-year longleaf rotation. Pine stumpage prices used were from Timber Mart South for Georgia. Scenarios were run with and without pine straw income for the three species. Site preparation, seedlings and planting costs, and an annual property tax plus management fee were included in all scenarios. A longleaf scenario was also run with the Conservation Reserve Program (CRP) CP-36 assumptions (signing bonus, cost share on site prep, seedlings and planting and an annual rental payment for 15 years). Finally a longleaf scenario was run using Environmental Quality Incentives Program (EQIP) site preparation, seedling and planting cost share and compared to the loblolly and slash scenarios. Without pine straw income, the BLVs at 4 and 6 percent for loblolly pine were greater than slash or longleaf pine. With pine straw, using differing dollar per acre returns for loblolly, longleaf, and slash pine, the BLV gap was narrowed but still favored loblolly over longleaf and slash pine. When the CRP CP-36 signing bonus, cost share and annual rental payments were added to the longleaf scenario the longleaf BLVs at 4 and 6 percent were greater than the loblolly or slash scenarios with or without pine straw. When EQIP establishment cost-share was added to the longleaf scenario, the longleaf BLVs with pine straw were greater than the loblolly or slash scenarios.

Wildfire Mitigation Decisions in The Presence of Collaborative Planning and Heterogeneous Management Purposes

Ibtisam Al Abri and Kelly Grogan

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Abstract—In recent years, the dramatic increase in the number of severe and uncontrollable wildfires in the Southern United States has become an important policy issue. Federal agencies spend billions of dollars on fire suppression, and this suppression, in combination with a lack of fuel management on the part of individual landowners, results in a large accumulation of hazardous forest fuels on landscapes putting communities at risk. While landowners, who predominantly utilize pine species, often cannot control the occurrence of wildfires, they can undertake fire prevention practices to mitigate fire losses. Previous literature has suggested that collaborative efforts between neighboring landowners, like sharing fuel treatment capital, could incentivize landowners to undertake an increasing level of fuel removal. However, no previous studies have evaluated a willingness to participate in collaborative efforts or investigated how collaborative planning encourages risk mitigation behavior. This study develops a stochastic dynamic model to examine two adjacent landowners who manage their stands simultaneously and seeks to understand how their risk mitigating decisions interact in the presence and absence of cooperative efforts. The derived model presents three main cases: (1) no cooperative efforts exist, (2) cooperative efforts exist, and (3) individuals choose to cooperate if doing so is individually optimal, and socially optimal management with cooperative efforts. Then, the optimal fuel reduction actions from the second case are compared to the social optimum to evaluate whether the landowner should participate or not to maximize combined net benefits. Results imply that government programs could be utilized to improve landowners' awareness and responses to cooperative efforts.

MANAGEMENT

Forest Land Dynamics in North Carolina: Analysis of USDA Crop Data Layer

Chinazor Azubike and Lyubov Kurkalova

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Abstract—According to the USDA Forest Service, the United States has 766 million acres of forest land (Oswalt and others 2014). Forest land is a large area of land, consisting of trees that protect, cover, and support various life forms. North Carolina's forest land is one of the greatest influences on the State, providing economic value and adding immeasurably to the quality of life for its residents. North Carolina's forests make up about 18.6 million acres of the State's land area (Brown and others 2014). North Carolina has three distinct physiographic regions, recognized as the Coastal Plain, Piedmont, and Mountains (Thwaites 1939). The Coastal Plain harbors pocosins, Carolina bays, and deep swamps. The Piedmont is hilly and dissected by streams and drains. The Mountains have numerous ridges, valleys, and peaks. This is believed to play a significant role in the complexity of the State's land. The purpose of this research is to study North Carolina's land use, the recent changes in transitions between agricultural and forest land, paying special attention to deciduous forest, evergreen forest, mixed forest and shrub land. The overall goal of the project is to develop an economic model of the State's land use. Currently, such economic models have been developed for the Midwestern part of the United States but no such models exist for North Carolina or the Southeastern United States. We analyze the USDA's Cropland Data Layer, National Land Cover Database, and the Forest Inventory and Analysis data. Crop Data Layer is a faster, geo-referenced, crop-specific land cover data layer created annually for the continental United States using moderate resolution satellite imagery and extensive agricultural ground truth. Acreage data on deciduous, evergreen, mixed forest and shrub land were collected and analyzed from the Crop Data Layer. The primary objective of the Forest Inventory Analysis data is to determine the extent, condition, volume, growth, and use of trees on the Nation's forest land. Data is collected and reported annually. The National Land Cover Database provides the capability to assess wall-to-wall, spatially explicit, national land cover changes and trends across the United States from 2001 to 2011. It also provides spatial reference and descriptive data for characteristics of the land surface such as thematic class (e.g., urban, agriculture, and forest), percent impervious surface, and percent tree canopy cover.

These data layers are merged using the ArcGIS software, an integrated suite of Geographic Information System applications to build, analyze, and model maps. The study aims to analyze changes in forest land by status and trends in forest area and location; in the species, size, and health of trees; in total tree growth, mortality, and removals by harvest; in wood production and utilization rates by various products; and in forest land ownership. The understanding of the forest land use changes will allow the economic analyses of the impacts of the changes in economic conditions (prices) and policies (e.g., bioenergy policy). Currently, such models have been developed for the Midwestern part of the United States but no such models exist for the North Carolina or the Southeastern United States. The better

understanding of land use would allow for analysis of employment in the State as well as the regional differences, both currently, and in the future. This could help design State policies to potentially create new jobs in resource-based industries.

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MANAGEMENT

An Economic Assesment of Silvopasture Systems in the Coastasl Plain of North Carolina

Stephanie Chizmar, Frederick Cubbage, Miguel Castillo, Erin Sills, Robert Abt, and Rajan Parajuli

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Abstract—We estimated the economic returns to monoculture loblolly pine and forage systems, and polyculture silvopasture systems in coastal North Carolina at a range of discount rates (results reported for 4, 8, and 12 percent). Loblolly pine plantations with low management intensity have the lowest land expectation value ($484.63, -$2.90, -$124.03 per acre), followed by traditional cattle-grazing systems ($1,268.89, $548.25, $331.13 per acre). Due to the intensive management of forage production for livestock grazing, tree growth in silvopastures is complemented by management practices such as fertilizer application. If cattle, pasture, and loblolly trees are complementary, e.g. the same or better forage production and animal weight gain for livestock at low forest stocking rates, silvopasture offers higher land expectation values at all discount rates ($1,807.08, $795.91, $489.71 per acre). If the components of the silvopasture system are competitive and production of forage for livestock and animal weight gain decrease, then returns from silvopasture are reduced roughly in proportion to the weighted average returns from grazing and forest management. In this case of competition between the components of the silvopasture system, the government could encourage adoption of silvopasture by offering incentives that reflect its unquantified environmental benefits like increased carbon sequestration.

INTRODUCTION

Agroforestry systems combine forest or horticultural species and grassland or cropland to make mixed land use systems that produce environmentally sustainable commercial benefits to landowners (Zomer and others 2016). Silvopasture, the most common branch of agroforestry in North America, is the strategic and managed agroecosystem in which livestock, forages, and trees or shrubs are integrated in space and time to improve individual components as well as maintain productivity as a whole system while providing diversified sources of income to landowners (Orefice and Carroll 2017, USDA 2012). Agroforestry systems also may be particularly appropriate for reducing monoculture crop failure and price risks, especially in areas with marginal soil quality for row crop production (Cubbage and others 2012), and favor enhanced long-term site productivity and soil protection (USDA NAC 2012), while being a vehicle for sustainable agricultural and forestry certifications as well as carbon offset markets. Agroforestry supports organic farming regulations through decreasing fertility inputs, reduced pest management, maintaining reliable sources of clean water, increased resilience to drought, and improved pollination (McEvoy and Haines 2016).

Agroforestry manages regimes based on the interactions, resource sharing, interference, and facilitation between system components along with the products created by each component. Agroforestry's philosophy maintains that functional linkages provide increased productivity and ecological sustainability when compared to rates of productivity typical in monoculture forest plantations or agricultural systems (Sharrow 2008). The components of a silvopasture regime (i.e., forage, livestock, and trees) may complement each other through symbiotic relationships at low levels of output for each product, or may be competitive at moderate to high levels of output for each product.

Pent and Fike (2017a, 2017b) suggest that there is a complementary relationship between animal health and weight gain for livestock and trees, even if there is somewhat less forage under the trees. With less heat or other environmental stress, animals do prosper just as well in fields with some trees and less grass volume production. In economics, this relationship can be modeled via a Production Possibility Curve. Figure 1 features a theoretical and hypothetical Production Possibilities Frontier (PPF) of cattle and trees. The complementary region—the segment of the PPF curve from the vertical axis to Point A on the PPF on figure 1—is where timber and forage for livestock production benefit one another mutually, reducing inputs and enhancing outputs for both. The rest of the PPF depicts competitive relationships between the two outputs, with more of either trees (in particular, since they can overshadow the understory forage production) or forage reducing the amount of the other output (Kallenbach and others 2006).

Silvopasture can have complementary relationships by decreasing heat stress and increasing grazing time (vs. loafing) of livestock through providing improved microenvironments through shade and shelter (Karki and Goodman 2010), potentially increasing livestock weight gains or reducing calving difficulty (Karki and Goodman 2015, Orefice and Carroll 2017, Walthall and others 2012).

Nevertheless, if silvopastoral systems are not managed to enhance productivity of each individual product and system components compete for resources, then productivity of one and/or multiple good(s) and service(s) may decrease. The competitive region, B, includes higher marginal costs per unit of production for one product over the other, possibly suggesting that monocultures, traditional cattle-forage systems in this case, are more attractive. However, there still may be an "optimal" competitive combination of land practices. The optimal combination when maximizing profit, represented by "π" in figure 1, corresponds to the derivative of the price of cattle over the derivative of the price of trees, where "P" refers to each product's price.

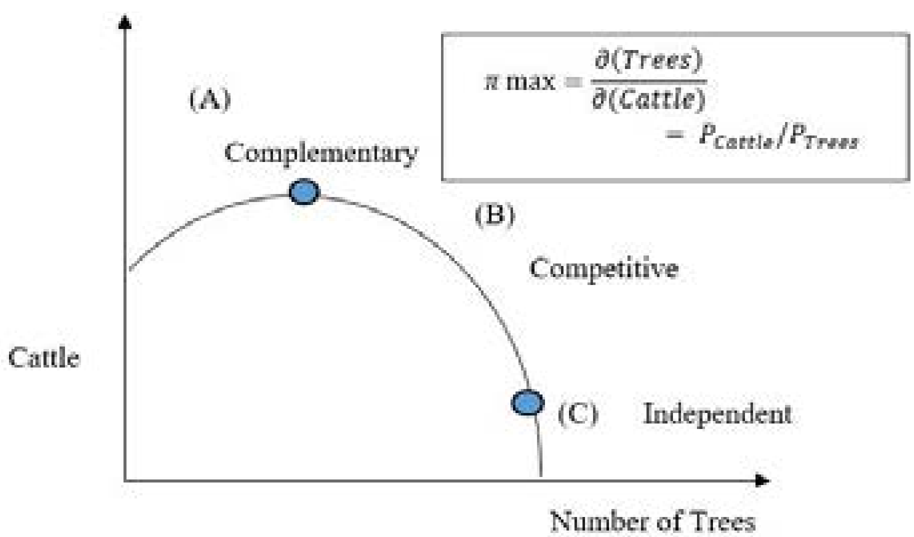

Figure 1—Production Possibilities Frontier of land use combinations of tree and cattle stocking rates.

Possible combinations of cattle and trees in the independent region, C, are characterized by a lack of change in the number of trees at low cattle stocking rates. An independent relationship between cattle and trees in agroforestry systems translates to a mutually exclusive combination where decreasing cattle stocking rates does not affect the volume of wood, or vice versa.

The objective of this research was to analyze the expected financial returns of silvopastoral and conventional systems in the Coastal Plain of North Carolina utilizing capital budgeting techniques and regional productivity data (Chizmar 2018). We also analyze the potential impact of combining traditional forestry and agricultural systems with climate change mitigation activities linked to payments for ecosystem services (PES) such as carbon storage on landowner income. For brevity in this proceedings, we focus on comparing silvopasture systems returns for varying complementary or competitive relationships. More details on ecosystem payments such as carbon are analyzed in Chizmar (2018), which we draw on for this summary.

METHODS

The study analyzes the predicted economic impacts of forest, silvopastoral, and pastoral systems in the Coastal Plain of North Carolina. We consulted farm managers, foresters, consultants, and agroforestry experts to develop the scenarios analyzed and gather production function data for forage, cattle, and forest systems. Table 1 summarizes the scenarios analyzed.

Table 1—Coastal Plain, North Carolina scenarios for forest and pasture monoculture and polyculture silvopasture systems

Scenario	Management activities	Growth and species	Cattle number and species
Forest Only: BAU	Site preparation: Chemical	3.24 tons acre^{-1} yr^{-1} *Pinus taeda* (Loblolly pine)	0
Warm-Season forage Production for hay and pasture	Site preparation: Chemical Fertilizer	4.25 tons acre^{-1} yr^{-1} *Panicum virgatum* L. (Switchgrass)	0
Cool-Season forage Production for hay and production	Site preparation: Chemical Fertilizer	3.18 tons acre^{-1} yr^{-1} *Lolium arundinaceaun* (Schreb.) Darbysh. (Tall fescue)	0
Cattle Only (no land)	Beef cattle operations	0	8 Red and Black Angus
Cows + Pasture: BAU	Site preparation: Chemical Fertilizer Beef cattle operations	4.25 tons acre^{-1} yr^{-1} Switchgrass 3.18 tons acre^{-1} y^{-1} Tall fescue	8 Red and Black Angus
Silvopasture	Site preparation: Chemical Fertilizer Beef cattle operations	4.86 m^3 tons acre^{-1} yr^{-1} P. *taeda* 4.25 tons acre^{-1} yr^{-1} Switchgrass 3.18 tons acre^{-1} yr^{-1} Tall fescue	8 Red and Black Angus

BAU = Business-as-usual, the counterfactual to polyculture systems.

We developed typical management regimes for loblolly pine (*Pinus taeda*) in the Coastal Plain of North Carolina. We utilized costs published in "2016 Costs and Trends for Southern Forestry Practices" to represent regional average costs for the Southern Coastal region of North Carolina (Maggard and Barlow 2017). Stumpage prices are based on South-wide averages from TimberMart South's "U.S. South Annual Review: 2016."

The pine monoculture, producing 3.24 tons per acre per year of merchantable wood, characterizes a "plant and leave" management regime with a pre-planting application of herbicide as the only treatment. Due to the intensive management of forage production for livestock grazing, we assume tree growth in silvopasture systems is complemented by management practices such as fertilizer application. For this reason, we assume complementary growth from forage fertilization increasing annual timber growth to 4.86 tons per acre in all silvopasture scenarios.

Traditional plantation forests in the Coastal Plain are planted at 600 trees per acre (TPA). In the model North Carolina silvopasture regime analyzed, loblolly pine (*P. taeda*) was planted in 2 rows at 10 feet by 10 feet spacing, equating to 435 TPA. Overall, that allots 30 feet of trees with an 80 feet paddock of pasture, repeated once more, to end at a density of 65 to 87 TPA.

In North Carolina, cool-season (CS) forage species flourish when temperatures range from 65º F to 75º F while warm-season (WS) species thrive when temperatures are between 80º F and 95º F (Castillo and others 2014). Three pasture-fed cattle systems typical of the Coastal Plain are of interest in this study: (1) beef wintering on CS species of pasture and supplemental hay in the summer, (2) beef summer grazing on WS species of pasture and supplemental hay in the winter, and (3) rotational stocking on CS and WS paddocks (Green and Benson 2013a, 2013b, 2013c, 2013d).

To maximize land usage and returns, pastures include separate paddocks of WS and CS grasses. The costs and benefits associated with each season of pasture are added to create a closed system. We utilized the percent of each pasture season out of the year to estimate a weighted cash-flow of the combined-system. Loblolly pine (*P. taeda*), switchgrass (*Panicum virgatum* L.), a WS forage, and tall fescue *(Lolium arundinaceaun* (Schreb.) Darbysh.), a CS forage, represent typical commercial species employed in the Coastal Plain. Consequently, the range of returns of the scenarios selected for analysis reflect typical returns of various land uses.

Productivity of switchgrass (*P. virgatum* L.) in North Carolina's Coastal Plains is about 8,500 pounds of dry matter yield per acre per year, or 699.8 animal unit (AU) days based on 30 pounds of forage consumed daily per cow. Productivity of tall fescue *(L. arundinaceaun* (Schreb.) Darbysh.) is about 6,350 pounds of forage per acre per year, or 522.8 AU days (Castillo and others 2015). For the scope of this study, we hold timber and forage growth rates constant and assume one AU represents one animal weighing 1,000 pounds (Husak and Grado 2002).

We modeled the introduction of crosses of red and beef angus on the land after 6 years, once trees grow beyond browse line and became large enough to avoid trampling. Costs and revenue for cattle systems were derived from the literature and local experts. We utilized North Carolina State University Cooperative Extension farm budgets for winter and summer stockers to determine cattle costs and revenue as well as forage management costs and prices. We parameterized the silvopasture scenarios by timber production's effect on forage growth for livestock grazing, whether complementary (increasing forage production as well as cattle stocking rates by 10 percent), independent (no effect, forage and livestock operate at full capacity), or competitive (decreasing forage and livestock production by 25 percent).

Tools in capital budgeting and cash flow analysis such as Net Present Value (NPV), Land Expectation Value (LEV), Annual Equivalent Income (AEI), and Benefit-Cost Ratio (BCR) allow for comparison of different land use systems. Financial analyses were performed using methods as described in Cubbage and others (2013) (2016), Wagner (2011), and Mercer and others (2014). Real discount rates of 4, 8, and 12 percent were used in all financial formulas to represent a range in the costs of capital or the opportunity costs of the next best investment option. We designed spreadsheets in Excel for systems in North Carolina so that we could map the cash flows of each land-use regime. The spreadsheets included necessary measures of productivity, product prices and costs, and management schedules, among other site-specific information, to calculate the net returns of annual activities. The systems were analyzed independently, as monocultures, and combined for mixed-use systems. For instance, conventional forestry includes only the returns of the tree plantation monoculture; however, conventional cattle-forage systems include a weighted average, corresponding to each land-use option and its proportion to the entire system, of the annual costs and benefits of WS forage, CS forage, and beef cattle. The Excel models and training for the models are available from the authors upon request.

RESULTS

Table 2 summarizes the capital budgeting results of all scenarios. Pure low-intensity forest investments provide the lowest returns in present value terms at all discount rates (LEV: 4% = $484.63 per acre (ac); 8% = -$2.90 per acre; 12% = -$124.03 per acre). Traditional cattle and pasture regimes earn higher net returns than plant-and-leave loblolly plantations (LEV: 4% = $1,537.69 per acre; 8% = $707.62 per acre; 12% = $453.11 per acre).

Table 2—Net present value (NPV) and land expectation value (LEV) for modeled systems

Scenario	NPV ($/acre)			LEV ($/acre)		
	4%	8%	12%	4%	8%	12%
Forest Only BAU	$302.84	-$2.90	-$124.03	$484.63	-$3.40	-$131.78
Forest Only SPS[a]	$578.01	$119.78	-$65.54	$924.99	$140.26	-$69.64
Warm-Season Only[a]	-$183.66	$106.16	$238.76	-$293.91	$124.31	$253.68
Cool-Season Only[a]	-$1,690.99	-$973.67	-$583.51	-$2,706.09	-$1,140.15	-$619.98
Cattle Onlya	$3,796.40	$2,076.10	$1,197.66	$6,075.38	$2,431.08	$1,272.51
Cattle + Pasture BAU	$960.87	$604.29	$426.45	$1,537.69	$707.62	$453.11
SPS Independent[b]	$1,033.13	$619.27	$418.26	$1,653.31	$725.15	$444.40
SPS Competitive[c]	$792.91	$468.19	$311.65	$1,268.89	$548.25	$331.13
SPS Complement[d]	$1,129.21	$679.70	$460.91	$1,807.08	$795.91	$489.71

BAU = Business-as-usual; SPS = Silvopasture systems.
[a]Systems cannot stand alone (SPS complementary relationships).
[b]SPS shares: Forest 25 percent; WS, CS, Cattle 100 percent.
[c]SPS shares: Forest 25 percent; WS, CS, Cattle 75 percent.
[d]SPS shares: Forest 25 percent; WS, CS, Cattle 110 percent.

Since the cash flow models for agroforestry systems were calculated based on the proportion of land each production system uses out of the total productive area, the results closely follow the cattle-grazing scenario which constitutes 110, 100, and 75 percent of the complementary, independent, and competitive systems, respectively. Silvopasture System Complements offered landowners the highest returns out of the systems evaluated in the study at all discount rates (LEV: 4% = $1,807.08 per acre; 8% = $795.91 per acre; 12% = $489.71 per acre). Systems that include products that must compete for resources such as growing space, light, and water generate lower returns than conventional cattle grazing regimes (SPS Competitive – LEV: 4% = $1,268.89 per acre; 8% = $548.25 per acre; 12% = $331.13 per acre). Silvopasture Independent earns higher returns, compared to conventional cattle-forage systems, at low discount rates (LEV: 4% = $1,653.31 per acre; 8% = $725.15 per acre; 12% = $444.40 per acre). At 12 percent, conventional cattle-forage systems generate greater net returns than silvopasture systems with independent product relationships.

When comparing land uses of varying harvest time-horizons, it is often useful to compare the AEI of the alternatives, since the annual metric makes it easy for farmers to compare with other annual crop returns per unit of area. Figure 2 demonstrates the expected annual returns of each land-use system. Forest monocultures had negative returns at higher discount rates. The agroforests had positive annual returns at all discount rates.

Pure forest investments demand the least in establishment inputs ($181.12 per acre) on existing pasture lands. However, due to the longer turn-around time before generating a positive net income, forest monocultures also include the longest payback period, in non-present value terms (18 years). While traditional cattle-grazing regimes required higher-cost inputs for establishment ($1,189.07 per acre), they produced positive net returns sooner than planted forests (4 years), because they received income from hay production while the trees were getting large and sturdy enough to be safe from cattle.

Landowners may receive various cost-share payments for conservation practices from the Federal Government or other entities. Table 3 summarizes planted forest establishment costs, 50 percent cost-share payments, the new LEV of each scenario with reduced costs, and the payback periods required to cover establishment costs. The cost-share payments in the initial years increase the NPV or LEV by the amount of the payment, ceteris paribus. More significantly, the payments reduce the payback period in independent silvopastoral regimes, which would make adoption more attractive for small landowners. When one policy intervention is not enough, combinations of more than one policy can be implemented. Table 4 summarizes the 10-year annuities necessary to break even with traditional cattle systems in North Carolina after establishment costs are reduced by 50 percent. These required payments ranged from $17 per acre per year to $30 per acre per year, which are quite small compared with payments for many farm programs that approach $100 per acre per year.

DISCUSSION AND CONCLUSIONS

We found that beef cattle—southern pine silvopasture systems in the North Carolina Coastal Plain with complementary product-product relationships could produce higher returns than any current conventional land use system in North Carolina at 4, 8, and 12 percent discount rates. The increased profitability may stem from the reduced management costs, compared to monoculture systems, and the increased productivity of the systems through complementary biophysical characteristics.

If products in an agroforestry regime are not complementary and/or at higher discount rates, the best financial investment choice as modeled here was conventional cattle grazing systems, assuming cattle health is equivalent. However, quantifying the rapidly emerging research on health and vigor of ruminants in silvopasture systems may alter this conclusion, tilting investment preferences more toward silvopasture systems. Therefore, merits of agroforestry systems depend on the product-product relationships as well as the opportunity cost of alternative investments.

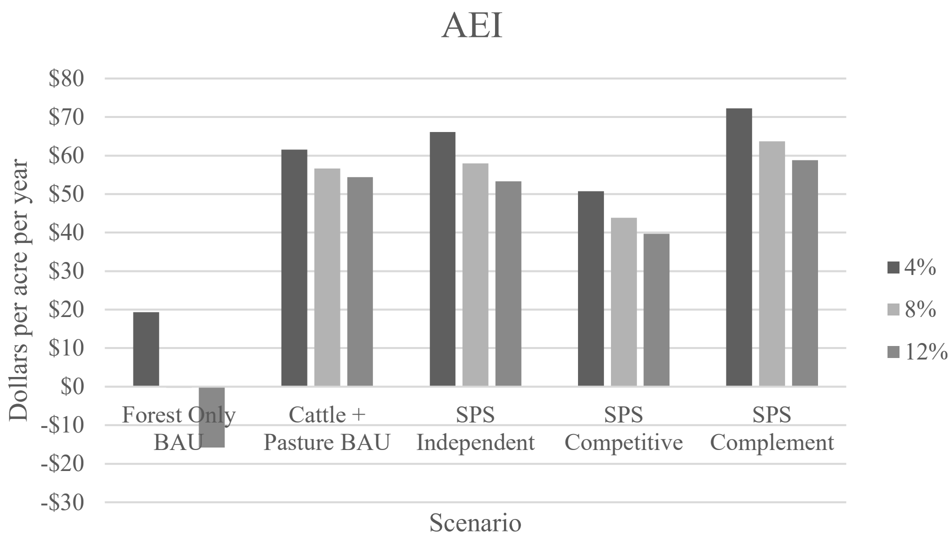

Figure 2—Annual Equivalent Income (AEI) of modeled systems.

Table 3—Effects of a 50 percent cost-share payment for the establishment of tree plantations

Scenario	Establishment cost ($/acre)	Payback periods (yrs.)	50% Cost share ($/acre)	New LEV ($/acre)			New payback periods (yrs.)
				4%	8%	12%	
NC SPS Independent	$45.28	4	$22.64	—	—	$467.04	3
NC SPS Competitive		4		$1,291.53	$570.89	$353.77	4

LEV = Land expectation value; SPS = Silvopasture systems.
— = Returns are more profitable than Business-as-usual Cattle and Pasture and do not require incentive.

Table 4—Cost share payment and 10-year annuity necessary to break even with conventional cattle operations

Scenario	New LEV Diff (w/ 50% payment; $/acre)			10-yr. Annuity: Difference in LEV ($/acre/yr.)		
Discount rate	4%	8%	12%	4%	8%	12%
NC SPS competitive	$246.16	$136.73	$99.34	$30.35	$20.38	$17.58

LEV = Land expectation value; SPS = Silvopasture systems.

Planted forests may be more cost effective for landowners with limited capital, and of course forests are more suited ecologically to lower site class lands, where pastures are not able to be established and thrive well. The somewhat unique opportunity for silvopasture systems is the ability to introduce trees in higher site class lands; benefit ruminants; produce more diverse environmental benefits; and provide commensurate or better financial returns to landowners compared to traditional grazing or forest systems.

Incentives such as cost-share payments or payments for ecosystem services encourage landowners to invest in land use systems by reducing the initial costs needed and increasing income sooner to establish a profitable system. Government support through direct payments could increase the profitability of silvopasture with competitive and independent relationships between cattle and trees in order to gain ecosystem service benefits such as carbon storage or improved water quality. Cost-share payments may make land uses that expand forest cover more desirable to landowners by reducing establishment costs. Cost-share payments also have the potential of shortening payback periods so limited income landowners can reach net positive cash flow sooner. When cost-share payments are not enough to make silvopasture more profitable, payments for ecosystem services, such as carbon storage, may be employed to provide a stream of annual benefits over some time period (e.g., the first 10 years when revenue is at its lowest).

Overall, silvopasture systems offer considerable promise as an economically and environmentally beneficial land use system in North Carolina, and probably elsewhere based on the emerging literature of complementary relationships among trees and forage at low tree density levels, as well for animal health and ecosystem service benefits. Nevertheless, purposeful adoption or management of these systems by farmers, other than scattered trees and shade on field borders, has been quite low. Further research and extension regarding the merits of silvopasture systems will certainly be needed to validate if such theoretical benefits are real, as well as the development of more specific programs in government cost-share payment programs.

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MANAGEMENT

An Analysis of Cost trends for Southern Forestry Practices

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Abstract—Costs of forestry practices have been reported periodically for the South for over 60 years, with few analyses of the cost trends. We report on an analysis of these trends between 1982 and 2016, including indices for overall costs and labor costs for forest management. The overall cost of intensive silviculture in the South, as measured by the southern forestry practices cost index (SFPCI), changed little; however, some practices experienced increases in real costs, while other costs changed little or declined slightly. Correlations between forestry wages and/or other variable cost components were identified for several practices and for the SFPCI. Results indicate that changes in the costs associated with practicing forestry in the South often correlate with changes in labor and fuel costs. Additional research could explore the effects of forestry practice cost change on the profitability of timber management scenarios.

INTRODUCTION

Pine plantation silviculture in the South saw remarkable growth in the second half of the 20th century, with planted pine acreage increasing from 1 percent to 15 percent of the region's timberland area (Conner and Hartsell 2002). Relative forest productivity also greatly increased, with the mean annual increment of pine plantations in the South more than doubling and average rotation lengths being cut in half (Fox and others 2007). In addition to improvements in rearing and breeding superior pine seedlings, much of this increase in productivity can be attributed to the development and use of a variety of intensive forestry practices (Fox and others 2007). The intensive use of these practices has shown the potential to maximize timber production, while providing attractive economic returns (Borders and Bailey 2001). However, these practices can be costly and impact profitability.

Understanding the costs associated with timber production is crucial to analyzing the profitability of any given forest management regime. Since 1953, average forestry practices costs for the South have been periodically reported in Forest Landowner magazine (formerly Forest Farmer) using survey results from timber managers of both private and public forest land (Barlow and Levendis 2015). Table 1 lists these studies in chronological order.

The first trend analysis of this data, covering 24 years, occurred in 1982 and found forest practices costs rising substantially faster than both the price of lumber and the wholesale price index, suggesting that the cost of practicing forestry was outpacing inflation and any potential increase in the price of sawtimber (Moak 1982). Over 20 years later Bair and Alig (2006) concluded that the real cost of some major forestry practices used on private lands in the South had remained relatively constant between 1982 and 2002, with a few costs rising slightly.

Table 1—Forest Farmer/Forest Landowner forestry practices cost studies, 1953-2016

Study year	Year published	Volume/issue/ pages	Author(s)	Publication
1952	1953	12(8):5,17	Worrell A.C.	Forest Farmer
1961	1963	22(13):6-8,15	Somberg S.I., Eads L.D., Yoho J.G.	Forest Farmer
1967	1971	30(7):42-50	Yoho J.G., Dutrow G.F., Moak J.E.	Forest Farmer
1974	1975	34(5):74-82	Moak J.E., Kucera J.M.	Forest Farmer
1976	1977	36(5):16-21	Moak J.E., Kucera J.M., Watson W.F.	Forest Farmer
1979	1980	39(5):50-63	Moak, J.E., Watson, W.F., Deusen, P.V.	Forest Farmer
1982	1983	42(5):26-32	Moak J.E., Watson W.F., Watson M.S.	Forest Farmer
1984	1985	44(5):16-22	Straka T.J., Watson W.F.	Forest Farmer
1986	1987	46(5):28-34	Watson W.F., Straka T.J., Bullard S.H.	Forest Farmer
1988	1989	48(5):8-14	Straka T.J., Watson W.F., Dubois M.F.	Forest Farmer
1990	1991	50(3):26-32	Dubois M.F., Watson W.F., Straka T.J., Belli K.L.	Forest Farmer
1992	1993	52(3):25-31	Belli M.L., Straka T.J., Dubois, M., Watson, W.F.	Forest Farmer
1994	1995	54(3):10-17	Dubois M.R., McNabb K., Straka, T.J., Watson, W.F.	Forest Farmer
1996	1997	56(2):7-13	Dubois M.R., McNabb K., Straka, T.J.	Forest Landowner
1998	1999	58(2):3-8	Dubois M.R., McNabb K., Straka, TJ.	Forest Landowner
2000	2001	60(2):3-8	Dubois M.R., Erwin C.B., Straka, T.J.	Forest Landowner
2002	2003	62(2):3-9	Dubois M.R., Straka T.J., Crim S.D., Robinson L.J.	Forest Landowner
2004	2005	64(2):25-31	Smidt M.F., Dubois, M.R., Folegatti, B.S.	Forest Landowner
2006	2007	66(5):11-16	Folegatti B.S, Smidt M.F., Dubois M.R.	Forest Landowner
2008	2009	68(5):5-12	Barlow R.J., Smidt M.F., Morse J.Z., Dubois M.R.	Forest Landowner
2010	2011	70(6);15-24	Barlow R.J., Dubois M.R.	Forest Landowner
2012	2013	72(4):22-29	Dooley E., Barlow R.	Forest Landowner
2014	2015	74(5):22-31	Barlow R., Levendis W.	Forest Landowner
2016	2017	76(5):30-39	Maggard A., Barlow, R.	Forest Landowner

Source: Dubois and others 1995.

Moak (1982) suggested that in the early years of the Forest Farmer magazine survey the easier sites for practicing forestry had been utilized, and over time forest managers had to move on to more difficult and, thus, more expensive sites. Various authors have suggested that changes in both labor costs and fuel prices play a role in changes in the costs of forestry practices (Bair and Alig 2006, Moak 1982, Straka and others 1992). Until 1999, a cost component breakdown was included for each practice in the cost studies, which suggested that labor was often the most significant cost component for many or most practices, while equipment costs, which incorporated fuel costs, contributed substantially to the cost of mechanized practices such as site preparation (Moak and others 1980). Mills and others (1985) found a significant relationship between forestry practices costs on national forests and the number of people employed by the contractors hired to complete the treatments, further demonstrating the relationship between labor costs and silviculture practice costs. In the case of herbicide applications and fertilization practices, chemical and fertilizer costs have been noted as making up the most substantial portion of the cost of these practices (Belli and others 1993).

Little recent work has been done in the way of examining long-term trends in forestry practices costs and cost components. Even less has been done to examine these trends without the influence of inflation. Finally, no forestry cost trend analysis representing a substantial amount of time as well as both private and public forest management costs has incorporated the use of a southern forestry wage-based index or an index representing a basket of southern forestry practices. Thus, the objectives of this study were as follows:

(1) Estimate the real average annual rate of change for the cost of nine major forestry practices in the South.

(2) Establish a measure of the change in forest practices costs as a whole in the South, by creating a southern forestry practices cost index (SFPCI).

(3) Develop a southern forestry employee wage index (SFEWI) to estimate the change in forestry labor costs.

(4) Use the SFEWI, No.2 diesel fuel index, and herbicide and fertilizer indices in the detection of correlations between forestry practices costs and labor and/or fuel costs.

METHODS

Data were compiled from all forestry practices cost studies published in Forest Farmer and Forest Landowner magazines between 1953 and 2017. Only summary data for years starting with 1982 were used for calculations due to limited reporting for some major practices for years prior to that. These forestry practices costs are presented in table 2. The year 1982 also served as the base year for all indices used in this study.

The SFPCI was developed from eight major forestry practices; hand and machine tree planting were combined. That index, using methods developed in Dubois and others (1991), was based on an aggregate index of forestry practices that was weighted by the number of respective acres on which the practices were used for a base year. Using methods in Dubois and others (1991), 1988 was used as the weight base year due to the lack of availability of acreage data for some practices before that year. Values for SFPCI are presented in table 3.

The SFEWI was also developed using the methods in Dubois and others (1991) and used wage data obtained from the Bureau of Labor Statistics for average annual wages paid to timber tracts (SIC 0811 and NAICS 1131) and forestry services (SIC 0851 and NAICS 1153) for 13 Southern States, including Kentucky and Oklahoma, as an indicator of forestry employee wages (USDL Bureau of Labor Statistics 2017a). Wage datasets for 1982-2000 and 2002-2016 were combined to cover the relevant time period. Unlike Dubois and others (1991), cost and wage data representing both private and public entities were used to produce these indices in order to correspond with the Forest Farmer/Forest Landowner magazine studies, which published data provided by the full spectrum of southern timber managers. Values for SFEWI are presented in table 3.

In addition to cost and wage data, values for the Producer Price Index (PPI) and No.2 Diesel index were also obtained for the corresponding years as a means of providing a comparison between cost and price data, and in the case of the PPI, to provide a measure of inflation (USDL Bureau of Labor Statistics 2017b). The No. 2 Diesel price index and SFEWI were used to determine correlations between changes in forestry practices costs and changes in fuel price and labor respectively. In order to further investigate cost components for herbicide and fertilization practices, herbicide and fertilizer price indices were obtained from the (USDA National Agricultural Statistics Service 2018a, 2018b). These indices were only available starting in year 1990.

Table 2—Forest Farmer/Forest Landowner cost study summary values, 1982-2016

Year	Controlled burning	Herbicide application	Timber cruising	Tree marking	Mechanical site preparation	Hand planting[a]	Machine planting[a]	Pre-commercial thinning	Fertilization
				$ per acre (planting costs are $ per seedling)					
1982	4.12	40.56	2.18	14.02	114.04	0.0484	0.0540	49.27	38.8
1984	7.16	64.82	2.26	14.63	90.23	0.0485	0.0505	43.18	40.35
1986	4.84	65.61	3.27	10.57	94.21	0.0524	0.0439	54.44	36.03
1988	6.52	57.26	3.47	8.58	92.66	0.0584	0.0492	55.58	35.84
1990	8.1	63.7	2.02	8.47	87.45	0.0597	0.0452	55.43	39.29
1992	8.14	62.73	2.49	12.72	98.42	0.0577	0.0519	75.71	43.17
1994	10.57	67.41	2.09	14.19	100.74	0.0587	0.0592	79.05	41.01
1996	14.65	67.65	3.06	12.21	108.05	0.0607	0.0651	89.22	56.52
1998	16.58	72.32	4.1	15.06	122.14	0.0670	0.0593	71.27	54.8
2000	17.7	68.12	3.45	25.7	136.03	0.0641	0.0770	82.27	43.08
2002	14.41	70.18	5.4	65.09	166.5	0.0800	0.1100	102.1	56.04
2004	21.08	69.45	3.32	14.62	105.23	0.0668	0.1162	74.98	50.08
2006	24.94	79.41	5.23	58.26	119.72	0.0863	0.1168	58.89	77.98
2008	29.31	48.82	6.28	86.99	157.32	0.1079	0.1386	80.18	110.28
2010	25.79	47.68	6.56	48.4	139.95	0.1200	0.1500	166.66	62.79
2012	32.42	55.12	13.2	43.48	168.13	0.1100	0.2400	50.27	86.33
2014	18.18	29.89	2.75	29.64	95.78	0.1100	0.1400	—	79.49
2016	26.63	69.53	10.64	29.25	140.99	0.1200	0.0900	159.44	70.41

[a]Planting costs do not include seedling costs.
— = Not available.

Table 3—Values for the Southern Forest Practice Cost Index (SFPCI), Southern Forest Employee Wage Index (SFEWI) and wProducer Price Index (PPI), 1982–2016

Year	SFPCI	SFEWI	No. 2 Diesel Fuel Price Index[a]	PPI[a]
1982	100	100	100	100
1984	99	108	86	104
1986	96	111	49	100
1988	96	123	50	107
1990	97	134	74	116
1992	106	147	62	117
1994	109	157	56	120
1996	120	168	70	128
1998	131	169	47	124
2000	135	183	93	133
2002	169	186	78	131
2004	132	194	128	147
2006	158	225	217	165
2008	195	256	325	190
2010	174	256	233	185
2012	211	283	326	202
2014	114	295	300	205
2016	186	290	144	185

[a]Data from the U.S. Bureau of Labor Statistics.

To provide a measure of change in forestry costs and commodity prices, the average annual percent change was calculated in both nominal and real terms for each cost and commodity price index. Given that the PPI for all commodities was most commonly published as a measure of inflation in the Forest Farmer/Forest Landowner cost and cost trends studies, it was used to measure the average inflation rate between 1982 and 2016. The average real rate of change for each practice was calculated using the inflation rate and nominal average rate of change for each cost and commodity index.

RESULTS AND DISCUSSION

Cost Change

Table 4 reports the average annual percent change in the cost of forestry practices in the South over a 34-year period. Though the costs of all the practices rose in nominal terms, only the cost of four practices rose in real terms. Controlled burning and timber cruising real costs increased the most, while precommercial thinning also showed a notable increase. The real cost of marking trees for harvesting rose only slightly.

The costs of all other practices decreased at least slightly. The real cost of mechanical site preparation decreased the most, however given the importance of the base year in determining the average rate of change, it is necessary to mention the possibility that the average in 1982 was weighted towards more intensive, and thus more expensive treatments. For instance, the average in 1982 was at least 17 percent higher in nominal terms than the average cost reported over the course of the next four studies. Though fuel prices did decrease during this period, it is unlikely that they had that dramatic of an effect. In addition, Straka and Watson (1985) mention that the way mechanical site preparation costs were reported was changed for the 1984 study in order to get more accurate results, suggesting that the value for 1982 may have been somewhat inflated.

Forestry practices as a whole, as indicated by the SFPCI, increased at a real average rate of less than a tenth of a percent annually. However, real costs of forestry labor as indicated by the SFEWI rose steadily at an average annual rate of 1.33 percent. To put this in perspective, the cost for all the labor-intensive practices also increased. The no. 2 diesel index decreased slightly at a real rate of 0.73 annually, and the more mechanically intensive practices most associated with fuel costs, slightly decreased annually on average. Figure 1 illustrates the real change of the SFEWI in relation to that of the SFPCI and No. 2 diesel price index.

Table 4—Nominal and real cost change for southern forestry practices, 1982–2016

Practice	Nominal cost change (%)	Real cost change (%)
Controlled burning	5.64	3.75
Herbicide application	1.59	-0.23
Timber cruising	4.77	2.89
Timber marking	2.19	0.36
Mechanical site preparation	0.63	-1.17
Hand planting	2.71	0.87
Machine planting	1.52	-0.30
Precommercial thinning	3.52	1.66
Fertilization	1.76	-0.06
Southern forest practice cost index	1.84	0.02
Southern forest employee wage index	3.18	1.33
Producer Price Index[a]	1.83	—
No. 2 diesel fuel price index	1.08	-0.73

[a]Change in producer price index was used as the measure of inflation and the value reported as nominal is the average annual inflation rate.

— = The real rate of change for this index is not applicable.

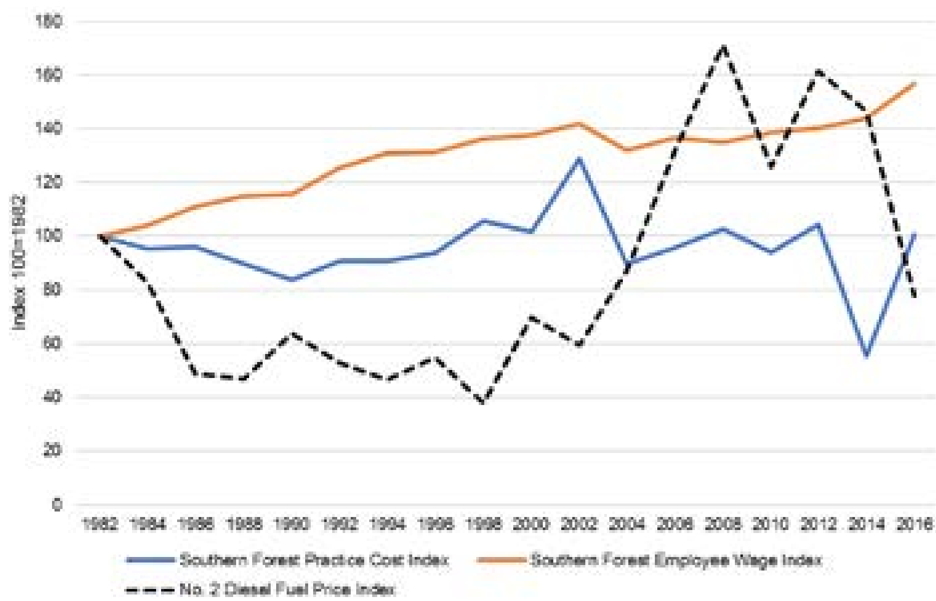

Figure 1—Real change in the Southern Forest Practice Cost Index (SFPCI), Southern Forest Employee Wage Index (SFEWI), and No. 2 Diesel Fuel Price Index.

Because some practices have continued to increase in real cost provides evidence for the importance of cost-share programs and other incentives that provide affordable means for smaller-scale timber producers to implement important silvicultural measures. However, a number of practices have not increased, and assuming these trends continue, it is unlikely that the cost of intensive silviculture as a whole will become markedly more expensive. Practices that continue to decline or remain steady in price could be potentially substituted in some cases for practices that continue to become more expensive. For example, controlled burns still cost less per acre than herbicide applications, and can achieve similar results (Maggard and Barlow 2017). Therefore, the liability associated with burning and the potential necessity of multiple burns to achieve similar results (Wigley and others 2002), combined with the decreasing cost of herbicide application, could make herbicide use a more attractive investment. At the very least, it is possible that the decrease in some costs may subsidize the increase in others, effectively maintaining an affordable basket of forest management practices.

Cost Component Analysis

Correlation analysis indicates moderate to strong relationships between labor and/or fuel costs and changes in certain forestry practices costs. The correlation coefficients for these results are listed in table 5. The costs of all practices except herbicide application were moderately to strongly correlated with forestry wages. The fact that the costs of hand planting and controlled burning were highly correlated with forestry wages is logical given the inherent labor intensiveness of these practices, and the fact that the majority of other practices were also correlated with forestry wages makes sense given that all forestry practices are somewhat labor intensive (Belli and others 1993).

Most practices had a correlation with diesel prices. This correlation was highest in fertilization and machine planting, which is expected given the mechanical intensity of these practices. Controlled burning often incorporates the use of bulldozers along with manpower, so this correlation with diesel prices makes sense. However, the fact that costs of less mechanically intensive practices such as planting by hand, timber marking, and timber cruising also had correlations with diesel fuel prices, is less logical. Upon investigation, diesel prices and forestry wages were found to be correlated, so it is possible that costs for non-mechanical practices could show correlations with diesel prices without a direct relationship. Due to this issue, if fuel prices or forestry wages were to be included as variables in the prediction of forestry practices costs, it would be important to recognize whether the nature of the practice made this appropriate.

Table 5—R values for correlations between forest practices costs and Southern Forest Employee Wage Index (SFEWI) and diesel price index

Forestry practice cost component	Controlled burning	Herbicide application	Timber cruising	Tree marking	Mechanical site preparation	Hand planting	Machine planting	Precommercial thinning	Fertilization	Southern forest practice cost index
Labor	0.90	-0.25	0.73	0.62	0.60	0.96	0.81	0.61	0.84	0.80
No. 2 Diesel	0.79	-0.52	0.60	0.70	0.51	0.83	0.88	0.19	0.89	0.69
Herbicide	—	-0.52	—	—	—	—	—	—	—	—
Fertilizer	—	—	—	—	—	—	—	—	0.92	—

— = Not applicable.

Herbicide application costs showed a moderate negative correlation with diesel fuel prices. However, it is unlikely that higher diesel prices would decrease the cost of herbicide application. Rather, it is more likely that herbicide application costs declined or increased for other reasons, at times when diesel fuel prices happened to be doing the opposite. For example, as diesel fuel prices declined in the early to mid-1980s, supply factors may have affected the cost of forestry chemicals such as the restriction of 2,4,5-T for forestry use in 1979 (Belli and others 1993, Fox and others 2007). Likewise, herbicide prices may have dropped due to the expiration of patents on some herbicides in the early and mid-2000s (Lunsford 2018, Woodburn 2000), a time period that happened to experience increases in diesel prices. However, the fact that herbicide application costs for 1990-2016 did not show a logical correlation with herbicide chemical costs during that time period may be due to the fact that, aside from glyphosate and 2-4-D, the index used represents a suite of herbicides more commonly used in agriculture than in forestry.

Despite the fact that the index used for fertilizer costs was also of an agricultural nature, fertilization practices had a strong correlation with fertilizer prices. This correlation is logical and has been supported by past cost studies (Belli and others 1993). It may be that the correlation was stronger than that between agricultural herbicides and forest herbicide application due to the fact that fertilizer components are often more similar between forestry and agriculture than herbicide components.

Other Influences

Although practices often dependent on the use of equipment, including herbicide application and mechanical site preparation, did not show stronger correlations with diesel fuel prices does not mean that the costs of these practices are not affected by them. It may, however, mean that for some practices other factors may at times have overshadowed the influence of labor costs and fuel prices. One factor playing a substantial part in influencing these costs may be changes in general forestry industry and market conditions. In the case of mechanical site preparation, it has been noted that significant moderation in costs in the late 1980s and early 1990s may have been due to an over-abundant supply of contractors resulting from many landowners switching to chemical site preparation (Dubois and others 2001). In addition, Smidt and others (2005) speculated that many contractors using mechanical-intensive methods may had borne the cost of increased fuel prices in order to remain competitive during a period of lower demand brought on by an increasing scrupulous forestry market. Likewise, during periods of intense sawtimber and pulpwood demand, the high demand for forestry practices may have influenced higher practices costs (Dubois and others 1999).

Another example of possible additional factors playing a role in influencing costs can be found with controlled burning. Though prescribed burning costs showed logical correlations with increasing forestry wages, burning costs have increased substantially faster than forestry wages. There is no doubt that over the years, increased liability, as well as regulations regarding smoke management, has played a role in driving up these costs (Dubois and others 2001). These factors become magnified as urban and suburban areas continue to encroach upon managed forests.

There are many complexities surrounding forestry practices cost components, market conditions, contractor supply, and regulations that likely influence the cost of forestry practices. Given the relatively constant nature of the SFPCI, and assuming markets for wood continue to be viable, it is not likely that costs associated with timber management will be a prohibitive factor. However, certain costs continue to change and in order to understand their impact on timber investment profitability it would be valuable to model how common management scenarios may respond to the noted rates of change in cost.

CONCLUSIONS

Understanding the costs associated with practicing forestry is important in assessing the potential risk and reward of any forestry investment. As important as it is to have this cost data available to land managers, it is perhaps as important to understand the trends associated with changes in the costs of these practices. Predictions regarding the future capital necessary to invest in forestry practices can be made more accurate, or at least better assessed, through understanding past cost trends and the forces driving them. Through analyzing published cost data, one can draw some conclusions regarding how the cost of specific forestry practices change in relationship to inflation, and whether intensive forestry is going to be harder to profit from in the future. Though the real cost of intensive forestry practices as a whole has changed little on average over the last 34 years, the real individual costs of several labor-driven practices have increased, indicating that some small-scale producers may continue to need cost-share assistance for certain practices, such as precommercial thinning and/or prescribed burning.

The relationships between the costs of forestry practices, labor, diesel fuel, and other variable cost inputs has been described in the literature and we have shown that the use of correlation analysis can be useful in some cases to strengthen the evidence of these relationships. However, though trends in variable costs undoubtedly influence change in the cost of forestry practices, other important market factors, like changes in forest management technology, changes in the forestry industry, and economies of scale, likely play an important role as well. Future research could focus on the role of historic forestry practices demand, as well as variable cost inputs, in influencing forestry practice costs. In addition, given that this study has demonstrated that the cost of several practices are indeed changing, it would be valuable to use these rates to assess forest investment sensitivity to change in forestry practices costs.

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MANAGEMENT

The Value of Canopy Cover: a Hedonic Pricing Study in Lakeland, Tennessee

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Abstract—Urban forests have been shown to impact residential property values. This presentation demonstrates the results of a hedonic pricing study to determine the impact of urban forest canopy cover on residential property values in Lakeland, TN. The results demonstrate that tree cover has a significant positive influence on the sales price of single family residential properties in this community during the time of the study. Results also show how hedonic pricing studies can be utilized to prepare benefit cost analyses for urban forestry programs and to guide strategic tree retention and replacement efforts in order to maximize benefits to a community.

Brandeis, Consuelo; Hodges, Donald G.; Poudyal, Neelam, eds. 2018. Forest resource economics in transition: traditional and emerging markets—Proceedings of the 2018 Meeting of the International Society of Forest Resource Economics. e-Gen. Tech. Rep. SRS-247. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 70 p.

The International Society of Forest Resource Economics 2018 Annual Meeting was held in Gatlinburg, TN, March 19–21, 2018. The meeting was attended by a range of forest economics professionals to discuss developments in various aspects of forest economics including traditional and emerging markets issues. The 37 talks and 12 poster presentations covered topics on regional economic contribution analysis, finance, management, carbon and greenhouse gases, non-market valuation, prescribed fire, private forest landowner issues, and international policy issues.

Keywords: Forest economics, forest resource policy, resource management, non-market valuation, forest products markets.