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Forest Economics and Policy in a Changing Environment: How Market, Policy, and Climate Transformations Affect Forests

Proceedings of the 2016 Meeting of the International Society of Forest Resource Economics

Editors:

Gregory E. Frey and Prakash Nepal

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Preface

The International Society of Forest Resource Economics (ISFRE) began as the Southern Forest Economics Workshop (SOFEW), whose first meeting was in Gulf Shores, Alabama, April 6-7, 1977. Over almost 40 years, then SOFEW and now ISFRE has fostered dialogue about research and practice surrounding all aspects of forest economics issues.

Economics can affect decisions about forest resource management and utilization, and in turn, the ecosystem benefits received. In a time of market, policy, and climate transformations, economic analyses are critical to help policy-makers and resource managers make appropriate decisions. At the 2016 ISFRE Meeting, researchers and practitioners from as far away as China and as nearby as Cary, NC travelled to Raleigh, NC to discuss novel ideas related to the economics of forest resources. Participants addressed this with 63 oral, 11 poster, 2 panel, and 2 keynote presentations. These presentations addressed topics including Economic Impact Analysis, International Trade, Ecosystem Services and Non-Market Valuation, Policy and Governance, Climate Change and Bioenergy Markets, Traditional and Non-Timber Forest Product Markets, Forest Landowners and Ownership Trends, and Forest Management. Participants also attended field tours on themes related to bioenergy production, forest management, and urban forestry.

Acknowledgments

We thank the following individuals for their assistance with the ISFRE 2016 Meeting.

North Carolina State University's Forestry & Environmental Outreach Program (NCSU FEOP), in particular Addie Thornton and Kelley McCarter, did an excellent job handling the logistics of the meeting. They worked diligently to ensure a safe, comfortable, and productive meeting. The 2016 Meeting Steering Committee planned and organized the event. The Steering Committee included Greg Frey (Chair, USDA Forest Service, Southern Research Station [SRS]), Addie Thornton, Kelley McCarter, Karen Abt (SRS), Robert Beach (RTI International), Kim Cesafsky (Enviva LP), Reid Miner (NCASI), Prakash Nepal (NCSU), and Jeff Prestemon (SRS). Additional planning and logistical assistance was provided by Ruhong Li (NCSU), Thresa Henderson (The Forestland Group), Natasha James (SRS), and Brian Doherty (SRS).

The ISFRE group at Mississippi State University, led by Changyou Sun and with assistance from Karen Brasher, helped with guidance for the Steering Committee, and with communication to ISFRE members.

Several anonymous judges judged the student posters.

Sarah Childs (Duke University), Zachary Manor (Raleigh Parks, Recreation and Cultural Resources Department), and Kim Cesafsky led the field tours.

Several people from Raleigh and surrounding areas helped make sure the meeting was a success, including Jack Benton and all the staff of the Sheraton Raleigh, and Gray Henderson and all the staff at the Greater Raleigh Convention and Visitors Bureau.

Finally, we thank all the participants of the meeting, especially keynote speakers David Wear (SRS) and Janaki Alavalapati (Auburn University), session moderators, panel presenters, oral presenters, and poster presenters.

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EMPLOYMENT IMPACT OF THE MARCELLUS SHALE GAS BOOM IN WEST VIRGINIA'S FOREST PRODUCTS INDUSTRY: A COUNTY LEVEL ANALYSIS

Kathryn A. Gazal, Kathleen G. Arano, and Rico M. Gazal[1]

During the period of the Marcellus shale gas boom, natural gas extraction activities from this geologic deposit has increased significantly due to advancement in drilling technology like horizontal drilling and hydraulic fracturing. While the boom in the Marcellus gas has benefited the oil and gas industry, it is interesting to see what this has done in the forest products industry in West Virginia. With the downturn of the economy in 2008, the forest products industry has suffered tremendously in the past few years resulting in mill closures and job loss. In addition, anecdotal evidence has shown that some forestry jobs may have been lost to the oil and gas industry due to the boom in Marcellus Shale drilling. We investigated the potential employment impact of the boom in natural gas production from the Marcellus shale in the employment in the forest products industry in West Virginia. We examined the spatial patterns of employment along with completed gas wells and developed an econometric model of employment in the forest products industry to establish causal relationships. Our findings suggest a certain degree of competition for workers between the forestry, oil, and gas exploration industries in West Virginia.

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IMPLAN SECTOR ASSIGNMENT FOR AN ECOSYSTEM RESTORATION PROJECT

Joshua D. Obermeyer and Matthew H. Pelkki[1]

Abstract—The Ozark National Forest in northwest Arkansas is participating in a multi-year Collaborative Forest Landscape Restoration Program (CFLRP) designated as the Ozark Highlands Project (OHP) by the U.S. Department of Agriculture Forest Service. IMPLAN was used to assess the impacts from the FY2014 timber production and restoration expenditures in the 11-county OHP region and nationally. There was uncertainty regarding the accuracy of IMPLAN sector assignment for several project activities. Therefore, a secondary sector mapping scheme was modeled to perform a sensitivity analysis on sector utilization. Collaborators were classified as local, commuter, or relocator depending on their proximity to the OHP region. At the national level, the total impacts based on primary and secondary sector maps were within 1 percent for employment, employee compensation, and total value added. In the regional model, the impacts were also within 1 percent for the totals in the aforementioned categories. The lack of sensitivity was likely due to the similarities in sector allocation between the primary and alternate models— i.e., allocations remained in major economic categories of agriculture, manufacturing, wholesale and retail trade, services, and government. Alternative sector allocations did not cross these broad aggregation groups. While the models indicated a robustness to sector allocation, leakage of impacts outside the OHP region for employment (33 percent), employee compensation (50 percent), and total value added (52 percent) was substantial.

INTRODUCTION

The Collaborative Forest Landscape Restoration Program (CFLRP) has been operating in the Ozark National Forest (ONF) in northwest Arkansas since 2011 (U.S. Congress 2009, USDA Forest Service 2011). The main objective of the Ozark Highlands Project (OHP) is to restore oak woodland habitats to their historical structure and function in an 11-county Ozark Highlands Region (OHR) shown in figure 1. The OHR consists of two urban counties and nine rural counties (USDA Forest Service 2011). Benton and Washington Counties were named the "urban two" as they are the two most populous counties containing a metropolitan area with a diverse range of industry clusters (IMPLAN 2015). The two counties combined have a median household income of $48,000 (U.S. Census Bureau 2015). Crawford, Madison, Franklin, Newton, Johnson, Searcy, Pope, Van Buren, and Conway were classified as the "rural nine" counties. These counties contain no urban centers, are heavily forested, lack economic diversity, and often depend on the forest to support themselves (IMPLAN 2015, USDA Forest Service 2015). The populations are in need of more jobs with a combined median household income of $35,000 in comparison to a national average of $52,000 (U.S. Census Bureau 2015).

Within the OHR, restoration activities taking place are: the thinning of forest to improve forest health; restoring grasses, forbs, and shrubs to increase indicator and game species; prescribed fire to reduce fuel loads and restore a frequent fire regime; increasing oak regeneration; and revitalizing healthy watershed functions. The Forest Service, U.S. Department of Agriculture, also has a goal of improving regional economic vigor through these activities and sustaining them as a result of a healthier forest ecosystem in the region (USDA Forest Service 2011). The restoration activities and timber harvests that are part of the OHP stimulate the local and national economies, and these impacts and regional leakage can be analyzed through input-output models using IMPLAN software (IMPLAN 2015).

IMPLAN was designed in 1976 by the Forest Service as an input-output economic modeling tool, initially outlining the contribution of chiefly natural resource outputs in regional economies in the United States (Hotvedt and others 1988, IMPLAN 2015). Input-output economics trace the flow of money through an economy and the interdependencies among economic sectors. Multipliers based on linear algebra matrices are used to link the interdependencies between industries. (Lindall and Olson 1996, IMPLAN 2015, Robison 2009). The software later expanded their data sets to cover an array of industry activities and functioned as the leading economic modeling system used by government and private sectors in the United States (IMPLAN 2015). IMPLAN

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Ozark Highland Region

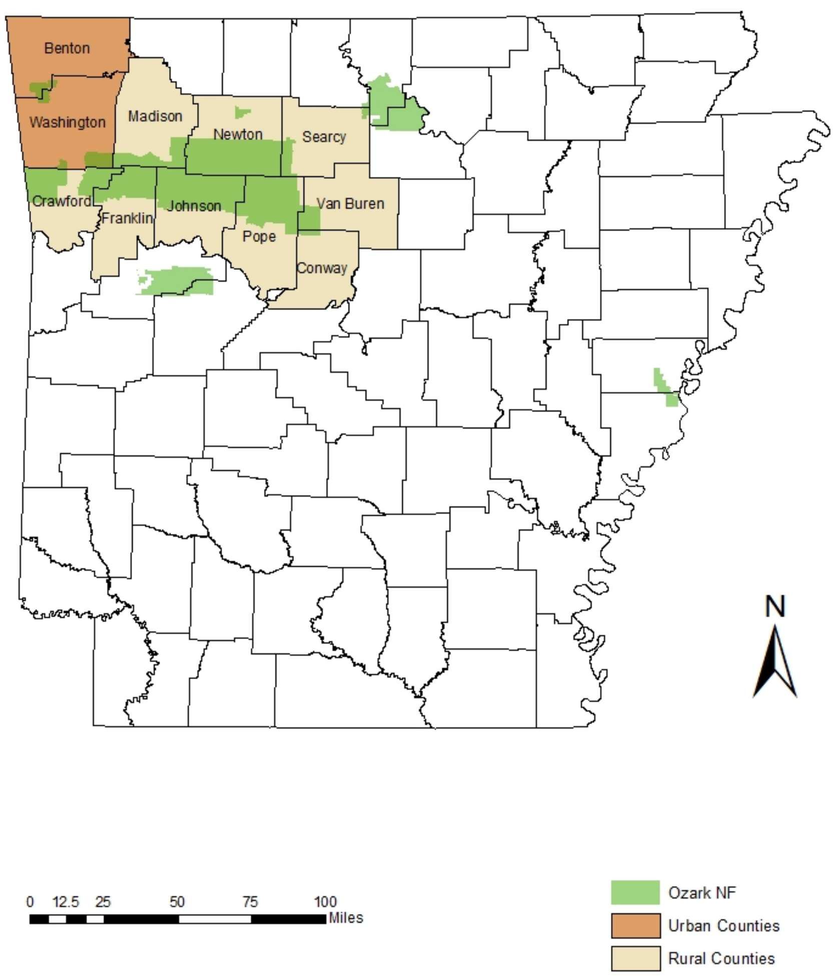

Figure 1—The Ozark Highlands Region outlining the Ozark National Forest, the two urban counties, and the nine rural counties.

is at present an acceptable tool used to map job growth, obtain a snapshot of goods and services circulating in the economy, and predict future business activities in the local and greater economies (IMPLAN 2015, McNay 2013).

The software contributes differently when applied to variable geographic and demographic regions. Rural forest communities, communities in close proximity to National forests in this scenario, remain among the poorest in the United States (Gibson and others 2000, Lee and Field 2005). These rural forest communities can grow their economy with natural resources providing greater ecological and recreational services, and improved commodity production, such as timber, to drive their economies (Gibson and others 2000, Hays 2009, Lee and Field 2005). Concentrating on the fields of conservation and economics alongside focusing on creating livelihoods for people in rural forest communities is a growing concept in natural resource management (Gray and others 2001, Moseley 2008, Moseley and Reyes 2008, Nielsen-Pincus and Moseley 2013). A forest restoration project such as the CFLRP/OHP has the potential to positively impact the regional communities in and near the Ozark National Forest.

Defining a set of new economic activities (shocks to the existing economy) and linking these events to specific economic sectors allows for an IMPLAN model to be built (IMPLAN 2015). Activities directly linked to the OHP were used to build an IMPLAN model. The economic sectors used to build the model were chosen by using the North American Industry Classification System (NAICS) manual (U.S. Census Bureau 2012). There are over 19,000 industry sectors in the NAICS manual; IMPLAN aggregates them into 440 sectors in the 2012 model (IMPLAN 2015 (2), U.S. Census Bureau 2012).

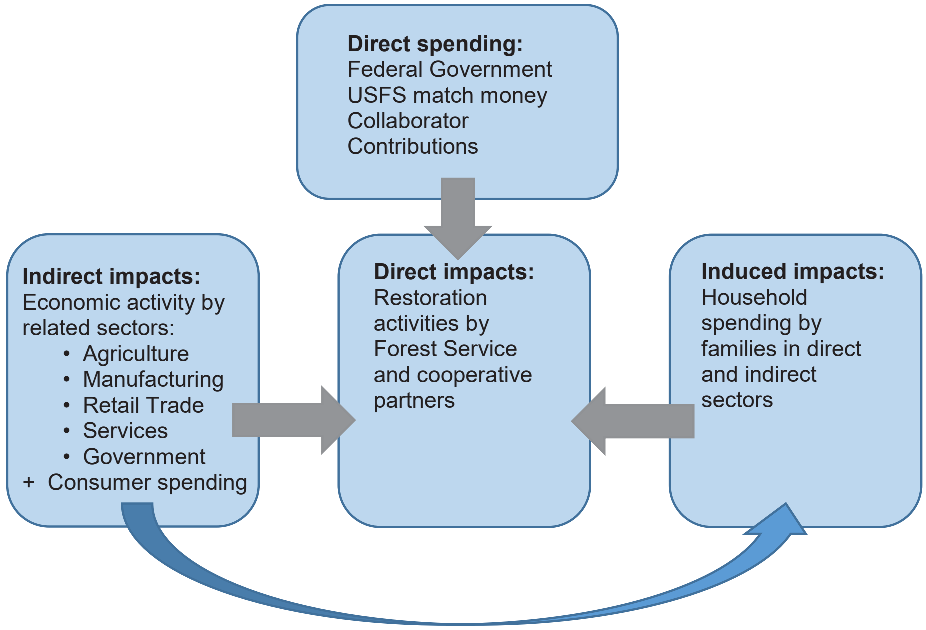

Figure 2—An example of an input-output economic flow chart of the Collaborative Forest Landscape Restoration Program (CFLRP) in the Ozark Highlands Region (OHR) showing examples of direct, indirect, and induced impacts.

These 440 sectors can be further aggregated and classified as agriculture, manufacturing, wholesale and retail trade, services, and government sectors. Aggregation like this reduces the amount of unmanageable detail on industry classification (Kelton and others 2008, U.S. Census Bureau 1993).

The Forest Service provided us with broad and specific financial information related to collaborator activities in the OHR for FY2014. This information was compiled and the optimal choice for sector application was used. To outline regional spending patterns prior to receiving information related to local expenditures, we assumed a percentage of money spent locally based on the distance of a collaborator's main establishment. The assumed percentages would provide the necessary information to build a regional model. As a result, this provided us with the information to calculate leakage from restoration activities and timber harvests.

The focus of this study is the use of IMPLAN software for regional and national economic impacts related to the restoration activities and timber harvests taking place due to the OHP in FY2014. The accuracy of our sector utilization presented uncertainty; therefore, we decided to create a second model with alternate sectors to perform a sensitivity analysis. We performed a sensitivity analysis on human decision making for selecting economic sectors when building an IMPLAN model. The sensitivity analysis was performed as the selection of economic sectors was not definitive given the amount of information provided for a range of commerce involved with an ecosystem restoration project. This was done to show the importance of sector application and how sensitive IMPLAN is to industry changes for an ecosystem restoration project.

METHODOLOGIES

Our selected tool to perform the input-output economic analysis was IMPLAN software. The expenditures reported for FY2014 were assumed to occur in CY2014 for use in IMPLAN, which uses calendar year data. The data for the IMPLAN model was for Arkansas in CY2012, but dollar amounts were adjusted to 2014 dollars. Within the IMPLAN model, social accounts for the regional model were based on the National Trade Flows, while the national model used the required supply-demand pooling. Multipliers were calculated using all households, State and local education, non-education and investments, as well as enterprises.

The data was collected in the form of work plans, general contracts, timber harvests, and other forms indicating collaborator agreements and in-kind contributions provided by the ONF. The CFLRP involves Federal and Forest Service 50/50 spending with multiple collaborators and contributors for the OHP, such as the National Wild Turkey Federation, the Rocky Mountain Elk Foundation, the Nature Conservancy, and other NGOs interested in supporting the OHP.

Direct expenditures collected from the ONF related to the OHP were entered into IMPLAN as direct impacts to create a scenario. Direct impacts create a flow of money as added indirect and induced impacts (fig. 2). Direct impacts are activities performed due to the CFLRP by the Forest Service or cooperative partners. Indirect impacts are economic activities created by economic sectors related to the direct activities, and induced impacts are the result of household (consumer) employees in direct and indirect sectors. For example, the direct cost for my position as a graduate research assistant is a direct impact. The spending on this research in economic sectors that supported it are indirect impacts. My personal spending outside of work and the spending of employees in supporting (indirect) economic sectors are induced impacts. IMPLAN uses the direct impacts with associated sectors and calculates the indirect and induced impacts, thus providing total output and a breakdown of other economic values.

The work plans and other reports submitted by the ONF for 2014 identified 294 activities and their expenditures. Each expenditure was assigned to 1 of 36 IMPLAN sectors chosen to represent the activities. To simplify analysis and presentation, the 36 (out of 440 available IMPLAN sectors) were aggregated into five major sectors: agriculture, manufacturing, wholesale and retail trade, services, and Government. The activities were mapped to the most appropriate sector, yet a lack of descriptive information for activities led to uncertainty in sector assignment.

Activities expending under $3,500 within the Forest Service may be purchased with a credit card and often lack a detailed description of the expense. For example, a credit card purchase described as “herbicide” presents multiple options for sector choice. One possible assignment is IMPLAN sector 323—a retail purchase of herbicide from a building material and supply store such as Lowes or Home Depot. Or, the purchase could be made from an online seller of herbicide in sector 331—retail non-store, such as Forestry Suppliers. Another is the application of herbicide spray as sector 19—support activities for agriculture and forestry. A fourth option could be a purchase directly from a manufacturer, sector 125—all other basic inorganic chemical manufacturing. Some sector sensitivity crosses the major aggregations from wholesale/retail trade to agriculture or even manufacturing. This explanation also displays a glimpse into the interdependencies among economic sectors and how sector assignment could impact IMPLAN results.

After allocating the sectors based on the information from the Forest Service, timber sales were added as a commodity production with the volume of timber produced in 2014 converted to delivered log prices using Timber Mart-South (2014) data for CY2014. The CFLRP activities were mapped to the most appropriate IMPLAN sectors and the primary model was constructed. Paucity of descriptive information led to uncertainty in sector assignment. An alternate sector was identified when there was “reasonable doubt” about the primary sector. This allowed us to perform a sensitivity analysis in IMPLAN to discover how sensitive sector choice is when performing an economic analysis of ecological restoration.

Another component to the CFLRP expenditures is the location of the establishment of the collaborating recipient and how their location impacts economic leakage outside of the 11-county OHR. Percentages based on location of collaborators and how much of the money was spent locally by an activity were assumed to be 90 percent, 60 percent, and 30 percent for local, commuting, and relocated collaborators, respectively. Local collaborators’ business location is defined within the 11-county impact region with 90 percent of spending in the OHR. Commuters’ businesses resided within three counties (daily travel) of the impact region and spent 60 percent locally. Relocator business establishments were not within commuting distance and were assumed to spend 30 percent of money within the 11-county OHR. These numbers were assumed as the actual data has not been collected at this time; actual percentages from surveys of the collaborating organizations will be determined in future research.

RESULTS

There were 294 activities associated with the OHP used in the primary model. There were a total of 36 sectors used in the primary model, with 3 less (33) in the alternate model. Eighty-nine out of the 294 (30 percent) activities presented uncertainty in their assignment; therefore, the sectors were changed to create an alternate scenario. In the alternate model, 55 (61 percent) out of the 89 sectors changed were credit card purchases under $3,500. A further 15 (17 percent) were purchases under $10,000, and eight (9 percent) of them were purchases over $10,000. The majority of the sector changes were similar in nature, and only 11 of the activities were allocations from 1 of the 5 major economic sectors to another. Fifty percent of the 294 activities were in two sectors: sector 439 (employment and payroll for Federal non-Military) and sector 19 (support activities for agriculture and forestry). Sector 439 represented 32 percent of total expenditures, while sector 19 consisted of 18 percent of all CFLRP expenditures in the OHP in 2014.

National expenditures and timber sales for the primary model can be found on table 1 with a total of $4,276,466 in direct expenditures and $4,029,645 as a commodity production. The direct spending on OHP activities combined with the timber commodity production resulted in 236 jobs created at a cost of $18,121 per job. Total employee compensation was $10,263,631 with an average employee compensation of $43,490, 59 percent more than the cost of each job. Total value added from the OHP in 2014 was $16,993,524 with a benefit cost ratio of 3.97:1 (value-added divided by direct OHP spending).

Total expenditures and timber sales for the alternate national model are listed in table 2 presenting the same total expenditures and commodity production as the primary detail (table 1). Expenditures differed among individual sectors between the models as expenses were re-allocated to alternate sectors. The spending and added commodity ensued the creation of 237 jobs at a cost of $18,044 per job. Total employee compensation was $10,323,849 with an average employee compensation of $43,560, 59 percent more than the cost of each job. The total value added in table 2 is $17,153,074 with a benefit cost ratio of 4.01:1, slightly higher than the primary scenario. The total values for employment, employee compensation, and value added produced little change and were within 1 percent for the primary and alternate impact models.

The 11-county primary impact detail found in table 3 resulted in $3,374,329 in direct expenditures and $3,626,680 (0.90 times $4,029,645) as the commodity production was retained locally. The spending and the additional timber created 157 jobs at a cost of $21,493 per job. Total employee compensation was $5,103,316 with an average employee compensation of $32,505, 35 percent more than the cost of each job. Total value added for the 11-county OHR in 2014 was $8,102,025 with a benefit cost ratio of 2.40:1.

Expenditures and the commodity unit sales for the 11-county OHR alternate scenario presented in table 4 are the same as the 11-county primary OHR detail (table 3).

Table 1—U.S. primary impact detail of the Collaborative Forest Landscape Restoration Program in the Ozark National Forest for FY2014

		DIRECT + INDIRECT + INDUCED IMPACTS		
Major economic sector	Direct spending	Employment	Employee compensation	Total value added
Agriculture	$1,181,170	89	$2,399,481	$2,914,484
Manufacturing	$524,342	13	$817,794	$2,106,514
Retail trade	$300,020	22	$859,990	$1,543,619
Services	$276,830	88	$3,798,160	$7,343,685
Government	$1,994,104	24	$2,388,207	$3,085,222
Total	**$4,276,466**	**236**	**$10,263,631**	**$16,993,524**

Table 2—U.S. alternate impact detail of the Collaborative Forest Landscape Restoration Program in the Ozark National Forest for FY2014

		DIRECT + INDIRECT + INDUCED IMPACTS		
Major economic sector	Direct spending	Employment	Employee compensation	Total value added
Agriculture	1,181,170	89	2,399,723	2,915,313
Manufacturing	524,342	13	822,876	2,120,080
Retail trade	300,020	23	900,328	1,618,527
Services	276,830	88	3,802,382	7,401,980
Government	1,994,104	24	2,398,540	3,097,174
Total	**4,276,466**	**237**	**10,323,849**	**17,153,074**

The spending from the alternate OHR scenario (table 4) created 159 jobs at a cost of $21,222 per job. Total employee compensation was $5,203,284 with an average employee compensation of $32,725, 35 percent more than the cost of each job. The total value added from the regional alternate model was $8,106,744 with a benefit cost ratio of 2.40:1. The total values for employment, employee compensation, and value added produced little change and were within 1 percent for the 11-county primary and alternate impact models.

Table 5 shows an example of the primary national model without timber harvests. The direct expenditures remain the same at $4,275,466 with timber harvests amounting to $4,029,645 in direct impacts. Output from the commodity is a total value added of $9,101,227, 54 percent of the total value added of the U.S. primary scenario.

The two models both demonstrate that leakage outside of the OHR was substantial. Leakage in direct spending was 21 percent, $3,374,329 of the 2014 OHP budget of $4,276,466 (tables 1, 2, 3, and 4). Leakage of employment outside of the OHR was 33 percent for the two scenarios, with 157 out of the 236 jobs created by the OHP retained locally (tables 1, 2, 3, and 4). Of the $10.2 million in employee compensation generated nationally, $5.1 million (50 percent) was leaked outside of the OHR represented in the separate models (tables 1, 2, 3, and 4). A total of $8.1 million of the $17 million attributed to the total value added of the OHP, leakage was 52 percent outside of the OHR for the primary and alternate models in both the national and regional impact details (tables 1, 2, 3, and 4).

DISCUSSION AND CONCLUSIONS

The alternate scenario was created when there was "reasonable doubt" that the correct sector had been chosen, usually from a lack of a detailed description of the expenditure. The majority of the sectors in the primary sector map were clearly defined and the sectors chosen did not cast doubt. There were fewer sectors in the alternate model due to a second round of choices based on the most appropriate alternative being chosen with a slightly more refined list of sectors.

The activities presenting the most uncertainty were credit card purchases under $3,500, which had no contract and only a few words describing the expenditure. We were unable to obtain a complete list of contracted activities and relied on work plans for the activities with missing contracts. There were also a small number of activities with payments under and over $10,000 lacking contracts. The reasoning for the absence of contracts on larger purchases was that contract data was stored at the ONF Supervisor's office in most cases, but for a few cases, the contracts were in district offices. These missing contracts are being sought, and their descriptions used to correct (if necessary) results in future research reports.

Greater detail in work plans, such as a short description about the activity, contractor identity, and whether the expense was local or non-local, would reduce the uncertainty in sector allocation and more precise determination of local impacts of the project. There were few sector changes involving the reassignment across the five major sector aggregates; most of the sector reassignments were to a closely related sector, and so the expected shifts in multipliers would be minor. The majority of the chosen sectors were in two IMPLAN sectors (19 and 439), and also two of the five aggregated sectors (Agriculture and Government). Agriculture was a main sector as the OHP involved an abundance of forestry related work. Government was also a chief sector as the project is managed by the Forest Service, a Government agency, which staffs a great deal of personnel to perform "in-house" work on the CFLRP.

The direct expenditures remained the same for both the national and regional, and the primary and alternate models (tables 1 and 2). The only variable to change when designing the models was the sector allocations. The observed changes in the indirect and induced impacts from these sector reassignments were minor as multipliers within broad economic sectors are similar. The end result of this was a small (< 1 percent) change in the total economic values when comparing the two national models and the two regional models.

The timber sales were not a part of the expenditures, yet they were added as a commodity production and produced indirect and induced impact values, therefore increasing the total values. Without timber harvests, the total value added for the primary model would result in 46 percent less value added to the gross domestic product (GDP) of the United States. The timber harvests represent an important component to the OHP with substantial impacts to the total output from the project. Proceeds from the timber harvests make the project more feasible and economically self-sufficient. The high impacts from the commodity production also present a scenario of increasing restoration activities as project costs can be off-set by timber sales.

The average employee compensation was substantially higher than the average cost of each job for both of the national and the regional models. The high benefit cost ratio of the project signifies around $4 was circulated within the national economy for each dollar directly spent on the OHP, and $2.40 was circulated within the 11-county OHR for each dollar spent on the OHP. The non-substantial change in total values between the national and 11-count OHR models shows that choosing a

Table 3—Eleven-county primary impact detail of the Collaborative Forest Landscape Restoration Program in the Ozark National Forest for FY2014

		DIRECT + INDIRECT + INDUCED IMPACTS		
Major economic sector	Direct spending	Employment	Employee compensation	Total value added
Agriculture	710,668	83	1,464,452	2,122,423
Manufacturing	422,032	6	259,274	450,937
Retail trade	260,936	11	418,767	727,936
Services	191,822	35	1,108,083	2,366,884
Government	1,778,157	22	1,852,740	2,433,845
Total	**3,374,329**	**157**	**5,103,316**	**8,102,025**

Table 4—Eleven-county alternate impact detail of the Collaborative Forest Landscape Restoration Program in the Ozark National Forest for FY2014

		DIRECT + INDIRECT + INDUCED IMPACTS		
Major economic sector	Direct spending	Employment	Employee compensation	Total value added
Agriculture	710,668	84	1,469,222	2,123,835
Manufacturing	422,032	6	236,820	422,721
Retail trade	260,936	11	431,264	747,275
Services	191,822	36	1,143,765	2,364,621
Government	1,778,157	22	1,922,214	2,448,293
Total	**3,374,329**	**159**	**5,203,284**	**8,106,744**

Table 5—The national primary impact detail of the Ozark Highlands Project in 2014 without timber harvests

Major economic sector	Direct spending	Employment	Employee compensation	Total value added
Agriculture	$1,181,170	38	$918,388	$798,830
Manufacturing	$524,342	9	$529,704	$1,297,232
Retail trade	$300,020	14	$488,631	$909,420
Services	$276,830	46	$1,982,706	$3,807,105
Government	$1,994,104	15	$1,751,935	$2,288,640
Total	**$4,276,466**	**124**	**$5,671,363**	**$9,101,227**

sector has minimal impacts as the multipliers were similar due to distribution of economic activity. The results are relatively insensitive to minor sector reallocations when building an IMPLAN model for OHP in the Ozark National Forest.

Leakage outside of the OHR was considerable in the primary and alternate models when compared to the regional models. Leakage was assumed to be minimal when a collaborator's establishment was within the 11-county impact area as the majority of distributed funds were anticipated to be spent locally. Commuters and relocators were assumed to spend less in the region as their establishments and residences were outside of the OHR. The circular flow mechanism of incomes and expenses were assumed to emit more expenditures in the region of the collaborator's business establishment, not the location of the fund source. Whether expenditures are local or non-local, leakage is inevitable, yet it can potentially be minimized by disbursing expenses locally. It is not feasible or realistic to source all business activities locally when a diverse range of economic sectors are involved. Therefore, it is expected a degree of leakage will occur. Further, whether employees are local or not, it is probable they will spend money and pay taxes outside of the OHR. Leakage expands when a circular flow of added indirect and induced impacts occur outside the region of interest. Smaller study regions typically have greater leakage than large regions.

Leakage transpired due to costs of goods and services from collaborators, employee household spending, taxes, and imports. About one-fifth of direct spending was outsourced, and one in every three jobs created was outside of the region as activities and economic sectors were expanded. While impact activities drift away from direct spending, units become more dependent on the greater economy due to the interdependencies of economic sectors. When indirect and induced impacts are included, more leakage occurs as there is more connectivity involved with inputs and outputs of national commerce. This caused half of the employee compensation from the OHP to be generated outside of the OHR. Around half of the total value added was retained locally, boosting both the local and national economies. The total value added represents the diversion of local and national impacts from the cost of goods and services, labor, depreciation, and profit. The primary and alternate models resulted in a snapshot of the OHR and the greater economy in relation to expenditures on the OHP in 2014. Restoration projects with a high amount of local spending will inherently cause leakage considering the interconnected and globalized economy. IMPLAN can be used to estimate how much leakage occurs and help decisionmakers put forth future expenditures aligned with their desired goals.

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ECONOMIC IMPACTS OF TIMBER SALES FROM ECOLOGICAL RESTORATION IN THE OUACHITA NATIONAL FOREST

Anusha Shrestha and Sayeed R. Mehmood[1]

The Shortleaf-Bluestem Community Restoration Project is being implemented by the Forest Service, U.S. Department of Agriculture to restore 348,482 acres of the Ouachita National Forest. Timber harvesting and commercial thinning are among major restoration activities that generate economic impacts within the regional economy by creating jobs and supporting businesses. This study estimated the economic impacts (direct, indirect, and induced) of the timber sales from the project and non-project areas of the Ouachita National Forest and compared characteristics of timber sales from these areas. Timber sale reports were collected from the Forest Service. Delivered prices of timber based on product type and volume of timber harvested were calculated using TimberMart-South data. Impact Analysis for Planning (IMPLAN) based on the input-output model was used to analyze the data. A total of 349 jobs and $35 million of output were generated in the regional economy from the sale of timber from the Ouachita National Forest of which 192 total jobs and $19 million of output were attributed to the timber harvested from the restoration project area. Characteristics of timber sales were compared using the Wilcoxon rank sum test. Sawtimber and pulpwood volumes harvested in the non-project area were significantly higher than those in the project area.

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EVALUATING ECONOMIC IMPACTS OF DIFFERENT SILVICULTURAL APPROACHES IN SWEETGUM- NUTTALL OAK-WILLOW OAK BOTTOMLAND HARDWOOD FORESTS IN THE LOWER MISSISSIPPI ALLUVIAL VALLEY

Sunil Nepal, James E. Henderson, Brent R. Frey, Donald L. Grebner, and Scott D. Roberts[1]

Abstract—This study explains the economic tradeoff, in terms of forgone timber revenue, between even-and uneven-aged management approaches for the sweetgum-Nuttall oak-willow oak forest type of the Lower Mississippi Alluvial Valley (LMAV). Thirty-four stands were collected from the U.S. Department of Agriculture, Forest Service, Forest Inventory and Analysis (FIA) database and used to simulate even-and uneven-aged management scenarios with the Forest Service Forest Vegetation Simulator/Southern Variant (FVS/SN). Historical timber prices were applied to the predicted timber volumes to estimate cumulative net present value. The even-aged management scenario outperformed the uneven-aged management scenario; however, the magnitude of the economic tradeoff depended upon the initial stand condition and discount rate. These analyses will allow landowners to understand how much economic gain or loss they may realize by adopting an alternative form of management in the sweetgum-Nuttall oak-willow oak forest in the LMAV.

INTRODUCTION

The Lower Mississippi Alluvial Valley (LMAV) encompasses 26.7 million acres of land along the course of the Mississippi River, covering seven States from southern Illinois to the Gulf of the Mexico (Oswalt 2013, Twedt and others 2012). Historically, much of this area was covered by bottomland hardwood (BLH) forest, but colonial settlement and agricultural conversion have reduced forest cover to less than 20 percent of its original extent (King and Keeland 1999, Oswalt 2013). Management of the remaining BLH forest has received increasing attention, with different approaches being advocated depending upon management priorities. Important management goals in BLH forests of the LMAV include timber production, habitat maintenance for high conservation priority wildlife species, soil and water conservation, and many other concerns.

The sweetgum-Nuttall oak-willow oak forest type is one important forest type in the LMAV, covering approximately 17 percent of the forested land in the LMAV (Oswalt 2013). Forest management approaches for the sweetgum-Nuttall oak-willow oak forest type differ in large degree depending on the objectives of landowners, whether focused on timber, wildlife or other values (Meadows and Hodges 1997). Today, timber-focused management regimes typically favor even-aged forest management approaches aimed at promoting optimal growth of commercially desirable tree species such as green ash and red oaks (Kellison and Young 1997). Silvicultural systems that are considered most suitable include clearcutting and shelterwood regeneration methods, although group selection may also be possible (Meadows and Stanturf 1997). In contrast, wildlife-focused management approaches tend to prioritize structural diversity (Twedt and others 2012). These "wildlife centric" approaches are considered to produce better habitat for some wildlife species (Twedt and Somershoe 2009). For this purpose, BLH forest managers often gravitate to uneven-aged forest management approaches using single tree or group selection methods (Meadows and Stanturf 1997), although an array of different multi-aged silvicultural approaches are possible (O'Hara and Ramage 2013).

Forest landowners and managers face uncertainty with regards to the tradeoff in timber revenue that may result from adopting even or uneven-aged management approaches in BLH forests. Much of this uncertainty stems from limited information on timber yields produced by each management scenario over time. Currently, there is little guidance in the literature that quantifies this economic and yield tradeoff of favoring one management system over another. This can hinder landowners' and managers' ability to evaluate the timber revenue tradeoff that may result. Comparative study of these two strategies in terms of the economic return based on timber production value should help managers and landowners

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to make a more informed management decision for their stands and to achieve their management objectives. Economic guidance could help BLH landowners and managers make more informed decisions about applying even- and uneven-aged management by stand conditions (i.e., forest type, composition, and site productivity) while also allowing them to understand how much economic gain or loss they may realize by adopting an alternative form of management.

In this study, we examined cumulative net present value (NPV) produced by both even-aged and uneven-aged management in the sweetgum-Nuttall oak-willow oak forest type. NPVs were used to evaluate the tradeoff between even-and uneven-aged management. Stand level information was collected from U.S. Department of Agriculture, Forest Service, Forest Inventory and Analysis (FIA) plots to simulate stands under both management scenarios using the Forest Service Forest Vegetation Simulator/Southern Variant (FVS/SN). The objective of this study was to explain the timber revenue-based economic tradeoffs between even- and uneven-aged management in the sweetgum-Nuttall oak-willow oak stands.

METHODS

Stand level data were collected from the FIA database. The study area was limited to three States: Mississippi, Louisiana, and Arkansas. More specifically, the Lower Mississippi Riverine Forest Province "234-Ecoregion category" was selected to confine the study within the LMAV. Selected stands were further classified into three stocking levels based on Goelz (1995): overstocked (>100 percent stocking), fully stocked (60-100 percent stocking), and understocked (<60 percent stocking). Stands were further classified into three site qualities: high quality site (sweetgum 115 feet at base age 50), medium quality site (sweetgum 99 feet at base age 50), and low quality site (sweetgum 83 feet at base age 50). Classification of site quality was estimated based on the site productivity class and site index information available in the FIA database for the selected forest type. All together, 34 stands were selected for the sweetgum-Nuttall oak-willow oak forest type.

Growth of selected stands was simulated using the FVS/SN, which is a distance independent growth and yield model. It does not predict regeneration after disturbance. Therefore, available regeneration information from the FIA database for the simulation stands was averaged and used to regenerate stands during the simulation process. The 34 existing stands were simulated under even- and uneven-aged management scenarios. Even- and uneven-aged management scenarios used in the simulations were developed according to the published literature, described below. For even-aged management, the initial existing stand was managed based on the decisionmaking criteria recommended by Goelz and Meadows (1997) (table 1) to maximize NPV. After harvesting the initial existing stand, the second rotation started with an assumed average regeneration and managed to maximize land expectation value (LEV) (fig. 1). The averaged regeneration was estimated based on average regeneration densities derived from FIA plot data for the sweetgum-Nuttall oak-willow oak forest type. Stands were thinned from below to control stocking level based on the stocking guide for bottomland hardwood forest by Goelz (1995). In each thinning, a majority of oak species were retained and non-oak species were removed by the use of species preference management tools in the FVS/SN simulator.

Uneven-aged management scenarios were developed based on Putnam and others (1961), which suggested a target uneven-aged stand structure with a 1.3 q-factor, 68 square feet per acre residual basal area, and 38 inch maximum DBH limit. Forty cutting cycles (maximum number of cycles possible in FVS/SN) were simulated for cutting cycles of 5−15 years length. Removals were targeted to produce and maintain a balanced uneven-aged diameter distribution. The amount of regeneration provided in the uneven-aged scenarios was adjusted for crown opening size and shade tolerance characteristics of species, and allocated at each cutting cycle.

Economic Analysis

Growth and yield data from the FVS/SN simulation were used to calculate cumulative NPV for both even-and uneven-aged management scenarios. For the even-aged scenario, NPV was calculated for the existing stand, and then revenue for a second rotation was calculated for an infinite series of identical rotations to calculate LEV (equation 1). Thus, cumulative NPV (equation 2) for the even-aged management scenario was a summation of NPV from the existing stand and discounted LEV from the infinitely identical second rotation (fig. 1). This was calculated for a range of possible final harvest ages for the existing stand. The final harvest age with the highest cumulative NPV was selected as the final harvest age for the existing stand.

$$LEV = \frac{NFV}{(1+i)^t - 1} \qquad (1)$$

$$NPV = \frac{NTR + LEV}{(1+i)^k} \qquad (2)$$

Table 1—Decisionmaking criteria for managing BLH stands (Goelz and Meadows 1997)

	Scenario	Prescription
Stand < 10 years from rotation age		Plan to regeneration when appropriate
Stand > 10 years from rotation age	Stocking <100%	
	Stocking of AGS≥C-10 line	Do nothing
	AGS<C-10 & QMD≥16 inches	Consider regeneration
	AGS<C-20 & QMD<16 inches	Consider regeneration
	AGS≥C-20 line & Whole stand stocking > B-line	Consider timber stand improvement
	Whole stand stocking ≤ B-line	Do nothing
	Stocking ≥100%	
	AGS> B-line	Thin stand
	AGS≤ B-line & AGS ≥C-10 line	Timber stand improvement
	AGS<C-10 line & AGS≥ C-20 line, & QMD ≥16 inches	Consider regeneration
	QMD of AGS<16 inches	Timber stand improvement
	AGS≤C-20 line	Consider regeneration

AGS is acceptable growing stock, QMD is quadratic mean diameter, B-line is suggested lower limit of stocking, C-10 lines represent stand needs 10 years to achieve B-line, C-20 line represents stand needs 20 years to achieve B-line stocking.

where:

LEV = land expectation value for infinite series of identical rotations starting at t

NFV = net future value of identical rotation at year t

i = interest rate expressed as a decimal

t = length of rotation

NTR = net timber revenue at k^{th} year (value of conversion period)

NPV = cumulative net present value (value of conversion period plus LEV)

For the uneven-aged management scenario, the initial cutting cycles tended to produce highly variable periodic NPVs, which eventually stabilized over an extended period of time (fig. 2). A financially optimal cutting cycle was identified for each stand (i.e., cumulative NPV maximization) once this stable condition was achieved. Steady periodic cutting cycle revenue (i.e., balanced uneven-aged condition) was usually achieved after several cutting cycles (i.e., the conversion period to balanced, uneven-aged condition). LEV (equation 3) was calculated for the balanced condition assuming average revenue produced in each cutting cycle as perpetual periodic revenue. Cumulative NPV (equation 2) for the uneven-aged management was also calculated by summing NPVs from the initial cutting cycles (e.g., conversion period) and discounted LEV of the balanced condition.

$$LEV = \frac{R}{(1+i)^t - 1} \qquad (3)$$

where:

LEV= land expectation value of future managed (balanced uneven-aged) forest

R= net timber revenue received every c years from future managed forest

t = number of years in the cutting cycle

i = interest rate, expressed in decimal

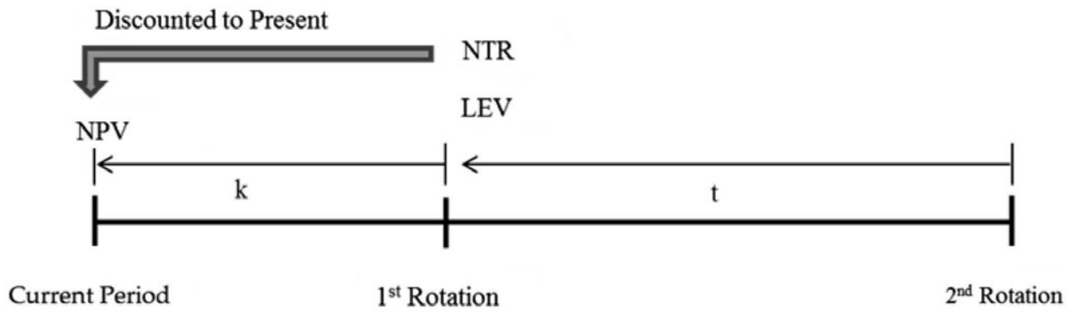

Figure 1—Timeline of NPV calculation in the even-aged management.

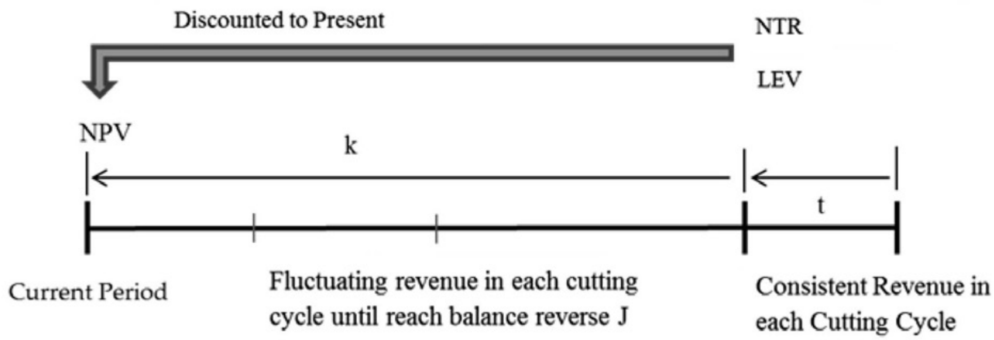

Figure 2—Timeline of NPV calculation in the uneven-aged management.

Product Price and Discount Rates:

Historical Timber Mart-South stumpage prices were used to calculate cumulative NPV for three different discount rates: 3 percent, 5 percent, and 7 percent. For Mississippi, Louisiana, and Arkansas, average stumpage prices from 2004 and 2013 were classified in three categories: oak sawtimber ($34.12/ton), mixed-hardwood sawtimber ($24.76/ton), and pulpwood ($8.43/ton) (Timber Mart-South 2004-2013). This study assumed the same management costs in both even- and uneven-aged management.

RESULTS

Among the 34 simulated stands, even-aged management scenarios produced higher cumulative NPVs as compared with uneven-aged management scenarios (table 2). The highest NPV for even-aged management scenarios was $9,681 and the lowest was $1,291 at a 3-percent discount rate. For uneven-aged management scenarios, the highest NPV was $8,358 and the lowest NPV was $ 787 at a 3-percent discount rate. At a 5 percent discount rate, even-aged management produced a maximum NPV of $8,735 to a minimum NPV of $449, and uneven-aged management produced a maximum NPV of $ 7,519 to a minimum NPV of $ 255. Similarly, at a 7-percent discount rate, even-aged management produced a maximum NPV of $8,454 to a minimum NPV of $192, and uneven-aged management produced a maximum NPV of $7,180 to a minimum NPV of $101.

NPVs for both even- and uneven-aged management increased with higher initial stand basal area (figs. 3 and 4). NPVs for both even- and uneven-aged management decreased with higher discount rates. Among the 34 simulated stands, even-aged management produced higher NPVs compared to uneven-aged management (fig. 5). At the 3-percent discount rate, even-aged management produced a maximum of $2,510 to a minimum of $101 more as compared with uneven-aged management. On average, even-aged management produced $882.56 (26.91 percent) higher NPV as compared with uneven-aged management at 3-percent discount rate.

DISCUSSION AND CONCLUSIONS

As expected, even-aged management scenarios produced higher cumulative NPVs compared to the uneven-aged management scenarios. Previously, Anderssen and Øyen (2002) conducted a similar study in a coastal spruce forest

Table 2—Initial stand conditions and calculated NPVs for the sweetgum-Nuttall oak-willow oak stands at 3%, 5%, and 7% discount rates

Stand		BA		QMD	Stocking	Site	NPV for even-aged scenarios			NPV for uneven-aged scenarios		
BA	BA Oak	Non-oak	TPA	(in.)	%	Quality	3%	5%	7%	3%	5%	7%
179	62	117	84	20	140	Low	$6,712	$6,023	$5,822	$5,742	$5,012	$4,735
178	110	68	96	18	141	High	$9,681	$8,735	$8,454	$8,358	$7,519	$7,180
163	133	30	102	17	131	Low	$7,257	$6,550	$6,342	$6,728	$5,605	$5,130
161	29	132	72	20	126	High	$7,390	$6,458	$6,178	$5,540	$4,787	$4,489
155	58	97	162	13	129	Low	$6,059	$5,367	$5,164	$5,186	$4,629	$4,398
154	59	95	199	12	136	Medium	$4,983	$4,176	$3,932	$3,885	$3,205	$2,962
145	83	62	138	14	121	Medium	$5,374	$4,566	$4,323	$4,556	$3,641	$3,245
145	108	37	114	15	118	High	$7,464	$6,509	$6,229	$6,628	$5,626	$5,205
126	59	67	138	13	106	Medium	$4,612	$3,801	$3,556	$3,803	$2,882	$2,545
125	23	102	211	10	110	Medium	$3,202	$2,477	$2,133	$2,360	$1,641	$1,388
122	87	35	114	14	101	Low	$4,893	$4,208	$4,007	$3,813	$3,225	$2,958
121	21	100	114	14	104	Low	$4,392	$3,705	$3,501	$3,544	$2,795	$2,485
120	54	66	108	14	101	Low	$4,995	$4,313	$4,112	$4,086	$3,257	$2,924
112	43	69	78	16	91	Medium	$4,743	$3,936	$3,693	$3,439	$2,774	$2,503
107	30	77	181	10	95	Medium	$2,676	$1,968	$1,754	$2,120	$1,309	$998
106	23	83	162	11	93	Low	$2,951	$2,061	$1,641	$2,605	$1,759	$1,417
105	46	59	150	11	91	Medium	$3,498	$2,609	$2,424	$3,090	$2,114	$1,698
99	49	50	253	8	93	Medium	$2,543	$1,456	$1,315	$2,369	$1,349	$940
97	76	21	102	13	82	Low	$3,432	$2,813	$2,608	$2,728	$1,909	$1,582
92	48	44	126	11	79	Low	$3,077	$2,408	$2,240	$2,412	$1,688	$1,388
88	65	23	72	15	72	High	$4,748	$3,798	$3,516	$3,333	$2,390	$1,979
88	28	60	120	11	75	Medium	$3,038	$2,599	$2,354	$2,727	$1,837	$1,512
86	65	21	78	14	71	Medium	$3,678	$2,891	$2,654	$2,380	$1,700	$1,387
85	47	38	60	16	69	Low	$4,518	$3,840	$3,638	$3,174	$2,232	$1,825
84	48	36	84	13	64	Low	$2,838	$2,051	$1,854	$2,349	$1,705	$1,444
82	42	40	169	9	74	Low	$2,249	$1,720	$1,519	$1,824	$1,083	$798
78	40	38	229	8	74	Medium	$2,499	$1,385	$894	$1,961	$1,077	$704
74	48	26	150	9	67	Medium	$2,217	$1,553	$1,313	$1,680	$887	$566
74	73	1	24	24	57	High	$5,032	$4,083	$3,802	$2,522	$1,566	$1,157
58	18	40	72	12	49	Medium	$2,327	$1,520	$1,277	$1,082	$537	$343
58	39	19	30	19	46	Medium	$2,978	$2,170	$1,927	$1,608	$755	$437
55	6	49	120	9	51	Medium	$1,927	$1,129	$942	$1,826	$864	$511
45	5	40	78	10	40	Medium	$2,241	$1,242	$822	$1,263	$520	$264
6	0	6	30	6	7	Low	$1,291	$449	$192	$787	$255	$101

Note: BA in square feet was calculated for three >5 inches.

BA=basal area; TPA= trees per acre; QMD=quadratic mean diameter.

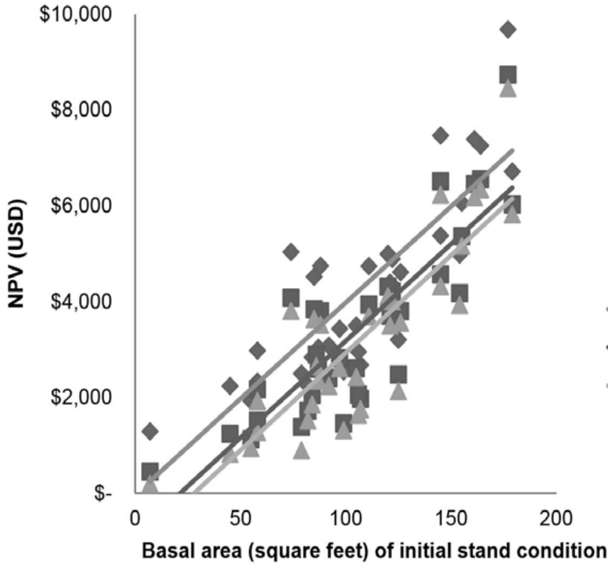

Figure 3—Scatterplot and trend lines showing the relationship between initial basal area and NPV with even-aged management in the sweetgum-Nuttall oak-willow oak forest type across all three discount rates.

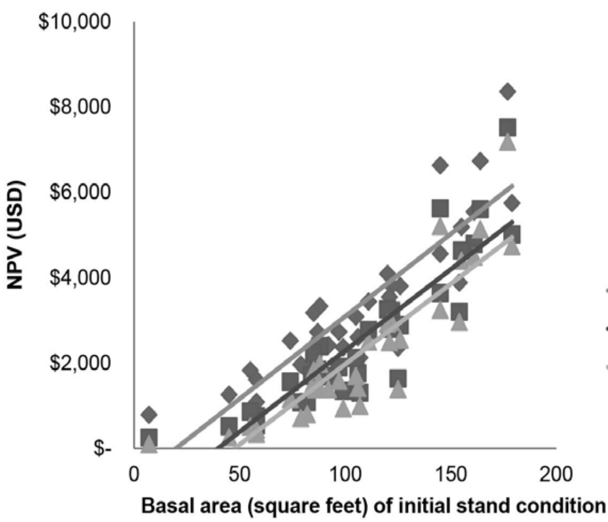

Figure 4—Scatterplot and trend lines showing the relationship between initial basal area and NPV with uneven-aged management in the sweetgum-Nuttall oak-willow oak forest type across all three discount rates.

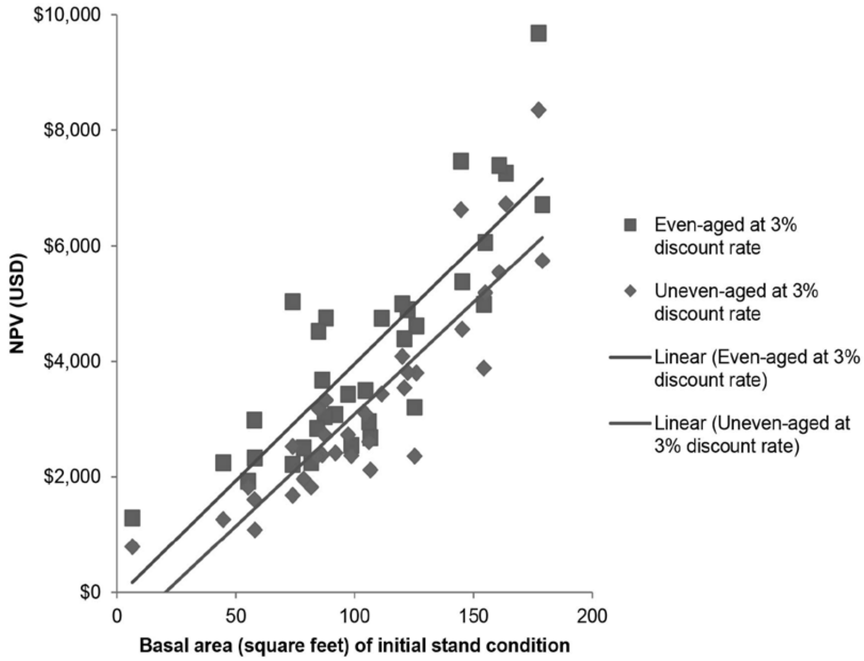

Figure 5—Scatterplot and trend lines showing the difference between NPVs of even-and uneven-aged management at a 3-percent discount rate.

and estimated that clearcut approaches produced NPVs that were 25-percent higher than single tree selection at a 3-percent required rate of return. NPVs in both even- and uneven-aged management decreased with higher required rates of return; further, with all required rates of return, even-aged produced higher NPVs compared to the uneven-aged management scenario. In contrast, Redmond and Greenhalgh (1990) found that natural pine forest with low percent (30-percent and 50-percent) stocking favored uneven-aged management over even-aged management.

The magnitude of the economic tradeoff depended greatly upon the initial stand condition and discount rate. As NPVs were cumulative, they included the revenues from management of the existing stands and the LEV of future grown stands. NPVs from existing stands greatly influenced cumulative NPVs because high basal area stands produced revenue sooner. Due to the time value of money, revenue generated earlier influences cumulative NPVs more than revenue generated later. Thus, initial stand conditions highly influenced cumulative NPVs in both even- and uneven-aged management scenarios. In particular, species composition, site quality, and QMD influenced NPVs to the greatest degree. Cafferata and Klemperer (2000) compared even- and uneven-aged management scenarios in loblolly pine stands and found that even-aged NPVs were higher than uneven-aged management and also suggested that magnitude of the difference in even-aged NPV over uneven-aged depended on the initial stand condition. Our results have similar conclusions to Cafferata and Klemperer (2000) regarding the superiority of even-aged management, in that higher basal areas, larger QMD, and greater oak species composition produced higher NPVs.

In even-aged management scenarios, stands of higher initial basal areas were harvested earlier, resulting in comparably higher NPVs. As a consequence, the second rotation started earlier than for stands of lower initial basal area which resulted in higher discounted LEVs. At the other extreme, stands of lower initial basal area required more time to grow to reach financial maturity (i.e., maximum NPV). Thus, the NPVs of those stands were lower compared to higher basal area stands due to time value of money constraints. The present values of LEVs on those stands were also lower because the second rotation started later. Consequently, cumulative NPVs became lower for stands of lower initial basal area as compared to stands of higher initial basal area. For uneven-aged management scenarios, existing stands with higher basal area produced higher NPVs because of higher timber harvest volumes achieved from initial cutting cycles. For stands of lower initial basal area, delaying several cutting cycle harvests was required to achieve the targeted residual basal area requirements. NPVs were lower in those cases due to time value of money constraints also.

There was not much difference in terms of dollar value between even- and uneven-aged management regardless of basal area (fig. 5); however, if we compare in percentage terms, then lower basal areas produced higher percentage tradeoff. Similarly, higher basal areas produced lower percentage tradeoff between even- and uneven-aged management.

For all simulated stands in a given condition, the even-aged management scenario was profitable, so landowners or foresters who aim to maximize profit may benefit from even-aged management. Revenue forgone by adapting uneven-aged management can be used as an opportunity cost of habitat improvement. Revenue forgone, in terms of percent, was higher in stands with a lower initial basal area and lower in stands with a higher initial basal area. Therefore, landowners or managers would forgo a higher percentage of revenue if they choose uneven-aged management in stands with the lower initial basal area. In summary, landowners and managers need to consider initial stand conditions such as species composition, QMD, and rotation length to estimate exact revenue tradeoff that may result from choosing uneven-aged instead of even-aged management.

LIMITATION AND FUTURE RESEARCH

This study is based solely on the valuation of timber yields. Management and harvesting costs were not considered, nor were price premiums for higher value products, both of which could affect the economic performance under even- or uneven-aged management. This study assumed the same management and harvesting costs for both even- and uneven-aged management (i.e., stumpage prices were the same for both management scenarios). As we were comparing even- and uneven-aged management, we did not consider any management cost in the NPVs estimation. Therefore, this assumption may overestimate NPVs in both management scenarios. Future research should address nonmarket values such as water and wildlife habitat, and costs associated with specific forest management practices in sweetgum-Nuttall oak-willow oak forest type and other BLH forest types in the LMAV.

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TO WHAT EXTENT DO COUNTY ECONOMIES BENEFIT WHEN MANUFACTURING OCCURS IN A NEIGHBORING COUNTY? THE CASE OF A MISSISSIPPI PAPER MILL

Ram P. Dahal, James E. Henderson, and Robert K. Grala[1]

Pulp and paper mills located in one county procure fiber from surrounding counties extending out 100 miles or more. Standard single-regional input-output analysis conducted at the individual county level does not report those contributions to neighboring counties that result from procurement of fiber and other inputs (e.g., labor). This study uses single-regional and multi-regional input-output (MRIO) analysis to estimate the economic contribution of the pulp and paper sector in Lawrence County, MS. Differences between the two analysis types and the resulting economic contribution estimates will be compared. Using Impact Analysis for Planning (IMPLAN) software and 2013 data, economic contributions were estimated in terms of direct, indirect, and induced effects for four key economic indicators: employment, labor income, value-added, and total industry output. MRIO differs from single-region analysis in capturing the leaked effects (i.e., indirect and induced effects that occur outside of the study area) and maintaining the specificity and individuality of the location of the direct effect (i.e., Lawrence County) and linked regions of interest (i.e., surrounding counties). Thus, this study will demonstrate how and to what extent economies of surrounding counties benefit when forest products manufacturing occurs in a neighboring county and how single-regional economic contribution analysis can underreport the benefits that are also realized by surrounding counties.

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IMPACT OF GROWING ECONOMIES ON TOURISM INDUSTRY IN NEPAL: A VECTOR ERROR CORRECTION MODEL

Raju Pokharel, Jagdish Poudel, Robert K. Grala[1]

Tourism is the second largest industry of Nepal after agriculture and it has contributed $356.72 million in 2012. However, since the political conflict stated in 1996, tourism industries have suffered an economic decline even though gross domestic product per capita (GDP) and income of countries, from where tourists arrive have increased. This study used a vector error correction model for investigating the short- and long-term impacts of the GDPs per capita of the top five countries (China, India, Sri Lanka, United States, and United Kingdom) from where tourists arrive in Nepal between 1962 and 1990. Our results indicate that regional economy has positive short- and long-term impact. India and Sri Lanka with cultural and religious similarity have positive effects on tourism in Nepal. The United States and United Kingdom had long run impact as they don't share regional proximity. The political conflict had an insignificant impact on regional economies. This could be because most of the tourism is pilgrimage or cultural associated. This study provides valuable information for decisionmakers and policymakers to design future economic outcome by understanding the long- and short- run opportunities. These results can be used to facilitate the growth of tourism industry and its adaptability to economic growth in Nepal as well as other countries.

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ESTIMATING IMPACTS GENERATED FROM AN INTEGRATED HARDWOOD SAWMILL/WOOD PELLET COMPLEX IN WESTERN NORTH CAROLINA

Adam Scouse and Thomas Eric McConnell[1]

Abstract—In an effort to identify regional economic development opportunities for western North Carolina, this study investigated the economic impacts generated by collocating a 10,500 ton-per-year wood pellet mill alongside a 10 million board-foot hardwood sawmill in the Asheville-Brevard combined metropolitan statistical area. Using the analysis-by-parts methodology within the input-output analysis framework, a custom production function was built to describe a small scale pellet manufacturing facility operating alongside a hardwood sawmill. The generated economic effects are described along with upper and lower bounds which represent potential estimates variability caused by raw material price fluctuation. The study found that wood product firms existing within the region had the opportunity to utilize excess woody biomass for pellet production and could diversify their product lines, create additional jobs, and stimulate value added economic activity for the region.

INTRODUCTION

The forest products industry has long served as a source of economic activity and employment in the Southeastern United States by providing timber, primary products, and secondary wood products for domestic and export markets. In the early 2000's, an economic downturn heavily influenced housing starts and resulted in drastic changes in the wood products manufacturing, paper manufacturing, forestry, and logging sectors. As the number of wood product manufacturing facilities operating in the Southeast declined from 2005 to 2009, the forest products sector's contribution to gross regional product dropped 24 percent while labor income dropped 32 percent (Hodges and others 2012). North Carolina in particular has experienced changes in its forestry sectors compared to other Southern States. From 1990 to 2009, North Carolina saw the number of primary wood-using plants drop from 366 to 141 (Cooper and others 2011). From 2004 to 2009, direct employment through North Carolina's forestry sectors dropped from 77,000 jobs to 50,000. The recession and lack of housing starts not only affected employment and forest products output for the region, but also influenced the timber inventory growing in southern forests. Increases in timber land productivity and steady (or slightly decreased) removals resulted in increased volumes of both hardwood and softwood tree species available on southern forest land (Brandeis and others 2012).

Despite the impact of the recession, forestry related sectors remain critical to North Carolina's economy, particularly in the western region of the State where forest-based economic development opportunities are being investigated. Forest-based employment in western North Carolina totaled 30,300 jobs, representing 43 percent of the State's total forest-based industry employment (70,300) in 2013 (Kays and others, In press; McConnell and others 2016). Amongst forest products sectors, sawmills in particular were identified as being key economic drivers for the region, possessing strong forward and backward linkages when compared to other industries (Kays and others, In press). With a growing inventory of small diameter woody biomass available in western North Carolina forests and strong inter-industry relationships existing within the sawmill sector, the integration of wood pellet manufacturing alongside lumber production could serve as an economic growth opportunity for the State.

Wood pellets are a form of lignocellulosic biomass, manufactured using sawdust, bark, wood chips, or round wood, which are burned to create heat or energy. Driven by the Renewable Energy Directive of the European Union, European demand for wood pellets has grown rapidly and spurred southeast pellet production to approximately 12 million green short tons. The majority of these pellets are sold to the United Kingdom, Netherlands, and Belgium for residential and district heating and co-fired power plant facilities (Abt and others

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2014). European pellet demand continues to grow and pellet manufacturing could offer economic development opportunities for regional economies by providing employment and value-added economic activity. As interest in bioenergy production has grown, researchers have attempted to define the market characteristics required for successful pellet manufacturing.

Traditional large scale pellet manufacturing for sale into European markets relies upon a dependable supply of woody biomass and close proximity to established transportation infrastructure. These conditions create favorable regions for pellet manufacturing along the southeast coast (North Carolina and Georgia) and within the Mississippi basin (eastern Arkansas, northern Louisiana, northern Mississippi, and eastern Tennessee) (Forest2Fuel 2014). In situations where large scale bulk production may not be advantageous due to raw material feedstock availability or prohibitive distances to ports, smaller scale pellet production may still offer revenue generation opportunities. Smaller scale pellet operations could be integrated alongside existing primary wood product manufacturing facilities to produce a higher quality "clean" pellet for sale in bagged quantities to satisfy local heating demand (Wolf and others 2006). This type of pellet production would utilize sawmill residues and white chips generated from forestry activity as a raw material feedstock to create a potentially higher quality pellet and could also generate employment and economic impacts in regional economies.

Pellet production at this scale could also serve as an opportunity for forest products firms to diversify their product mix by utilizing a potential combination of mill processing residues and/or woody biomass from smaller diameter timber that has more limited market opportunities. Often, these materials exist in excess in many timber market regions. The gradual decline in pulp and paper manufacturing capacity along with the recent economic downturn has created surpluses of smaller diameter pine trees in many areas where forest management activities have been delayed. Moreover, the hardwood timber inventory trend for the Eastern United States has continued to skew towards smaller diameter classes (Luppold and Miller 2014). Where local opportunities do not exist for mill residues, facilities often have to pay tipping fees to dispose of slabs, chips, and dust. Manufacturing wood pellets would create both additional sales and purchases for regional forest-based enterprises, but how this would impact a local economy is currently unknown. Hunsberger's and Mosey's (2014) financial analysis coupled with regional input-output accounts provided us a means for quantifying the economic impacts of one potential test case: collocating a small scale pellet manufacturing facility with a proprietary hardwood lumber mill in western North Carolina.

OBJECTIVES

The overall objective of this study was to evaluate the economic impacts resulting from collocating a 10,500 ton-per-year pellet manufacturing facility, producing clean bagged pellets, with a 10 million board-foot proprietary hardwood sawmill existing within a functional economic area of western North Carolina, the Asheville-Brevard combined metropolitan statistical area (MSA). This was accomplished by constructing a fully integrated sawmill/wood pellet production function for the region, with key purchases that were not likely to be "new" sales (at least in the near term) deducted from the gross impacts. Secondly, the potential change in generated impacts resulting from raw material price fluctuation was described.

METHODS

The Social Accounting Matrix

An extension of the input-output model, the social accounting matrix (SAM), was used to estimate economic impacts of the study's scenarios. IMPLAN version 3.0, a software system that combines a general input-output model with regional economic data sets, was used to build a 2014 SAM model representing the Asheville-Brevard combined statistical area (containing the counties of Buncombe, Hayworth, Henderson, Madison, and Transylvania). The SAM created in IMPLAN represented regional inter-industry purchases for 536 sectors along with household and other non-market income flows taking place within the study area. Model outputs for logging (16) and forestry, forest product, and timber tract production (15) sectors were customized to reflect delivered wood values and timber stumpage values available at the time from North Carolina Cooperative Extension (Jeuck and Bardon 2014). Model estimates for regional employee compensation were also updated based on occupational employment statistics provided by the U.S. Bureau of Labor Statistics (2015).

Sawmill Characterization

To estimate the potential economic impacts generated by a hardwood sawmill within the region, it was necessary to define the operating characteristics and output of a typical hardwood sawmill. A mill producing 10 million board-feet of lumber annually and operating at 93 percent capacity was modeled. The sawmill's lumber product mix consisted of the following commercial species at their respective percentages of the region's hardwood sawtimber inventory: 8 percent red maple, 26 percent white oak, 23 percent red oak, and 43 percent yellow poplar (USDA Forest Service 2014). The mill's bark-free product mix (fig. 1) was calculated to be 59 percent lumber, 31 percent residue, and 10 percent sawdust using Forest Service, U.S. Department of Agriculture mill conversion data (Hanks 1977). Bark volume was estimated from Koch (1985) to be 18 percent of wood volume and 8 percent of gross volume. Lumber grade mix for the mill, described in figure 2, was 12 percent FAS and F1F, 34 percent Selects and No. 1 Common, 38 percent No. 2 Common, and 15 percent No. 3 Common across species, with grade specifications following National Hardwood Lumber Association rules (Hanks and others 1980). The 53 percent lumber product yield of No.2 and below was slightly better than the 57 percent average recently reported for Eastern U.S. hardwood sawmills (Burbeck 2016). An overall lumber price of $679 per thousand board foot was derived by weighting lumber production according to lumber grade yield, species availability, and final product prices posted in Weekly Hardwood Review (Hardwood Review 2014). Model prices for bark, sawdust, and wood residue were set to $0.22, $0.19, and $0.35 per cubic foot, respectively (Settle and others 2015). Annual sawmill output in 2014 dollars totaled $6.53 million.

The sawmill employed 1 proprietary owner and 24 employees in 10 job positions, each receiving fringe benefits equal to 30 percent of their annual salary. Salaries were based on Bureau of Labor Statistics occupational employment statistics for Asheville, NC (U.S. Bureau of Labor Statistics 2015). The total value of employee and proprietor compensation was $1.33 million.

Pellet Mill Characterization

A prototype wood pellet manufacturing plant with a nameplate capacity of 10,500 tons and operating at 93 percent capacity was modeled. Engineering cost analysis data, derived from Hunsberger and Mosey (2014), were used as a basis for determining annual operating costs, which were regionalized to better reflect local conditions. The pellet mill's annual raw material input requirement of 19,000 green tons was assumed to consist of 50 percent sawmill residues and 50 percent white chips at an 87 percent hardwood to 13 percent softwood ratio based on Forest Service Forest Inventory Analysis data (USDA Forest Service 2014). Sawmill residue and white chip prices to the pellet mill were "free on board" (RISI 2015). Annual electricity expenses were obtained for North Carolina from a U.S. Energy Information Administration (EIA) regional average of $0.085 per kilowatt hour. All intermediate expenditure prices were margined where appropriate using industry-to-industry margins so that costs reflected producer prices as required by the IMPLAN input-output model. Based on a search of wholesale and retail prices across the Eastern United

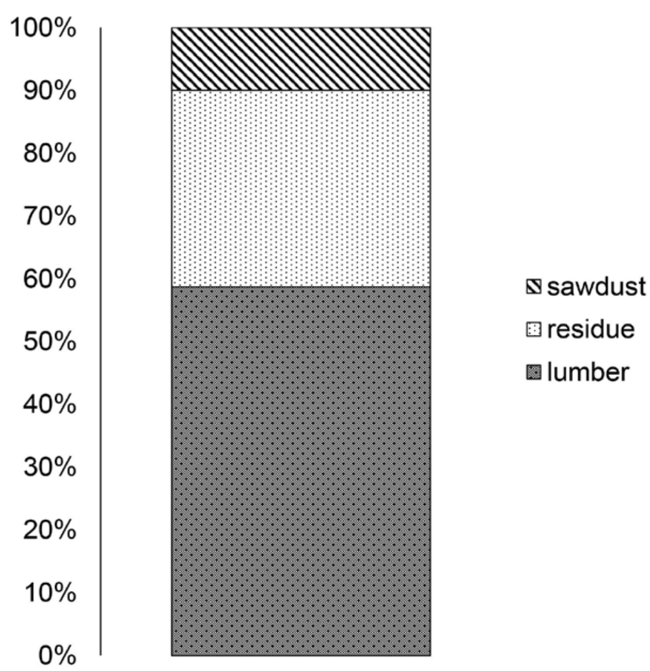

Figure 1—Bark free sawmill product breakdown.

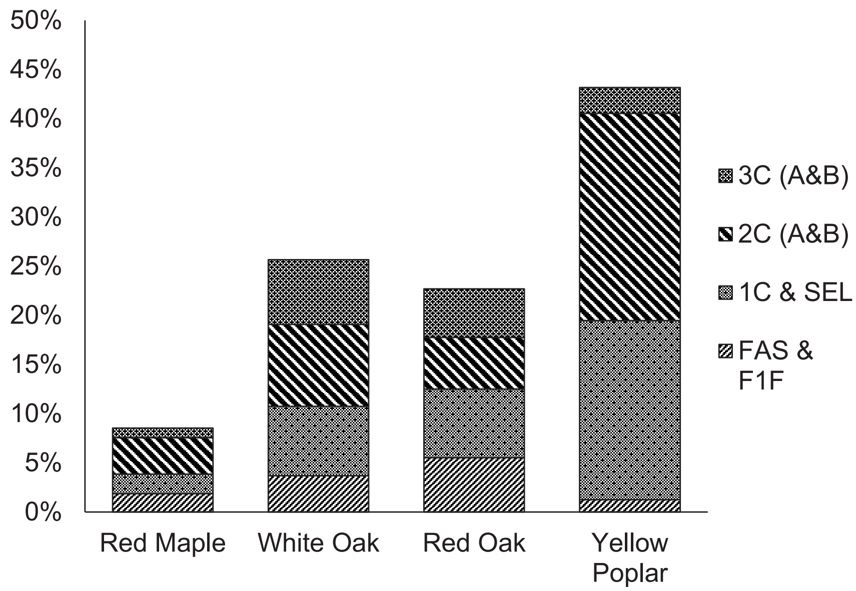

Figure 2—Cumulative sawmill lumber grade yields by species. 3C (A&B) = No. 3A&B Common; 2C (A&B) = No. 2&B Common; 1C & SEL = No. 1 Common & Selects; FAS & F1F = Firsts and Seconds One Face & Firsts and Seconds.

States, we assumed a margined pellet price of $268 per ton paid to the producer.

The modeled pellet mill employed 1 plant supervisor and 12 shift employees in 4 job positions, each receiving fringe benefits equal to 30 percent of their annual salary. Salaries for pellet mill operational positions were based on Bureau of Labor Statistics occupational employment statistics for Asheville, NC, with total employee compensation valued at $0.54 million (U.S. Bureau of Labor Statistics 2015). Pellet mill construction costs were accounted for by treating them as payments to financial institutions, and they represented a construction loan taking place over a 10-year lending period (Swenson 2006).

Estimating Economic Impacts

Economic impacts of sawmill and pellet mill operation were estimated in IMPLAN using an analysis-by-parts methodology (ABP). The ABP technique allowed us to create scenario-specific industry spending patterns containing interindustry purchases and the labor portion of value added. The technique required defining annual interindustry purchases to arrive at a commodity coefficient, a decimal between 0 and 1 that represented the ratio of commodities purchased per dollar of output. In addition to defining intermediate purchases, scenario labor estimates were defined based on regional wage data and represented a component of value added. With the industry spending pattern defined, it was then scaled according to scenario output and was used to generate economic impact estimates.

Economic impacts resulting from the hardwood sawmill operation were derived using IMPLAN's default sawmill sector (134) production function and were scaled to the previously described output ($6.53 million). Economic impacts resulting from the collocation of a pellet mill with the hardwood sawmill were derived by integrating the individual operation production functions together and scaling them by a total output of $9.01 million; this included sawmill output (net of resides) plus $2.62 million of bagged pellet sales.

Because IMPLAN did not have a sector representing pellet manufacturing, a custom production function was created to represent wood pellet manufacturing. The production function was derived by bridging the pellet mill's operational costs [derived from Hunsberger and Mosey (2014) and adapted to western North Carolina] to IMPLAN's input-output accounts (Willis and Holland 1997). This allowed us to create and define the normalized expenditure shares for a pellet manufacturing sector. The interindustry and value added costs were allowed to sum to 95 percent of the total industry spending pattern. The remaining five percent was proportionally assigned to the spending pattern of the "All Other Miscellaneous Wood Products Manufacturing" (IMPLAN code 145) sector (Lazarus and others 2002). By incorporating purchases from the miscellaneous wood products manufacturing sector, a more comprehensive production function was created for pellet mill activities. This increased the number of sectors represented in the spending pattern from 18 to 141.

Exogenous constraints were placed on particular sectors in the integrated facility scenario to better reflect economic realities in the region and provide a more accurate representation of regional impacts over simple gross measures. Constraints on the pellet mill's purchase of residual chips from the sawmill sector were instituted because these represent purchases of by-products which existed in excess capacity within the region, as indicated by timber product output surveys (USDA Forest Service, FIA 2016). These chip purchases were not believed to stimulate additional sawmill production. In addition, because the IMPLAN database designated 37 percent of logging output as exported from the region, it was reasonable to assume that white chip production would not increase as a result of pellet production (at least in the near term), but instead wood pellet manufacturing would utilize chips previously exported from the region. Constraints on raw material purchases were practically applied by setting these sectors' regional purchase coefficients to zero, which restricted their outputs to remain at existing levels. Lastly, because the energy sector is a large, declining cost industry based on economies of scale, it is realistic to expect that pellet mill operations would generate only negligible marginal outcomes in the electrical sector (Swenson 2006). This expectation was reasonable as pellet mill energy demand was relatively small, representing only 1.7 percent of the excess electricity capacity existing within the region.

Because wood costs were the dominant expenditures of an integrated mill (table 1), representing 36 percent of all direct requirements, the influences of raw material and final product price fluctuations on economic impacts were analyzed. This provided one set of upper and lower bounds for impact estimates. Price changes for wood fiber and woody biomass were obtained from RISI and were observed to fluctuate approximately 8 percent over the 2014 calendar year (RISI 2015). Therefore, raw material and final wood pellet prices were adjusted by 8 percent to represent upper and lower cost and revenue boundaries for the collocated sawmill and pellet mill. The same analysis-by-parts methodology described previously was used for each scenario.

RESULTS

Stand-Alone Sawmill

Impact estimates of a 10 million board-feet hardwood sawmill operating at 93 percent capacity in the Asheville-Brevard combined metropolitan statistical area are provided in table 2. The direct effects generated by annual production level were valued at $6.53 million, including the sale of bark, sawdust, and residues, and required 25 employees including laborers, clerical staff, supervisors, and a chief executive officer. In addition, regional industries involved in the sawmill's supply

Table 1—Top five scenario costs along with total output for annual operation of a stand-alone sawmill and collocated sawmill and pellet mill

Stand-Alone Sawmill		
IMPLAN Sector	IMPLAN Cost Category/Industry	US$ per year
16/134	Wood costs	2,572,000
5001/6001	Employee and proprietor compensation	1,332,000
395	Wholesale trade distribution services	827,000
411	Truck transportation services	228,000
461	Management of companies and enterprises	215,000
	Total Output	6,532,000
Collocated Sawmill & Pellet Mill		
IMPLAN Sector	IMPLAN Cost Category/Industry	US$ per year
16/134	Wood costs	3,230,000
5001/6001	Employee and proprietor compensation	1,874,000
395	Wholesale trade distribution services	836,000
49	Electricity	289,000
3433	Monetary authorities and depository credit intermediation	254,000
	Total Output	9,008,144

Table 2—Economic contributions of a hardwood sawmill

	Employment	Value added	Total output
Direct effect	25	$1,435,000	$6,532,000
Indirect effect	20	$1,357,000	$3,003,000
Induced effect	15	$909,000	$1,645,000
Total effect	**60**	**$3,701,000**	**$11,180,000**

chain produced indirect sales equivalent to $3.00 million and supported 20 jobs, primarily in the wholesale trade, logging, transportation, and sawmill sectors. If the spending of income generated by employment (induced spending) is considered, an additional $1.64 million in output was generated while supporting 15 jobs in the services, health care, and real estate sectors.

Collocated Sawmill and Pellet Mill

Direct operation of a pellet mill producing about 9,800 tons of pellets annually, in conjunction with a hardwood sawmill, required an additional supervisor, laborers, plant operators, and electricians, resulting in 13 new jobs. Producing pellets in addition to hardwood lumber increased direct economic output of the facilities by 38 percent to $9.01 million. Regional industries associated with the pellet mill supply chain experienced an increase in indirect economic output of 11 percent, totaling $3.32 million. Lastly, induced economic effects created by the additional spending of wages increased 29 percent to $2.11 million (table 3).

The range of economic impacts created by a collocated sawmill and pellet mill, as influenced by raw material and final product prices, is described in table 4. Regardless of sensitivity scenarios, the collocated mills directly supported 38 jobs, while the number of spillover employment created through inter-industry linkages ranged from 39 to 43 jobs. Product pricing structure influenced total direct output by approximately 8 percent, which was expected due to the linear behavior of input-output techniques. However, direct value added fluctuated by approximately 15 percent due an 8-percent change on both intermediate inputs and final product prices. Total value added economic activity varied by approximately 10 percent, with value added ranging from $4.72 million to 5.72 million. Lastly, total economic output, which includes spillover effects, ranged from $13.44 million to $15.45 million. The ranges of effects generated by price changes serve to illustrate the importance of raw material prices on wood product manufacturing profitability (Mani and others 2006).

DISCUSSION AND CONCLUSION

Collocating a pellet mill alongside of a hardwood sawmill in western North Carolina resulted in increases in both direct and spillover economic effects versus a stand-alone lumber manufacturing facility. Thirteen new jobs were supported by the addition of the pellet mill with the entire collocated operation supporting a total of 81 jobs. In addition, pellet mill collocation increased total economic output by 29 percent from $11.10 million to $14.44 million. The economic impacts generated by the collocated mills varied as a result of biomass and pellet price fluctuation, and changed total sales by approximately $1.0 million dollars (or 7 percent), as these costs are critical to the regional product returned to the economy. However, these price changes did not heavily influence regional employment. Forest product firms existing in regions where sawmill residues are underutilized and where forestry activity creates an excess capacity of woody material could use small scale pellet manufacturing for an opportunity for product diversification and regional economic development.

Purchases of sawmill residues and white chips from the logging sector represented the largest inputs to pellet production, which is consistent with other southeastern wood pellet studies (Pirraglia and others 2012). Together, these purchases made up 36 percent of the pellet mill spending pattern. Constraints were applied here and elsewhere to prevent the overestimation of economic impacts generated by the collocation scenario. These constraints, illustrated by Swenson (2006), accounted for pre-existing raw material surpluses in the region, opportunities foregone elsewhere (rather than selling residues, the mill held them in storage for use in pellet production), and the likelihood of any impacts truly occurring in a large, declining-cost utility industry. These purchase constraints provided more conservative and realistic descriptions of the economic effects generated by the collocated mills scenario than simple gross measures that provide no offsetting circumstances. An even more cautious assessment could discount all indirect effects emanating across the supply chain due to wood pellet processing activities and count only the induced impacts

Table 3—Economic contributions of a collocated hardwood sawmill and pellet mill

	Employment	Value added	Total output
Direct effect	38	$2,492,000	$9,008,000
Indirect effect	21	$1,559,000	$3,323,000
Induced effect	20	$1,168,000	$2,113,000
Total effect	**79**	**$5,219,000**	**$14,444,000**

Table 4—Sensitivity analysis impact ranges

	Direct effects	Direct effect % difference from base	Total effect	Total effect % difference from base
Base case				
Employment	38		79	
Value added	$2,492,000		$5,219,000	
Output	$9,008,000		$14,444,000	
Lower bound				
Employment	38	—	77	-2.5%
Value added	$2,132,000	-14.5%	$4,722,000	-9.5%
Output	$8,294,000	-7.9%	$13,439,000	-7.0%
Upper bound				
Employment	38	—	81	+2.5%
Value added	$2,858,000	14.7%	$5,723,000	+9.6%
Output	$9,723,000	7.9%	$15,449,000	+7.0%

— = not applicable

from spending of employee wages. The actual impact of the collocated scenario lies somewhere between our estimate and this harsher option.

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THE IMPACTS OF FOREST CERTIFICATION ON INTERNATIONAL TRADE OF FOREST PRODUCT

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Abstract—This research investigates the impact of forest certification on the international trade of timber products. Forest certification has become an important signal to consumers and business buyers about a company's commitment to sustainable development. What, if any, economic benefits accrue to firms using these standards is, however, not clear. Due to the forest management and social restrictions imposed by forest certification standards, and cost and administrative challenges in becoming and maintaining certification, developing-country firms may be disadvantaged by the increasing adoption and requirement of these standards. Therefore, it is unclear what, if any, trade facilitation impacts are offered by forest industry standards. A Gravity model was used to analyze the extent to which forest certification affects the international flow of timber products. Timber trade is examined in aggregate, by specific standards, by product type, and by the development status of trading partners. Initial analysis indicates use of certification is concentrated in a few countries. In addition, adoption of forest certification was found to have little to no impact on the trade of industrialized products, and have a positive impact on the trade of wood and less processed products.

INTRODUCTION

Forest certification (FC) was initially a market instrument to combat deforestation and to promote sustainable forest management in tropical forests. Since the first companies adopted the certified standards, the range of forest certification goals has expanded from forest management to chain of custody (COC) including tropical and temperate forests areas. Nowadays, FC has become an important signal to consumers about the company's commitment to sustainable development.

Sustainable management practices and improvement on the quality of timber production have been claimed by FC supporters (Acharya and others 2015, Auld and others 2008, Elbakidze and others 2011, Gullison 2003). Nevertheless, the economic benefits are not as clear as the ecological; financial returns depend on consumers' willingness to pay a price-premium and/or increase on market share. Willingness to pay a price-premium varies according to region and markets; products from tropical forest tend to have higher price premium than products from non-tropical forests (Aguilar and Vlosky 2007). Espach (2006) estimated that certified tropical wood exported from Brazil received a 20–50 percent premium over comparable non-certified products. Nebel and others (2005) showed statistical differences between certified and non-certified prices from 5 to 51 percent according to species type in Bolivia.

In some regions, having certified products is not an advantage. In Malaysia, furniture producers are highly dependent on exports but do not consider price premium as the main motivation to get certified. Ninety-three percent of their survey sample were not certified and do not intend to become certified, due to the lack of demand, lack of price premium, and insufficient knowledge (Ratnasingam and others 2008). In addition, 85 percent of Malaysian furniture exports flow to America and the Middle East, where demand for certified wood products from Malaysia is low.

High costs are also a barrier to FC. Production cost of certified companies increases from 2 to 56 percent as companies implement FC standards (Kollert and Lagan 2007). Companies located in developing countries are likely to be the most affected by the forest management and social restrictions. The uncertainty whether price premiums would overcome the increase in costs and long-term restriction for returns are a barrier for certain firms. While forest certification-setting bodies have made the adoption of these standards by smaller or less competitive firms easier, it is not clear that these new procurement requirements are fair across countries.

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Cubbage and others (2010) estimated forest certification costs in the largest cross-sectional study performed, with data from Argentina, Brazil, the United States and Canada, and Chile, through a series of personal interviews and email surveys. The mean reported average total costs for small forest tracts of less than 4000 ha were expensive, at $6.45 per ha per year for Forest Stewardship Council (FSC)-US to $39.31 per ha per year for Sustainable Forestry Initiative, which surely would deter adoption for small ownerships. Costs decreased significantly with increasing tract size, becoming as little as $0.27 per ha per year for SFI in the 40,001–400,000 ha size class, and $2.40 for FSC-US, and less than $0.50 per ha per year for ownerships greater than 400,000 ha on average for any forest certification scheme. Costs in the Southern Cone countries in South America were generally greater than in North America. However, average total costs among systems and countries were a statistically significant function only of ownership size, not type of certification system.

Literature about FC has covered many aspects; for instance: (i) as a market governance mechanism (e.g., Marx and Cuypers 2010, McGinley and Cubbage 2011), (ii) price premium and costs of certification process (e.g., Kollert and Lagan 2007, Nebel and others 2005, Stevens and others 1998) and (iii) FC role on forest conservation (e.g., Ebeling and Yasué 2009, Rametsteiner and Simula 2003). However, to date, no research has explicitly analyzed the impact of FC on international trade of forest products.

This research examines forest certification effects on international trade of forest products. Importantly, to date, there have been no comprehensive, ex post empirical analyses examining this issue. Using the Gravity model, we investigate the role of forest certification on the flow of products as well as bilateral trade. We also are interested whether classic variables of a Gravity model (such as Gross Domestic Product (GDP), distance between countries, membership in World Trade Organization (WTO), common language, and international agreements) have an impact on international trade of timber products. This paper is structured as follows: the next section is a literature review about the international trade model and its use with forest products. The subsequent portion explains the market of forest certification and its characteristics. Understanding this market will explain how competition between labels was established and how it affects the empirical analysis. Subsequently, a review of current trade of forest products, as well as international trade theory and its application are presented. Fundamentals of the Gravity model are summarized in the next section; the remainder of the paper describes the empirical models, results, and conclusions.

Bilateral Trade of Timber Products

In 2014, $356 billion of timber products were traded worldwide; historically, paper and paperboard, wood manufactures, and pulp and waste have shared more than 75 percent of the international trade market **(**fig. 1A**)**. From 2000 to 2014, on average trade of wood products (sum of all products on figure 1) increased by 70 percent, in which trade of fuel and wood charcoal has raised 250 percent during the same period **(**fig. 1B**)**.

The market of timber products is concentrated in a few regions, with 10 countries sharing more than 50 percent of imports and exports. Germany, the United States, and China are the largest traders and, together, they share 29.5 percent of imports and 31.1 percent of exports in the market (table 1).

Bilateral trade between Canada and the United States has presented, historically, the largest flow of goods. In 2014, around $26 billion of timber products were traded (7 percent of total value traded in 2014); however, since 2004, trade between these countries has declined 37 percent (fig. 2A). This drop is explained partially by the growth in trade between the United States and China. From 2004 to 2014, United States–China trade increased from $7.4 billion to $14.3 billion. In fact, China has increased significantly its share of the trade market more than any other core country in the last decade. Trade between China and its main partners (United States, Canada, Russia, Indonesia, and Brazil) is now 1.5 fold greater than in 2004 (fig. 2B).

The dominance of few countries is also observed after desegregating the transactions by products. The United States and Canada, for instance, have the highest value traded in 3 of 8 forest products analyzed; the flux of product between these countries represents a large share of the market of each good (23.54 percent of Pitprops, poles, NES; 11.96 percent of Sawnwood; and 3 percent of Paper and paperboard) (table 2).

The increasing demand for derivatives of timber and nontimber products has positively affected the flow of timber products among countries (Bonnefoi and Buongiorno 1990, Lundmark 2010, Michinaka and others 2011). On the other hand, consumers have demanded from governments, private sector, and international institutions, mechanisms of regulation to address nonsustainable forest management practices and illegal logging (Cabarle and Heiner 1994). Forest products commercialization has been constrained by several types of regulations in order to address consumers' and governments' standards. Over the last decades, FC has become very popular among the eco-labels.

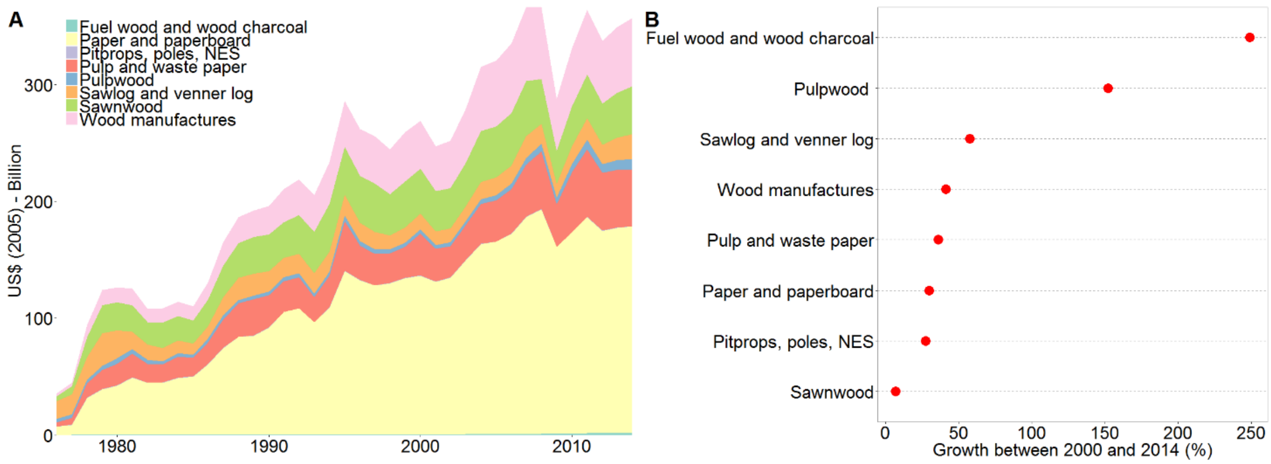

Figure 1—(A) Value of timber products trade, billion USD. (B) Real increase in the trade of timber products between 2000 and 2014. Data source: UN comtrade (2003).

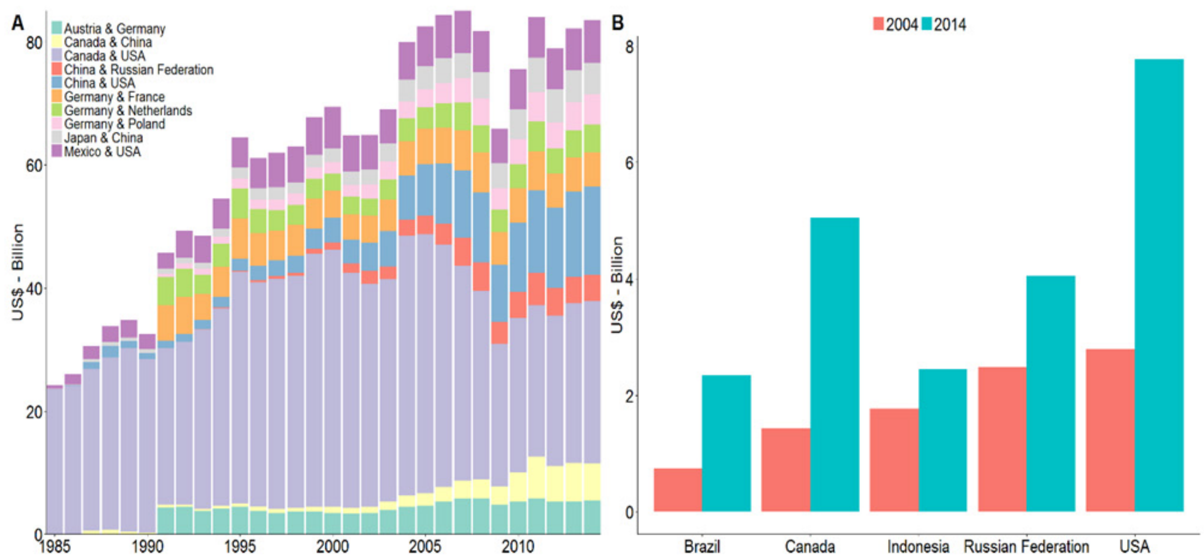

Figure 2—(A) Value of timber products trade among the top 10 largest trading partners, billion USD (2005). (B) Increase of timber product trade between China with its main partners. Data source: UN comtrade (2003).

Table 1—International trade of timber products: value and share of the market per country

Exports			Imports		
Country	$ Billion	Share	Country	$ Billion	Share
United States	37.6	10.3%	China	45.3	12.7%
China	34.9	9.6%	United States	37.1	10.4%
Germany	34.2	9.4%	Germany	28.7	8.0%
Canada	28.8	7.9%	United Kingdom	18.3	5.1%
Sweden	18.2	5.0%	Japan	16.7	4.7%
Finland	15.0	4.1%	France	16.2	4.5%
Russian Federation	11.5	3.2%	Italy	13.3	3.7%
France	11.1	3.0%	Netherlands	10.6	3.0%
Italy	10.7	2.9%	Canada	10.3	2.9%
Austria	10.4	2.8%	Belgium	9.8	2.7%
Others	152.6	41.81%	Others	150.5	42.2%

Certification of Forest Products

There are two main forest certification systems: Forest Stewardship Council (FSC) and Program for the Endorsement of Forest Certification (PEFC). FSC was officially founded in 1993 by environmentalist groups after Rio de Janeiro Earth Summit in 1992 to reduce deforestation in tropical forests. Companies certified by FSC must follow 10 principles and 56 performance-based criteria (FSC 1996). Their principles cover tenure and land use rights, indigenous peoples' rights, conservation, management, and financial return. FSC has three types of certificates: (i) forest management, (ii) chain of custody (COC), and (iii) controlled wood (material that could be mixed with certified wood during manufacturing). Currently, FSC is present in 125 countries; the total certified area is equivalent to 183 million ha and 28,000 companies under COC in 2014 (fig. 3A).

PEFC has a different structure; it is an umbrella organization composed of local and government schemes. Founded in 1999 by forest producers in Europe, PEFC is present in 69 countries in two categories: forest management and chain of custody. In 2014, 263 million ha and 10,000 companies under COC were certified by PEFC. Their principles vary according to local regulations; however, they follow six main criteria for forest management, from socio-economic functions and conditions of the forest to its contribution to the global carbon cycle.

Table 2—Main international bilateral trade in 2014: value and share of the market per partners

Product	Bilateral trade	$ Million	Share of each product market (%)
Fuel wood and wood charcoal	Germany & Poland	54.48	3.46
Pulpwood	China & Viet Nam	630.28	7.20
Sawlog and veneer log	New Zealand & China	1,658.28	7.78
Pitprops, poles, NES	Canada & United States	72.07	23.54
Sawnwood	Canada & United States	4,899.61	11.96
Pulp and waste paper	China & United States	3,947.87	8.07
Wood manufactures	China & United States	1,948.66	3.35
Paper and paperboard	Canada & United States	5,314.84	3.00

NES= Not else specified.

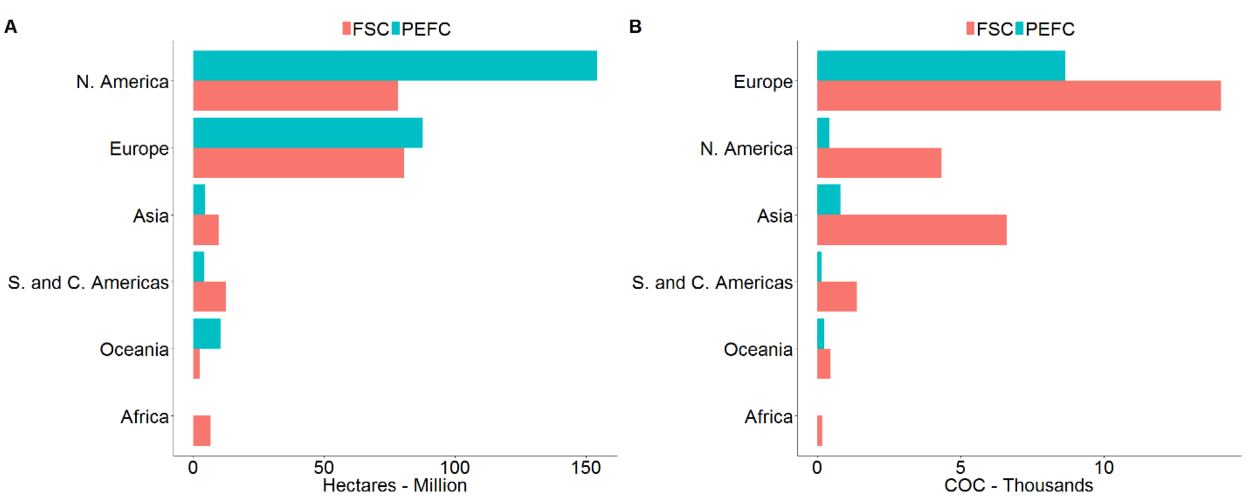

Figure 3—(A) Total area certified by FSC and PEFC in 2014. (B) Number of companies with Chain of Custody (COC) certification by Forest Stewardship Council (FSC) and Program for the Endorsement of Forest Certification (PEFC) in 2014.

Most of the certified forest areas are located in the North America (50 percent) and Europe (38 percent) (table 3). This contradicts the initial goal to prevent deforestation of tropical forests, located mainly in Africa, South America, and Asia. The concentration of COC certification is highest in Europe (61 percent), followed by Asia (21 percent) and North America (10 percent). Africa has the lowest share of the worlds certified forests (1.2 percent) and COC companies (less than 1 percent) (fig. 3A).

International Trade Models and Forest Products

The use of economic models on international trade of forest products was initiated in the 1980s. Precursor studies described wood consumption, trade in a post-war scenario, and the world's forest policy programs (Glesinger 1945). Holland (1973) was a pioneer in describing the different markets worldwide, as well as analyzing a potential increase of the bilateral trade between the United States and Canada. The use of empirical models examining the international trade initiated with Sedjo and Lyon (1983). The authors compared hypothetical scenarios in which a region dominated by forest plantations (South America, Australia, and Asia) has comparative advantage to old growth forests (United States, Canada, and Europe). In a global approach, Bonnefoi and Buongiorno (1990), analyzed impacts of forest endowment among 63 countries between 1960 and 1980; they confirmed the hypothesis that countries with a large endowment of forest resources are likely to be exporters. Later, the similar models were used to study trade of forest products and fuel in Europe (Lundmark 2010) and the influence of endowment in forest products trade in the long run (Uusivuori and Tervo 2002).

Another approach practiced in studies about international trade of forest products is the use of Spatial Equilibrium Models (SEM). The most common model used is the Global Forest Products Model (GFPM) (Buongiorno and others 2003, FAO 1999). GFPM has been used to project timber products and to study the impacts of external shocks in the international timber market due to tax changes and timber production quotas (see e.g., Buongiorno and others 2011, 2012; Gan 2004; Sun and others 2010).

These studies explained the international flow of products, but neither model explains specific bilateral trades. For this purpose, the Gravity model has been used widely in the literature. The Gravity model relates bilateral trade flows to GDP, distance, and other trade barriers. The theoretical foundation of gravity is based on homothetic preferences of consumer theory, in which countries maximize their utility (consumption) by trading goods, subject to their budget constraints (GDP) (Anderson and Wincoop 2003). It is expected that GDP and distance would have positive and negative effects, respectively, on international trade. Empirical research has investigated the impact of several trade barriers such as taxes, language and historical connection. In the trade of forest products, few researchers have explored the potential of Gravity model.

Kangas and Niskanen (2003) and Akyüz and others (2010) studied trade in forest products between the European Union (EU) and possible future members. Both found a negative impact on international trade due to the barriers of trade access into the European Union. Once these countries became members, their trade in forest products increased. Zhang and Li (2009) investigated the role of forest endowment and logging restriction on China's wood products trade. The authors found similar trends to previous studies using the Heckscher-Ohlin (H-O) model; countries with a large amount of commercial forest tend to be net exporters. In addition, logging restrictions had positive effects on China's imports. The Gravity model also was used to investigate international

Table 3—Area and number of companies with Chain of Custody per scheme and region, 2014

Region	FSC area (ha)	PEFC area (ha)	Total (ha)	FSC COC	PEFC COC	Total
Africa	5.67	—	5.67	163	1	164
Asia	9.5	4.66	14.16	7,433	818	8,251
Europe	81.84	89.33	171.18	14,752	8,949	23,701
Central and South America	12.75	4.56	17.3	1,431	426	1,857
North America	70.76	154.25	225.02	4,012	152	4,164
Oceania	2.58	10.4	12.98	456	245	701
Total	**183.1**	**263.21**	**446.31**	**28,247.00**	**10,591.00**	**38,838**

— = None; COC = Chain of Custody; FSC = Forest Stewardship Council; PEFC = Programme for the Endorsement of Forest Certification.
Sources: Forest Stewardship Council (2014) and Forest Stewardship Council (2014).

trade among members of EU (Buongiorno 2015).The benefits to international trade varied from 1.7 percent (wood and articles of wood) to 13.8 percent (paper and paperboard, articles of pulp) according to different products. Finally, Guan and Gong (2015) showed the negative effect on exports of timber products from China because of international efforts to reduce illegal logging.

As observed above, the literature in the forest sector has covered logging restrictions, trade agreements, and monetary unions. However, we expect that other factors, such as forest certification, might play a significant role in international trade of timber products. Using a Gravity model, the objective of this study is to assess the trade facilitation impacts of forest certification on bilateral trade of forest products.

DATA AND METHODS

Data

The bilateral trade flow data were collected from the United Nations (UN) Comtrade data, SITC Rev.2 – 2, 3, and 4 digits (table 4). The number of the digits was based on the research hypothesis. For instance, we are interested in analyzing the impact of FC on different types of forests; therefore, product code 247 was disaggregated into 2471–Sawlogs and veneer (coniferous species) and 2472–Sawlogs and veneer (non-coniferous). On the other hand, manufactured goods, such as Paper and Paper Board (SITC Rev.2–64) was analyzed as an aggregated class.

Population, Gross Domestic Production (GDP) and forest area data are from World Bank Development Indicators. Gravity variables such as distance between countries, currency, language, and World Trade Organization (WTO) members were collected from Centre d´Etudes Prospectives et d´ Informations Internationales (CEII). Forest certification data (area and number of companies under COC) were provided by the certification standards (FSC and PEFC) and were updated using information from their Web sites.

The trade data cover 252 reporting and partner countries between 1985 to 2013; those that do not cover this period were indicated as zero.

Model Specification

To analyze the impact of forest certification on international trade, we used the Gravity model. This model is based on Newton's Law of Universal Gravitation, which states that the attraction between two bodies is directly proportional to the product of their masses and inversely proportional to the square of their distance.

The theoretical foundation of the Gravity equation has been derived from monopolist competitive and H-O model along the last decades (Anderson and Wincoop 2003; Anderson 1979, 2011; Bergstrand 1985; Deardorff 1998). Assuming market-clearance condition, different production between countries, identical and homothetic demand, Gravity model is defined as (Anderson and Wincoop 2003):

$$X_{ij} = \frac{y_i y_j}{y_w} \left(\frac{T_{ij}}{P_i P_j}\right)^{1-\sigma} \qquad (1)$$

where:

X_{ij} = the trade flow between country i and j,

y = the incomes of country i, j, and world (w),

T_{ij} = the bilateral trade barriers,

P = price indices or "multilateral resistance".

Equation 1 is estimated by using a logarithm transformation and Ordinary Least Square (OLS). This approach excludes bilateral trades that have value zero, and it presents heteroskedastic in the error term. Heteroskedasticity Heads to "adds up" problem where

Table 4—Products studied in the Gravity model

Code SITC Rev.2	Product	$ Billion
S2-245	Fuel wood and wood charcoal	1.57
S2-64	Paper and paperboard	176.96
S2-2471	Sawlogs–Coniferous	10.36
S2-2472	Sawlogs–Non-coniferous	10.94
	Total	**199.83**

exports or imports are systematically overestimated (François and Shepherd 2013). An alternative approach to take account of the zero values and heteroscedasticity is the Quasi Poisson Maximum Likelihood (QPML) proposed by Santos Silva and Tenreyro (2006). This approach corrects heteroskedasticity in the error term and does not exclude bilateral trades with value zero. Therefore, equation 1 is transformed to:

$$\begin{aligned} \text{Log}(Y_{ijt}) = {} & \beta_0 + \beta_1 \text{Log}(\text{GDPcap}_{it}) + \beta_2 \text{Log}(\text{GDPcap}_{jt}) \\ & + \beta_3 \text{Log}(\text{dist}_{ij}) + \beta_4 \text{WTO}_{ijt} + \beta_5 \text{WTO1}_{ijt} \\ & + \beta_6 \text{currency}_{ijt} + \beta_7 \text{RTA}_{ijt} + \beta_8 \text{language}_{ijt} \\ & + \beta_8 \text{border}_t + \beta_9 \text{colony}_{ijt} + \beta_{10} \text{RC}_{it} \\ & + \beta_{11} \text{RC}_{jt} + \varepsilon_{ijt} \end{aligned} \tag{2}$$

where:

Y_{ijt} = the imported value of forest product between country i and j during period t;

GDPcap = GDP per capita of country i or j during year t;

$dist_{ij}$ = the distance between country i and j;

WTO_{ijt} = a dummy variable which assumes value one if both countries are member of the World Trade Organization and zero otherwise;

$WTO1_{ijt}$ assumes value one when at least one country is member of WTO and zero otherwise;

$Currency_{ijt}$, $language_{ijt}$, $colony_{ijt}$, and RTA_{ijt} = dummies variables for countries with common currency, language, former colonies and part members of Regional Trade Agreements;

RC_{it} and RC_{jt} are the ratio of the total forest area certified by FSC or PEFC and, the total area covered by forestland in the country i and j during period t, respectively.

The effect of FSC and PEFC are modeled separately due to multicollinearity; it is likely that areas certified by FSC are also PEFC certified, which affects the estimator consistency.

RESULTS: OVERALL EFFECT OF FOREST CERTIFICATION

In general, Gravity model results were consistent with those expected by economic theory (tables 5 and 6). GDP per capita of both importer and exporter countries had positive effect on trade. Except for Sawlogs-Coniferous, distance had negative effect on trade. When both trading partners are members of the WTO, membership had positive impact on the trade of every product studied. The impact of WTO membership, however, negatively affected forest products trade for all products except coniferous sawlog when only one partner was a member. As expected, Regional Trade Agreement membership had a variable impact on trade depending on the product being considered. Shared language, common border, and colonial ties generally facilitated trade between trading partners.

The effect of forest certification on a country's trade of forest products was found to vary depending on which certification and which products are being considered. In examining aggregate trade, relative proportion of area certified to FSC in either the importing or exporting nation was found to be positively correlated with increased trade. Relative adoption of PEFC, however, was not found to significantly impact trade. When disaggregated products are considered, however, results were mixed. Importer adoption of FSC positively impacted trade of paper and paperboard, and coniferous sawlogs. However, it negatively impacted trade of fuel wood and wood charcoal. Exporter adoption of this standard had a negative impact on trade of paper and paperboard, and non-coniferous sawlog. Relative use of PEFC had a much more limited impact on trade. Use of this standard by exporters facilitated trade only of fuel wood and charcoal, but negatively impacted all sawlog trade.

CONCLUSION

This paper offered an initial analysis of forest certification impacts on international trade using Gravity model. The impact of certification on trade depends on the products being considered, the level of product disaggregation, and the specific certification being considered.

Different certification schemes have distinct effects on international trade. For instance, PEFC has a larger share of the North American market which domestically consumes much of its production. On the other hand, FSC is more widely adopted in South America, a market dependent on exports. It is not surprising then, that PEFC would be correlated with less trade facilitation than FSC. Interestingly, despite environmental regulations and forest management restrictions, the trade facilitation benefits of these voluntary certifications were notably less then when both countries are members of the WTO.

Future research will evaluate the extent to which certification facilitates (or not) trade from countries of different development status' (i.e., developed and/or developing nations), and will consider a broader range of products.

Table 5—Comparison of Gravity equation with value of imports for five forest products, Forest Stewardship Council (FSC)

Variables	Sum of all product		Fuel wood and wood charcoal		Paper and paperboard		Sawlogs-Coniferous		Sawlogs-Non-Coniferous	
	Coef	SE	Coef	SE	Coef	SE	Coef	SE	Coef	SE
Intercept	-8.218[a]	0.284	-7.388[a]	0.534	-9.058[a]	0.216	-12.092[a]	0.888	-5.559[a]	0.672
GDP per capita-Importer	0.271[a]	0.006	0.239[a]	0.008	0.266[a]	0.005	0.214[a]	0.021	0.089[a]	0.023
GDP per capita-Exporter	0.304[a]	0.006	-0.057[a]	0.010	0.338[a]	0.005	0.369[a]	0.028	0.032	0.021
Distance	-0.318[a]	0.019	-0.687[a]	0.027	-0.383[a]	0.014	0.173[b]	0.074	-0.348[a]	0.052
WTO – both *i, j* members	1.121[a]	0.059	1.179[a]	0.085	1.123[a]	0.054	-0.799[a]	0.141	0.359[a]	0.118
WTO – *i* or *j* member	0.246	0.227	1.44[a]	0.499	-0.180	0.173	0.237	0.578	0.842	0.532
Common Currency	0.502[a]	0.047	0.515[a]	0.093	0.584[a]	0.032	0.336	0.243	0.439	0.233
Regional Trade Agreement	1.544[a]	0.042	-0.238[a]	0.066	1.79[a]	0.034	0.086	0.175	-0.587[a]	0.149
Common Language	0.652[a]	0.035	-0.366[a]	0.071	0.658[a]	0.027	-0.354[b]	0.171	-0.079	0.120
FSC Area / Total Forest-Importer	-0.618[a]	0.074	-0.285[b]	0.087	-0.433[a]	0.056	-1.937[a]	0.270	-2.142[a]	0.272
FSC Area / Total Forest-Exporter	-0.807[a]	0.059	0.865[a]	0.150	-0.921[a]	0.042	-0.955[b]	0.295	-1.111[b]	0.372
Degrees of Freedom	329838		89737		483652		57634		105285	

[a] 1 % of significance, [b] 5 % of significance.
Coef = Coefficients; GDP = Gross Domestic Products; SE = Standard Error; WTO = World Trade Organization.

Table 6—Comparison of Gravity equation with value of imports for five forest products, Program for the Endorsement of Forest Certification (PEFC)

Variables	Sum of all product		Fuel wood and wood charcoal		Paper and paperboard		Sawlogs-Coniferous		Sawlogs-Non-Coniferous	
	Coef	SE	Coef	SE	Coef	SE	Coef	SE	Coef	SE
Intercept	-8.286[a]	0.284	-7.216[a]	0.534	-9.131[a]	0.216	-12.213[a]	0.888	-5.462[a]	0.672
GDP per capita-Importer	0.271[a]	0.006	0.232[a]	0.008	0.265[a]	0.005	0.21[a]	0.021	0.072[a]	0.023
GDP per capita-Exporter	0.295[a]	0.006	-0.052[a]	0.010	0.328[a]	0.005	0.368[a]	0.028	0.026	0.021
Distance	-0.299[a]	0.019	-0.707[a]	0.027	-0.363[a]	0.014	0.196[a]	0.074	-0.341[a]	0.052
WTO – both *i, j* members	1.08[a]	0.059	1.164[a]	0.085	1.079[a]	0.054	-0.845[a]	0.141	0.33[a]	0.118
WTO – *i* or *j* member	0.215	0.227	1.424[a]	0.499	-0.210	0.173	0.163	0.578	0.824	0.532
Common Currency	0.511[a]	0.047	0.419[a]	0.093	0.603[a]	0.032	0.381	0.243	0.521[b]	0.233
Regional Trade Agreement	1.434[a]	0.042	-0.261[a]	0.066	1.687[a]	0.034	-0.037	0.175	-0.684[a]	0.149
Common Language	0.718[a]	0.035	-0.34[a]	0.071	0.735[a]	0.027	-0.331	0.171	-0.067	0.120
PEFC Area / Total Forest-Importer	-0.431[a]	0.074	1.214[a]	0.087	-0.542[a]	0.056	0.220	0.270	-0.102	0.272
PEFC Area / Total Forest-Exporter	0.705[a]	0.059	-0.519[a]	0.150	0.714[a]	0.042	-0.277	0.295	-0.475	0.372
Degrees of Freedom	329838		89737		483652		57634		105285	

[a] 1 % of significance, [b] 5 % of significance.

Coef = Coefficients; GDP = Gross Domestic Products; SE = Standard Error; WTO = World Trade Organization.

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INCIDENCE OF RUSSIAN LOG EXPORT TARIFF: A VERTICAL LOG-LUMBER MODEL

Ying Lin and Daowei Zhang[1]

Since 2007, Russia imposed an ad valorem tariff on its log exports, primarily to stimulate its domestic sawmill industry. In this paper, we use a Muth-type equilibrium displacement model to investigate the impact of this tariff on price, quantity, and welfare across vertical production stages in a large open economy setting. Our results show that the log export tariff burden is shared almost equally between foreign log buyers and domestic producers and that a 1-percent ad valorem tariff on log exports decreases lumber price by 0.29 percent. Further, the welfare gains for Russian domestic consumers, lumber producers, and tax revenue exceed the loss in its logging sector.

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GRAVITY MODELS OF FOREST PRODUCTS TRADE, WITH APPLICATIONS TO FORECASTING AND POLICY ANALYSIS

Joseph Buongiorno[1]

To predict the bilateral trade between countries, differential gravity models were formulated and estimated with large panel data sets. The gravity theory was confirmed with three alternative estimation methods for wood products, pulp products, and paper and paperboard. The estimated equations were used to predict the effects of the Trans-Pacific Partnership on trade and to judge the consequences of the monetary union on the intra-European trade of forest products.

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Ecosystem Services and Non-Market Valuation

PANEL PRESENTATION

MATCHING THE MEANS TO THE ENDS: CHOOSING APPROPRIATE METHODS FOR VALUATION OF FOREST ECOSYSTEM SERVICES

Erin O. Sills, Thomas P. Holmes, Gregory E. Frey, and Lydia Olander[1]

At both the State and Federal level, forest management and policy are now assessed in terms of their implications for ecosystem services. While the provisioning, regulatory, and cultural services provided by forests are widely recognized, quantifying the value of those services remains controversial. The speakers in this panel will discuss the challenges and choices involved in valuation of ecosystem services, focusing on how to tailor the approach to the objective of valuation. Dr. Sills will discuss the motivations, methods, and findings of previous State studies. Dr. Holmes will discuss the empirical challenges encountered when estimating economic values for forest watershed ecosystem services at the meso-scale including non-linearities, misspecification, and missing links. Dr. Frey will discuss the challenges and opportunities of estimating a value for forests' provisioning ecosystem service of nontimber forest products. Dr. Olander will discuss the outcomes of a project that addressed how to quantify ecosystem services if decisionmakers cannot or do not want to monetize them. This work was designed to support Federal Government efforts to incorporate ecosystem services broadly into the decision-making process.

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CAUSALITY OF BIODIVERSITY-PRODUCTIVITY RELATIONSHIP

Jingjing Liang, Mo Zhou, Patrick C. Tobin, A. David McGuire, and Peter B. Reich[1]

The loss of biodiversity is threatening ecosystem productivity and services worldwide, spurring efforts to quantify its impacts on the functioning of natural ecosystems. Here, we demonstrate that biodiversity loss reduces plant productivity, other things held constant, through theory, empirical evidence, and simulations under gradually relaxed assumptions. We developed a theoretical model named niche–efficiency to integrate niche complementarity and a heretofore-ignored mechanism of diminishing marginal productivity in quantifying the impacts of biodiversity loss on plant productivity. We also explored the effect of productivity on plant diversity, and proposed a study to investigate the direction of causality between productivity and biodiversity. The study demonstrates unique strength by integrating economic and ecological theories, and has wide implication in economics and biological conservation.

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LONG RUN EVOLUTION OF WILDERNESS VALUE: A COMBINED CROSS-SECTION TIME-SERIES ANALYSIS OF BACKCOUNTRY HIKING

Thomas P. Holmes and Jeffrey Englin[1]

There is an ongoing public debate regarding the evolving relationship between the American people and the Great Outdoors. Using long run data on participation, some have argued that the observed decline in per capita participation in many outdoor activities is due to the growth in consumption of electronic technology. Although economic theory suggests that participation in outdoor recreation should be related to access prices, socio-economic characteristics and other demand factors, we are unaware of any analyses investigating long-run trends in the economic demand for, and value of, outdoor recreation. To address this gap, we collected a quarter-century of permit data from wilderness areas in the Western United States and estimated several count-data travel cost demand models. We discuss long-run trends in the price and income elasticity of demand for wilderness trips as well as the long run evolution of wilderness value (consumer surplus). Further, we describe how these results can be used to compute an ecological discount rate that is appropriate for evaluating the costs and benefits of wilderness protection policies.

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ESTIMATING THE WILLINGNESS TO PRESERVE OPEN SPACE IN COASTAL WATERFRONTS

Ram P. Dahal, Robert K. Grala, and Jason S. Gordon[1]

Open space associated with coastal waterfronts provides opportunities for recreational activities and other benefits, such as ecological and economic development. However, with growing population, the number of waterfront open spaces has decreased. Expansion of urban residential and commercial areas entrenches on open space and converts it into man-made concrete structures, such as buildings and roads. Loss of open space impacts people's quality of life. Thus, this study evaluated citizens' willingness to preserve open space in coastal regions of Mississippi (Ocean Springs and Gulfport) and Alabama (Daphne and Mobile). A contingent valuation method (CVM) was employed to estimate citizen's willingness to pay to support open space preservation. The CVM involved two scenarios where citizens voted for or against the open space preservation with an offered bid amount ranging from $1 to $100 at $10 increments. Results will help guide local elected officials in maintaining a balance between urban and waterfront developments, as well as access to waterfronts and the associated benefits.

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WILLINGNESS OF FOREST LANDOWNERS TO IMPLEMENT FUEL TREATMENTS

Robert K. Grala, Hugh R. Medal, Jason S. Gordon, J. Morgan Varner, and Katarzyna Grala[1]

Many decades of wildfire suppression have resulted in extensive forest fuels accumulation which increases the likelihood of large wildfires. Fuels management in these areas can not only reduce wildfire hazard but also restore and maintain healthy ecosystems. This study involved a mail survey to examine the cost effectiveness of fuel treatments on nonindustrial private forest lands in Mississippi. The study also involved a contingent valuation scenario to determine landowner willingness to pay (WTP) for fuel treatments and associated wildfire prevention benefits. Landowners were randomly assigned a preselected payment level and a dichotomous choice question will be used to elicit their response whether they would be willing to pay this amount for the treatment to be implemented on their land. A binary probit regression was used to determine landowner WTP and examine impacts of expected wildfire prevention benefits, attitudinal factors, and landowner socio-demographic characteristics on reported WTP amounts. The study results will help managers more effectively prioritize fuel treatment investments and generate the largest possible benefits when compared to incurred costs.

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NONMARKET VALUATION THROUGH INVERSE OPTIMIZATION

Mo Zhou[1]

Standing trees provide substantial values through numerous ecosystem services but it is challenging to determine such values explicitly, especially if they do not have consumptive uses. To this end, an inverse approach is proposed with the assumption that if the observed harvesting decisions deviate from the optimal decision solely based on timber values, they may disclose landowner's valuations and preferences of ecosystem services, being consumptive or not. By treating the observed behavior as the optimal decision of a forest planning problem, this approach derives the overall rewards associated with forest conditions and management actions because they reveal the values of benefits of ecosystem services provided by standing trees as well as those of disbenefits of harvesting trees in terms of foregone ecosystem services.

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THE AMENITY VALUE OF RESIDENTIAL TREES: A META-ANALYSIS OF HEDONIC PROPERTY-VALUE STUDIES

Shyamani D. Siriwardena, Kevin J. Boyle, Thomas P. Holmes, and P. Eric Wiseman[1]

Trees in residential neighborhoods and communities induce costs and benefits for homeowners that are capitalized into residential property values. The implicit value of trees in locations of interest is recovered in hedonic property value studies. In this paper, we conducted a meta-analysis of the impact of tree canopy cover on the value of residential properties using data from prior hedonic property value studies from various locations in the United States and merging ancillary spatial data describing forest and socio-economic characteristics surrounding each study area. The meta-analysis suggests that property-level tree cover of about 30 percent and county-level tree cover of about 38 percent maximize the implicit price of tree cover in property values. The desire for less tree cover at the residence level may be due to both the private cost and public good aspects of tree cover; property owners bear the costs of tree damage on or adjacent to their properties and enjoy the benefits of trees located at a distance from their homes. The findings have implications for community forest programs regarding planting and protecting trees to address potential changes in tree abundance, species diversity, and stand age due to development and climate change.

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THE EFFECT OF SPATIAL INTERPOLATION ON THE HEDONIC MODEL: A CASE OF FOREST DAMAGES

Xiaoshu Li, Kevin J. Boyle, Thomas P. Holmes, Evan Pressier, and David A. Orwig[1]

The hemlock woolly adelgid (HWA) is an exotic forest insect pest that causes hemlock mortality in eastern North America. The population growth of HWA is sensitive to temperature and precipitation, and climate change is expected to favor the spread of HWA (Orwig and others 2002). The subsequent losses of trees can impact property values via reductions to the amount of shade, which reduces heat impacts, and reductions in the scenic aesthetics. Dying and dead trees can pose risks to residents and their homes. Thus, exploring the economic effects of forest pest infestation is important to support forest and climate policy.

Previous studies have used hedonic property value models to estimate the loss in property values from damages caused by hemlock morality (Holmes and others 2010). However, the studies are restricted to specific area, e.g., county. In our study, we employed geostatistical interpolation methods to scale up the analysis from sampled hemlock stand to State level, specifically Connecticut and Massachusetts. Different geostatistical interpolation methods are employed, including inverse distance weighting (IDW), Kriging, and splines. We have also employed cross validation information from Kriging to adjust the spatial interpolation errors. We predicted the hemlock damage characteristics, hemlock vigor, and hemlock live basal area, respectively, for years 2007, 2009, and 2011.

Then, these interpolated hemlock health data were matched with property sale data to construct the hedonic model and identify the impacts from HWA infestation. We investigated the effects of spatial data interpolation and the interpolation adjustment methods on the estimation of a hedonic model analysis. Instead of employing the traditional hedonic model, we also estimated the repeat sale model to avoid the missing variable problem.

The results of this study indicate that HWA has caused dramatic damages to hemlock stands in central Connecticut and central Massachusetts during the period 2007–2011. This landscape change caused the decrease of the sales price for properties residing in the study area. The repeat sale model gives relatively consistent estimation results that the hemlock damage caused by HWA infestation will decrease the value of residential properties, which locate inside a 0.1-km buffer area by about 3 percent.

Spatial interpolation methods provide useful tools to broaden the scale of our analysis and lead to consistent inference. After spatial interpolation (Kriging, Spline, and IDW), we could utilize repeat sale models to conduct quasi-experimental design. The results based on repeat sale models show the robustness over different interpolation methods and the cross validation adjustments.

Breakouts of forest pests can produce large economic losses to private property owners in residential forests. Slowing the advance of HWA into residential forests could convey substantial benefits to homeowners and may substantially exceed the cost of such programs. Protecting or delaying the onset of HWA in such areas may be a smart investment of public and private funds.

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METRO NATURE AND HUMAN HEALTH: VALUATION CHALLENGES

Stephen C. Grado, Marcus K. Measells, Kathleen L. Wolf, and Alicia S.T. Robbins[1]

Scientific evidence demonstrates nature contact generates substantial ecosystem services, which includes extensive human health and well-being benefits. However, economic valuations of these benefits have lagged behind similar valuations for other ecosystem services. In particular, there are limited studies associated with linkages between public health/epidemiology (PHE) and valuations of nature benefits in a metro nature context. A thorough literature review revealed more than a dozen global themes of services and benefits associated with nature contact and human health and well-being. Based on this review, we identified 15 health and well-being benefits which economic valuations could be applied. However, most source studies were not designed to include a valuation component, thus conversion to economic terms is not straightforward. Limitations include: (1) geographic scope or scale of measurement variations between the urban natural resources (UNR) and PHE fields, (2) outcome measures vary substantially across studies, (3) few studies acknowledged potential confounding factors (i.e., mitigating or mediating variables), and (4) other limitations such as small sample sizes, lack of comparability between human populations studied, studies crossing cultural boundaries, as well as nature vegetation implementation and management actions that confound the ability to assess valuation techniques to human health and well-being issues. It appears there are different fundamental assumptions between the UNR and PHE fields concerning metro nature research.

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Policy and Governance

PANEL PRESENTATION

REDD+ REDUCING EMISSIONS FROM DEFORESTATION AND FOREST DEGRADATION PLUS CONSERVATION OF FORESTS IN DEVELOPING COUNTRIES

Pamela Jagger, Subhrendu K. Pattanayak, Alexander Pfaff, and Erin O. Sills[1]

Reducing emissions from deforestation and forest degradation (REDD+) is a key element of the 2015 Paris Agreement under the UNFCCC. While the purpose of REDD+ is to reduce carbon emissions, its legitimacy and success also depend on its socio-economic impacts. The speakers in this panel discuss approaches and findings regarding these dual goals of REDD+, including use of secondary data to monitor social safeguards, methods for rigorous impact evaluation of pilot REDD+ initiatives, design of protected areas to reduce poverty as well as protect forest, and evidence on the impacts of a REDD+ pilot in Nepal. Dr. Jagger will present the paper, "Using Publicly Available Social and Spatial Data to Evaluate Progress on REDD+ Social Safeguards in Indonesia" co-authored with Pushpendra Rana. Dr. Pattanayak will present the paper, "REDD+ Impacts: Evidence From Nepal" co-authored with Bishnu Prasad Sharma, Mani Nepal, Priya Shyamsundar, and Bhaskar S. Karky. Dr. Pfaff will present the paper, "Multiple Use Protected Areas Can Reduce Poverty and Deforestation: evaluating two types of PA impact given competition for land allocation" co-authored with Maria Carnovale, Cesar Delgado, Charles Palmer, Luz Rodriguez, and Stephan Schwarztman. Dr. Sills will present the paper, "Building the evidence base for REDD+: Evaluating the impacts of conservation interventions on human welfare" co-authored with Claudio de Sassi, Pamela Jagger, Kathleen Lawlor, Daniela A. Miteva, Subhrendu K. Pattanayak, and William D. Sunderlin.

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IMPERFECT PAYMENTS FOR FOREST ECOSYSTEM SERVICES: NEGLECTED EXISTENCE VALUES, FREE-RIDERSHIP, AND BENEFICIARIES' WILLINGNESS-TO-PAY

Elizabeth A Obeng and Francisco X. Aguilar[1]

Ecosystems and their services are vital to human wellbeing. Forest ecosystems provide a multitude of services but many of them are not traded in formal or informal markets, hence becoming externalities. Payment for Ecosystem Services (PES) programs have emerged as a voluntary tool to create financial incentives to ameliorate externalities. However, they only include monetary compensations as proxy for non-marketed ecosystem services (primarily regulating) and neglect to pay for ecosystem existence values. Free-riding is thus inherent to PES as participants and non-participants benefit from their existence without explicitly paying for it. This free-riding is reflected on a mismatch between reported estimates for ecosystem service values and PES contracts. The mismatch between PES payments and estimated monetary values of ecosystem services may need to revisit potential levels of payments that direct or indirect beneficiaries might be willing to pay to preserve ecosystems and their flow of services. Some beneficiaries might be willing to pay for some ecosystem services but expect themselves or others to free-ride on them. Given the inherent challenge of including existence values and free-ridership in PES, efforts should be dedicated to better understand beneficiaries' willingness-to-pay and reduce uncertainties of PES programs.

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USING CONSERVATION AUCTIONS TO IMPROVE EFFICIENCY: THE CASE FOR INTRODUCING AN AUCTION INTO COSTA RICA'S EXISTING PES PROGRAM

Natasha James, Erin O. Sills, Tabaré Capitán, Francisco Alpizar, and Ariana Salas[1]

Payments for ecosystem services (PES) are "voluntary transactions between service users and service providers that are conditional on agreed rules of natural resource management for generating off site services" (Wunder 2015). In many PES programs, the Government or implementing agencies pay the service provider, often landowners, to implement specific management practices to generate ecosystem services for the community at large. PES programs have been established in a variety of contexts to address a diversity of environmental issues including forest degradation and biodiversity protection. Although economists advocate for PES as more efficient than indirect incentives, there are many barriers to realizing those efficiencies in practice.

One barrier to realizing the theoretical advantages of PES is information asymmetries. An efficient program would pay each landowner an amount equal to her opportunity cost of participation. However, opportunity cost is private information, and implementing agencies typically do not have enough information to determine a value for each landowner, given constraints on data collection budgets and the landowners' incentive not to reveal this information (Chan and others 2003, Ferraro 2008).

As a result of this information asymmetry, in many PES programs, the Government pays a flat, per-hectare rate for conservation of the ecosystem. This is inefficient because only landowners whose per hectare opportunity cost are at or below the fixed price will participate in the program. The difference between payments received by landowners and their actual opportunity costs is their informational rent. Fixed rates inherently offer rents to landowners whose opportunity costs are low and hence whose lands are hardly at risk of degradation or deforestation. Informational rents are a source of inefficiency as the implementing agency obtains fewer ecosystems services per dollar than it would if landowners were paid their true opportunity costs (Deng and Xu 2015, Ferraro 2008).

To increase efficiency, implementing agencies for PES need a mechanism that both reduces informational rents and attracts participants who offer high value in terms of ecosystem services (Deng and Xu 2015). Procurement auctions can potentially deliver both (Ferraro 2008). Unlike an auction where goods are being sold, procurement auctions involve goods being bought. These auctions are well-suited to the typical PES system because they involve an implementing agency purchasing multiple units of a heterogeneous good (i.e., environmental services) from multiple suppliers (Doole and others 2014).

Once procurement auctions are announced, interested landowners determine the payment they would like to receive for providing the environmental service. The landowners then submit their desired payments as bids. Bids are often accompanied by a metric measuring the level of environmental services provided, which can either be self-declared or developed and validated by Government agents or natural resource professionals. This metric is then used to rank the bids. Bids providing the highest environmental benefit per dollar are selected first, with bids accepted according to rank until the budget is exhausted (Reeson and others 2011).

Bidding rules can be designed to increase competition among landowners and have been shown to help overcome information asymmetries and reduce opportunistic behavior (Banerjee and others 2015, Cason and Gangadharan 2004, Reeson and others 2011). With competitive bidding, a high bid may increase the net payoff to a landowner, but a bid that is too high reduces the likelihood a landowner will be selected for the program. Therefore, competitive bidding creates an incentive for a landowner to bid close to their opportunity cost (Amdur and others 2011, Deng and Xu 2015). This allows for the implementing agency to efficiently allocate ecosystem services dollars without having prior knowledge of landowners' private costs or using resources

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to collect information about each landowner's opportunity cost (Chan and others 2003). Thus, theory suggests with appropriate design (e.g., preventing collusion), procurement auctions could increase the efficiency of the typical PES program. The objective of our study is to explore how an auction mechanism could be incorporated into the Costa Rican PES program, *Pagos por servicios ambientales* (PSA).

The Costa Rican Government is faced with the challenge of setting the correct level of payments for its PSA program. Currently landowners are paid a flat, per-hectare rate to conserve forests providing various ecosystem services. While PSA is considered a model for PES programs to conserve tropical forests (Snider and others 2003), there is increased pressure from both international donors and the national auditor general to increase efficiency. Over the two decades since the program has been implemented, the Costa Rican Government has made various adjustments, indicating they are responsive to criticism and willing to implement changes in the program. We assess the feasibility of implementing a temporary procurement auction as a mechanism for defining payment levels for forest conservation in Costa Rica by examining the properties of procurement auctions used in various countries and determining whether and how the properties of each auction could be applied to a future procurement auction within PSA.

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TRENDS IN SPECIES CONSERVATION BANKING IN THE UNITED STATES

Jagdish Poudel and Daowei Zhang[1]

Since the inception of the species conservation banking program in the United States in 1995, there has been the substantial supply of conservation credits over time. We quantified and analyzed the trends of conservation banking in the United States. Our preliminary result reveals that 129 different species were conserved in 104 conservation banks covering almost 58,000 acres of land. Almost 66 percent of conservation credits were sold by private firms, generating a total of $57.2 million in revenue. Price ranges from $1,500 to $198,560 per credit across different species. We conclude that species conservation banking has adopted a business-based habitat planning system. Ecological services companies and social entrepreneurs are attracted towards this market-based approach to get involved in solving environmental issues while making a profit.

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PRICES VERSUS QUANTITIES IN FOREST POLICY INSTRUMENTS: THEORY AND NUMERICAL ANALYSIS

Gregory S. Amacher and Markku Ollikainen[1]

We investigate whether Weitzman's (1974) results and follow-up extensions of his work hold for the forestry case, which is characterized by myriad informational asymmetries in forest establishment costs, forest productivity, and amenity enhancement effort costs. We use a simple but traditional problem to match Weitzman's static analysis and develop general and explicit expressions for quantity and price (tax) instruments used to promote amenities. We show how to transform this forest rotation analysis into one consistent with the marginal cost and marginal benefit notions discussed in the Weitzman literature. Several new results are uncovered. We find that the well-known and cited Weitzman rule based on the slopes of marginal costs and benefits is not always valid for forest policy instruments and that symmetrical expectations around true values can result in asymmetric changes in marginal cost of compliance curves; most importantly, we find that the extent of any mistake on the part of the regulator now matters to price versus quantity choices. Our analysis also extends the well-known Hartman model to incorporate the costly effort a landowner incurs to enhance amenities, finding that policy packages consisting of at least two instruments are needed, and the optimality of a command and control type of quantity constraint becomes a rule rather than an exception. Collectively, these new results demonstrate that forest policy questions are much richer than previously thought and need considerable additional investigation.

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A CERTAINTY PROGRAM FRAMEWORK FOR MARKET-BASED CONSERVATION OF LONGLEAF PINE CONSERVATION

Damien Singh, Fred Cubbage, Nils Peterson, Michelle Lovejoy, Jessica Pope, Suzanne Jervis, Chris Serenari, Amanda Dube, and Brian Hays[1]

Abstract—This research analyzed the potential supply of longleaf pine habitat in southeast North Carolina for an ecosystem-based credit market using landowner surveys. Results from a logistic regression analysis and a choice-based conjoint (CBC) statistical analysis revealed that landowners were most influenced by program requirements such as contract length and legal obligation in a conservation contact. Short-term contract agreements of 5 to 10 years were favored, as were minimal land restrictions. Annual payments were somewhat less important than contract agreement or level of obligation, although higher payments were more desirable, as expected. The initial cost-share rate and level of technical assistance were the least important factors affecting willingness to participate in longleaf conservation programs. The presence of longleaf pine on the landowner's property, previous participation in a Farm Service Agency benefits program, a willingness to participate in a permanent easement to promote longleaf pine, the amount required to accept a permanent easement, and ownership of 101–500 acres of forest positively impacted landowners' interest in a conservation credit program to promote longleaf pine habitat. Conversely, persons who were unwilling to participate in a permanent easement were less interested.

INTRODUCTION

We performed a U.S. Department of Agriculture (USDA) Conservation Innovation Grant (CIG) project entitled, "Market Based Conservation Initiative for Longleaf Pine Habitat Improvements in Eastern North Carolina." This paper summarizes research based on surveys of landowners in the key counties to assess their willingness to plant longleaf pine, work with nontraditional partners seeking habitat credits, interact with farm and forestry support agencies, gauge their knowledge of Endangered Species Act issues, and determine cost-share payment rates that might be required to foster credit creation. A map of the counties is shown in the methods section. We used one large survey and two statistical methods—a choice-based conjoint (CBC) analysis and a regression analysis, described below— to examine the interest of landowners in participating in various conservation programs to create, enhance, or restore longleaf pine ecosystems.

Conservation markets need a supply of a product or service—landowners who will supply the service—and demand from some entity to buy the conservation good or service. In the case of conservation credit markets, private landowners may enter into temporary contracts or permanent easements directly with buyers or with brokers to create and ultimately supply credits to individuals, businesses, or Government entities seeking an investment opportunity, positive public relations coverage, and/or to offset damages to the environment. Such agreements can vary in their provisions; however, they generally place stringent land management and legal requirements on the participant in return for financial compensation, regulatory assurances, and program assistance.

Private lands are crucial for ecosystem services and habitat conservation. In the United States, 914.5 million acres of land were classified as farmland (40 percent of the total area), and there were 2.1 million farms (USDA NASS 2014). In the lower 48 States, about 70 percent of the *total* land area is in private ownership, and about half of all the land is managed as cropland, pastureland, and rangeland by private landowners (Heard and others 2000, cited in Gray and Teels 2006). Approximately 65 percent of *all* land in the United States is owned privately.

For the 766 million acres of *forest* land in all States, the public sector owns a greater share at 321 million ha (42 percent). There are 445 million acres of private forest land, or 58 percent, with about 10 million forest

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landowners. Private noncorporate owners hold 39 percent (298 million acres) of the Nation's forest land, and private corporate owners hold 19 percent (147 million acres). In the 13 Southern States from Texas to Virginia, private noncorporate and family forest owners hold 60 percent of the forest land, and private corporate owners hold 27 percent (Oswalt and others 2014).

Public assistance for natural resource conservation by individuals on private lands is an objective of Government and nongovernment organizations, ranging from international, to local scales. There are literally thousands of financial and technical assistance programs and cooperative programs that provide economic incentives for sustainable use, conservation, and protection of natural resources, including land, water, fish and wildlife, forests, rangelands, and croplands.

Various conservation programs provide payments to encourage private landowners to perform conservation practices on their land. The structure of the payments required, contract or easement terms, and technical assistance required influence the enrollment in and success of the programs (e.g., Rodriguez and others 2012, Sorice and others 2011, 2013). Longleaf pine has become an important conservation priority in the South in the last decade or so, and we examined the economics and program characteristics that would encourage private landowners to plant or restore more longleaf. Approximately 4.7 million acres of longleaf pine (LLP) exist in the southeast region, of which 61 percent are on private lands (ALRI 2014). Given these conditions, successfully promoting LLP habitat through the implementation of a credit market hinges on its widespread adoption by private, nonindustrial landowners. LLP is most noted for its ability to provide habitat for the endangered red-cockaded woodpecker (RCW), but it has many other broad biodiversity and ecosystem functions and values that would make it attractive as a credit market opportunity.

This paper is divided into two parts. First, we review current literature on landowner interest in conservation in Southeastern United States. Second, we analyze a survey conducted of landowners in 38 eastern North Carolina counties to examine how they prioritize provisions of a theoretical performance contract and the variables associated with interest in LLP conservation.

BRIEF LITERATURE REVIEW

Considerable research has examined landowners' views and interest in conservation in the Southeast United States in North Carolina. Rodriguez and others (2012) found landowners prefer contracts to permanent easements, and while many were interested in protecting endangered species, it was the lowest priority among conservation issues. They also found interest in conservation was negatively correlated with age and positively correlated with past participation in conservation programs, positive perceptions of endangered species protection, and lower property requirement scores. Golden and others (2012) studied North Carolina landowners and found that they are more likely to be interested in wildlife conservation if they resided on their property, hunt and/or have a family member that hunts, and were younger and male.

Although the terms of conservation performance contracts may vary, they usually contain several common attributes including, but not limited to: length; legal obligation to maintain land during and after contract; financial assistance to help with establishment costs; incentive payments to compensate for potential loss in income; and level of program assistance received prior to and during the contract period. Some research has used novel approaches to shed light on how landowners prioritize such conditions. For instance, Sorice and others (2013) studied family-forest landowners in the Southeast United States, using a choice model to determine preferences for participation in a program to protect the gopher tortoise. They found a strong aversion to strict regulatory programs, or ones that require permanent easements or put landowners at risk of future regulation.

In general, conservation programs may provide contracts, which are temporary legal agreements between the program's managing agency and a landowner, and easements, which are permanent changes in the rights to use the land. Conservation contracts usually provide a specific cost-share payment for establishing a conservation practice, and usually have annual payments for maintaining those practices. The cost-share payment covers a portion of the costs that landowners incur when performing a practice, ranging from 50 percent to 100 percent depending on the needs, the practice, the State, and the type of landowner. The annual payments may occur for a decade or more for conservation contracts, where the landowner agrees to keep a practice in place for the duration of the contract. Landowners also may enter into a long-term or permanent easement, which is a specific legal instrument that mandates they perform a practice or restricts their land use rights and is registered on the title to their land. This may include some establishment costs and then a fixed payment for the easement rights, usually as a lump-sum, up-front payment (Cubbage and others 2017).

Easement agreements are more expensive than conservation contracts, and they are less common but still prevalent. Most landowners are apt to prefer short-term easements with payments for a fixed term so they can break a contract if need be, or simply wait until it expires before changing the conservation practice or land use. However, landowners who truly want to protect and conserve their land use in perpetuity, and receive a greater payment for themselves, not their heirs, may prefer to sell their land with a permanent conservation easement, or just sell the conservation easement and retain the land (Cubbage and others 2017).

LANDOWNER INTEREST IN LONGLEAF CONSERVATION PROGRAMS

Landowner Survey Methods

We conducted a survey of landowners in 38 counties in eastern North Carolina that fell within the historical longleaf pine range as identified by the Longleaf Alliance strategic plan (fig. 1).

Working with various forest and agriculture associations and cooperative extension agents, we developed a sample frame composed of (1) individuals for whom the research team secured personal email addresses (e.g., North Carolina Forest Development Plan longleaf incentive program participants), and (2) organizations who would rather not share internal information but agreed to send our emails with links to the survey directly to landowners on our behalf (e.g., The Farm Bureau). Drafts of the survey were developed, reviewed by the project personnel, presented for discussion at CIG stakeholder meetings, and revised for the final survey instrument. The surveys were reviewed by the North Carolina State University Institutional Review Board, modified, and approved before sending them out.

Data were collected from respondents through a pre-tested questionnaire constructed and administered on an online server hosted and maintained by North Carolina State University. Approximately 1,000 survey requests we sent electronically and another 2,000 via regular postal service mail. These requests asked landowners to go to the Web site to complete the survey because part of the survey specifically required interactive Web replies. Our sample included 374 landowners (only 243 completed the entire survey) who owned forest, agriculture land, or a combination thereof with acres ranging from less than 50 acres to more than 5,000 acres.

The survey consisted of two parts. First, it asked 1 open-ended question (age) and 25 multiple-choice questions related to respondents' demographics, land characteristics, interest in conservation programs and

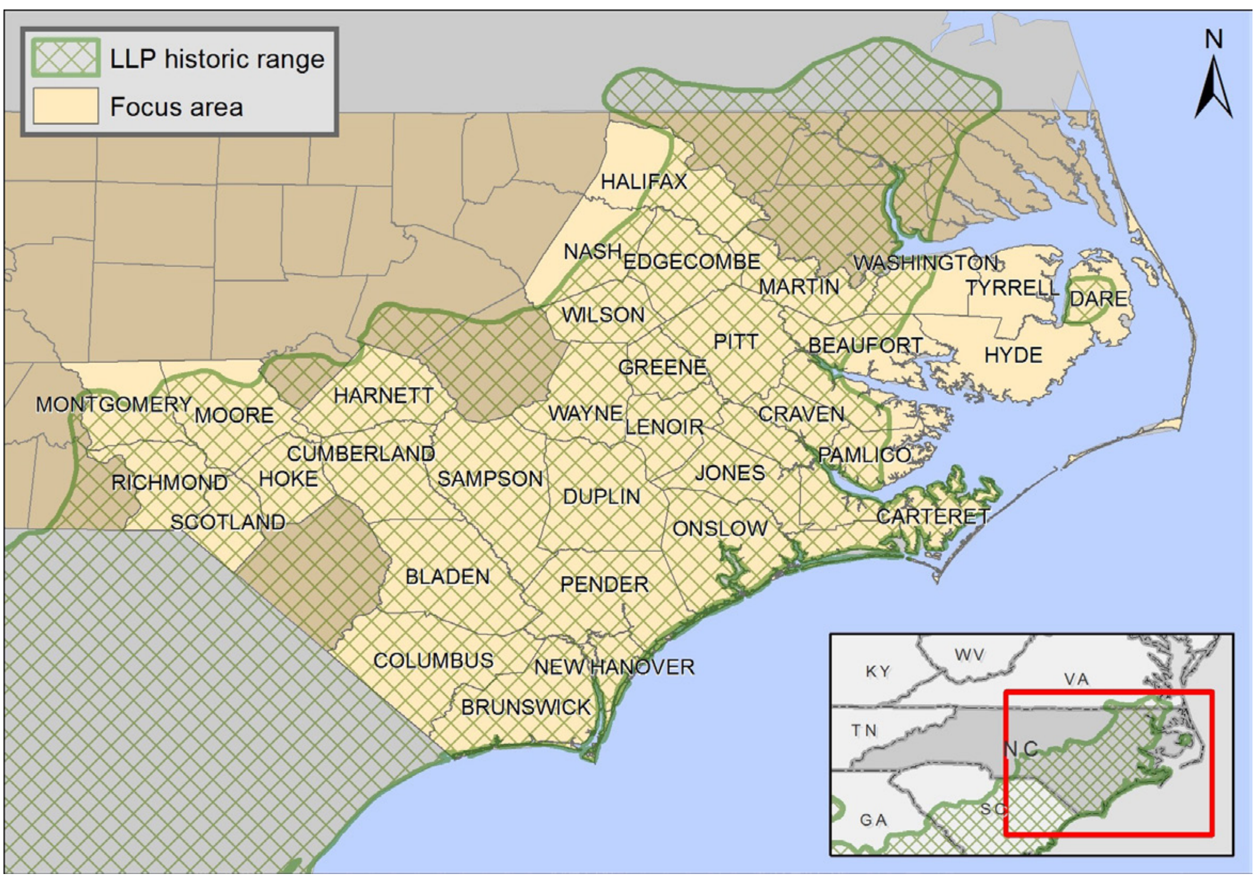

Figure 1—Map of Conservation Innovation Grant Longleaf Pine Project Area.

easements, having management plans, participation in the North Carolina deferred tax program based on agriculture, forestry or wildlife usage [present use value (PUV)], and using Natural Resources Conservation Service (NRCS) and Farm Service Agency (FSA) benefits/cost-share programs. We also included a question on their willingness to participate (WTP) and the amount required to participate (willing to accept, or WTA) in making a permanent conservation easement. Table 1 summarizes the independent variables measured from the survey.

Statistical Analysis

We analyzed the data using regression analysis and conjoint-based choice analysis. Using these two methods provided a means to triangulate landowner interest and opinions using two approaches, thus providing more robust results.

Regression analysis—We analyzed the data from the survey using SAS JMP Pro Version 12.0.1. First, we developed a correlation matrix to examine the relationships of variables measured and identified those with a correlation coefficient with the variable Interest in a Longleaf Pine Conservation Program (LLPInterest) greater than 0.1. These were organized into four conceptual categories based on landowners' wealth, past participation in a benefits program, interest in participating in a future credit program, and land characteristics. We then ran separate Ordinary Least Squares (OLS) regressions taking the variable LLPInterest as a function of all the others and recorded their parameter estimates and p-values.

Based on the OLS models and correlation matrices, we used the most impactful variables (those with high coefficients and p-values below 0.05) in a logistic regression model using SAS JMP procedure Nominal Logistic to estimate those that had the most impact on LLPInterest—the likelihood that landowners would be interested in planting or restoring longleaf pine.

The regression model forms then were:

Ordinary Least Squares:

$$P = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_3 X_n$$

Table 1—Independent variables measured

Variable	Options
LL Cons interest	Yes, No, I don't know
Currently has LLP	Yes, No, I don't know
Present use value registered	Yes, No, I don't know
Receives FSA benefits	Yes, No, I don't know
Receives NRCS benefits	Yes, No, I don't know
Agriculture management plan	Yes, No, I don't know
Forest management plan	Yes, No, I don't know
Conservation Program for Ag Land	Yes, No, I don't know
Forest management plan, who helped	NC Forest Service, NC Wildlife Resources Comm, Consultant, Yourself, Other
Age	Years
Gender	Male, Female
Education	High School, Tech, Associates, Bachelors, Graduate
Acres forest owned	1-49, 50-100, 101-500, 501-999, 1,000-4,999, 5,000+
Acres ag owned	1-49, 50-100, 101-500, 501-999, 1,000-4,999, 5,000+
Income	<$24,999, $25-$49,999, $50-$74,999, $75-$99,999, $100,000+
WTP perm easement	Yes, No, Depends on Payments/Property Requirements, Not Sure
WTA perm easement	$500, $1,000, $2,000, $2,500, Other (please specify)

Logistic Regression:

$$P = \beta_o X_1^{\beta 1} X_2^{\beta 2} \ldots X_n^{\beta n}$$

where:

P = willingness to participate in a longleaf pine conservation program

X_i = various land and landowner characteristics

Choice-based conjoint analysis—The second part of the survey required respondents to select an ecosystem credit program scenario among those presented in 12 choice tasks. (A choice task consisted of two different randomly generated scenarios and one 'I don't know'.) Table 2 shows the five attributes included in each scenario along with their descriptions and possible levels. This portion of the survey, or the choice-based conjoint (CBC) analysis, was analyzed using Sawtooth Software version 8.2.0, Orem, UT. CBC poses questions in a way that reflects how people make choices and enabled us to examine landowners' underlying values and preferences as they relate to environmental, land use, and economic concerns.

Most of the choice-based conjoint analysis values are self explanatory, including contract length, annual payment, cost-share rate, and assistance level. Obligation covers how the landowner is to manage their land once the contract ends. It has three values: (1) No Obligation = landowners will not be required to maintain any endangered species habitat after the contract ends; (2) Baseline = landowners are NOT obligated to maintain endangered species habitat above the level that existed before the contract started; or (3) Full = landowners must maintain habitat they create until the species have recovered and are delisted.

The cost-share percentage represents the possible program benefits to provide financial compensation to establish the forest.

Landowner Survey Results

Descriptive statistics—Table 3 summarizes the descriptive statistics of the survey data. Respondents averaged 62 years of age and were predominately male (82 percent) and retired (42 percent) or employed full time off property (34 percent). Households with annual earnings of \$50,000–\$100,000 and greater than \$100,000 made up 46 percent and 39 percent of the sample, respectively. While some landowners resided outside of the project area, they would have had to own land or attend conservation programs in the area in order to be included in our survey.

A large share of respondents reported having longleaf pine on their property (58 percent), a forest management plan (68 percent), PUV (68 percent), and to a lesser extent a conservation plan for their agricultural land (28 percent). Finally, 52 percent and 39 percent have participated in a FSA and NRCS benefits program, respectively. These are high rates of longleaf forests and farm programs due to the fact that we obtained our survey samples from existing program participants. This may provide some upward bias in the landowners' willingness to participate in longleaf programs, but it was unavoidable in order to get an adequate sample, given that we were asking persons to complete a complex survey online.

Table 4 provides a breakdown of respondents by land ownership type. For instance, 80 percent of landowners with 1–49 acres of forest also own 1–49 acres of agriculture land. Similarly, 50 percent of landowners with 1–49 acres of agriculture land also own 1–49 acres of forest. However, there are very few large forest landowners that own large amounts agriculture land. But the large agriculture landowners tend to own large amounts of forest as well. One might expect this because North Carolina is 60 percent forested, and forests will tend to occur in streamside zones, swamps, or hillsides on almost any farm in the State.

Table 2—Attributes with importance scores and descriptions

Attribute	Levels	Description
Contract length	5, 10, 20, 30	Number of years required by contract
Obligation	None, Baseline, Full	Landowner's legal obligation to maintain habitat
Annual payment	\$25, \$50, \$75, \$100	Payment per acre received by landowner
Cost share	25%, 50%, 75%, 100%	Percent of \$300/acre establishment cost
Assistance level	None, Prior Consult, Full Consult	Outside help to manage the land under contract

Table 3—Descriptive statistics for survey participants

Survey participants	Completed (244) Started but did not complete (132)
Sex	Male (81.8%) Female (18.2%)
Employment	Full-time (33.6%) Part-time (3.1%) Unemployed (.4%) Disabled (1.3%) Retired (42.4%) Self-employed (19.2)
Education	<High School (.4%) High School/GED (12.8%) Vocational/Tech (10.7%) Associates (14.5%) Bachelors (37.2%) Graduate/Professional (24.4%)
Household earnings	<$24,999 (4.6%) $25-49,999 (11.1%) $50-74,999 (23.6%) $75-99,999 (22.2%) $100,000+(38.4%)
Presence of LLP on property	Yes (57.7%) No (28.3%) Not Sure (14%)
Forest management plan	Yes (67.9%) No (29.1%) Not Sure (3%)
Ag conservation plan	Yes (27.5%) No (60.4%) Not Sure (12.2%)
Present use value	Yes (68.1%) No (13.4%) Not Sure (18.5%)
FSA benefits program	Yes (52.1%) No (34.5%) Not Sure (13.4%)
NRCS benefits program	Yes (38.7%) No (50.4%) Not Sure (10.9)
County participant resides	B Bertie (.4%) Bladen (3%) Brunswick (1.7%) Carteret (1.7%) Cabarrus (.9%) Caswell (.9%) Columbus (1.7%) Craven (.4%) Cumberland (10.3%) Dare (.4%) Davidson (.4%) Duplin (2.6%) Halifax (.9%) Harnett (8.6%) Hoke (2.6%) Gatson (.4%) Guilford (.9%) Johnston (6%) Jones (1.3%) Lee (.4%) Lenoir (1.3%) Mecklenburg (1.3%) Montgomery (3.9%) Moore (11.6%) New Hanover (.4%) Onslow (2.6%) Pender (3.9%) Pitt (1.7%) Randolph (1.3%) Richmond (1.3%) Robeson (.4%) Sampson (6.5%) Scotland (1.3%) Union (.4%) Wake (3.9%) Watauga (.4%) Wayne (10.3%) Wilson (.9%)

Regression analysis—Tables 5 and 6 provide information on the relationship of those variables that affected interest in longleaf pine conservation programs (LLPInterest). The p-value measures the significance of the results, and generally those less than 0.05 are considered strong, between 0.1 and 0.05 significant, and greater than 0.1 weak. The Logworth estimator provides information about the magnitude of the variable and how much it positively or negatively impacts the dependent variable, in this case LLPInterest.

Table 5 shows that presence of longleaf pine on the landowner's property, previous participation in a FSA benefits program (FSABenefits), a willingness to participate in a permanent easement to promote longleaf pine (a yes or no answer, depending on the property requirements; variable WTP Depends on Property Requirements), the actual required amount to accept a permanent easement ($2,500), and ownership of 101–500 acres of forest positively impacted landowners' interest in a conservation credit program to promote longleaf pine habitat. Conversely, Table 6 shows that those less likely to be interested included persons who were unwilling to participate in a permanent easement.

These all make intuitive sense—existing program and FSA participants were likely to be interested in longleaf programs as well, and higher payments for easements would encourage more participation. Owners with medium-sized forest tracts of 101–500 acres were the most likely to be interested; small and large forest owners were not. However, ownership size of agricultural land had no effect on interest in program participation. Similarly, education, employment, income, gender, having forest or farm management plans, and/or being enrolled in PUV programs had no effect on landowners' interest in participation. NRCS program participation may have been influential as well, but less so than FSA use, so it was eliminated in the first OLS regressions in order to avoid a high correlation between independent variables in the logistical regressions.

Choice-based conjoint analysis—The CBC analysis provides insight into how landowners prioritize the

Table 4—Land characteristics of survey participants

Forest landowners by acres with agricultural land							
Acres of ag	1-49	50-100	101-500	501-999	1000-4999	5000+	
1-49	80%	33%	37%	26%	19%		
50-100	15%	39%	30%	26%	14%		
101-500	5%	26%	27%	32%	48%	100%	
501-999		2%	5%	11%	10%		
1000-4999			2%	5%	10%		
5000+							**Total**
Forest owners with ag / total forest owners	59/84	51/69	60/92	19/23	21/29	2/2	**210/299 (70.2%)**
Agriculture landowners by acres with forests							
Acres of forest	1-49	50-100	101-500	501-999	1000-4999	5000+	
1-49	50%	16%	6%				
50-100	18%	36%	26%	13%			
101-500	23%	33%	32%	38%	25%		
501-999	5%	9%	12%	25%	25%		
1000-4999	4%	6%	20%	25%	50%		
5000+			4%				**Total**
Ag owners with forest / total ag owners	95/103	55/57	50/50	8/8	4/4		**212/222 (95.5%)**

Table 5—Positive significant variables, LLPInterest

Variable	P-value	LogWorth	Est.
CurrentLLP (Yes)	0.00459	2.338	0.5154
WTA ($2,500)	0.01828	1.738	0.4983
FSABenefits (Yes)	0.03864	1.413	0.3805
WTP (Depends Property Req.)	0.04367	1.36	0.4917
Acres Forest (101-500)	0.10482	0.98	0.3374

Table 6—Negative LLPInterest correlation

Variable	P-value	LogWorth	Est.
WTP (No)	0.00006	4.23	-0.8093

program scenario attributes by assigning relative importance scores to each, as seen in Table 7. A higher score represents a greater value placed on the attribute by the respondents. Contract length, level of obligation, and annual payments were identified as the most important factors to landowners. Conversely, cost share and technical assistance level both scored comparatively low.

This CBC analysis also enables us to examine how values within each attribute fared by providing total zero-centered utility values for each (only levels within an attribute can be compared), as seen in figure 2. Again, higher scores represent a greater preference by the survey respondent. Respondents showed a steady decreasing preference for greater contract lengths. Preference steadily increased with greater assistance levels, cost-share percentages, and incentive payment amounts. Obligation preference decreased slightly between no obligation and baseline obligations, but dropped radically for full obligation.

CONCLUSIONS

Landowners were most influenced by contract length and legal obligation in a conservation contact. Short-term contract agreements of 5 to 10 years were favored, as were the least land restrictions. Annual payments were somewhat less important than contract agreement or level of obligation, although higher payments were more desirable, as expected. The initial cost-share rate and level of technical assistance were the least important

Table 7— Choice-based conjoint (CBC) attributes with importance scores

Attribute	Score
Contract length	28.40%
Obligation	25.90%
Annual payment	20.80%
Cost share	12.40%
Assistance level	11.40%

factors affecting willingness to participate in longleaf conservation programs. The presence of longleaf pine on the landowner's property, previous participation in a FSA benefits program, a willingness to participate in a permanent easement to promote longleaf pine, the amount required to accept a permanent easement, and ownership of 101–500 acres of forest positively impacted landowners' interest in a conservation credit program to promote longleaf pine habitat. Conversely, persons who were unwilling to participate in a permanent easement were less interested.

Although our findings suggest contract programs could generate more supply of longleaf, additional funding from Government or private organizations would be needed to support such contracts. So far, moderate Federal and State longleaf incentives have been successful and well subscribed, but more funds and perhaps higher payment

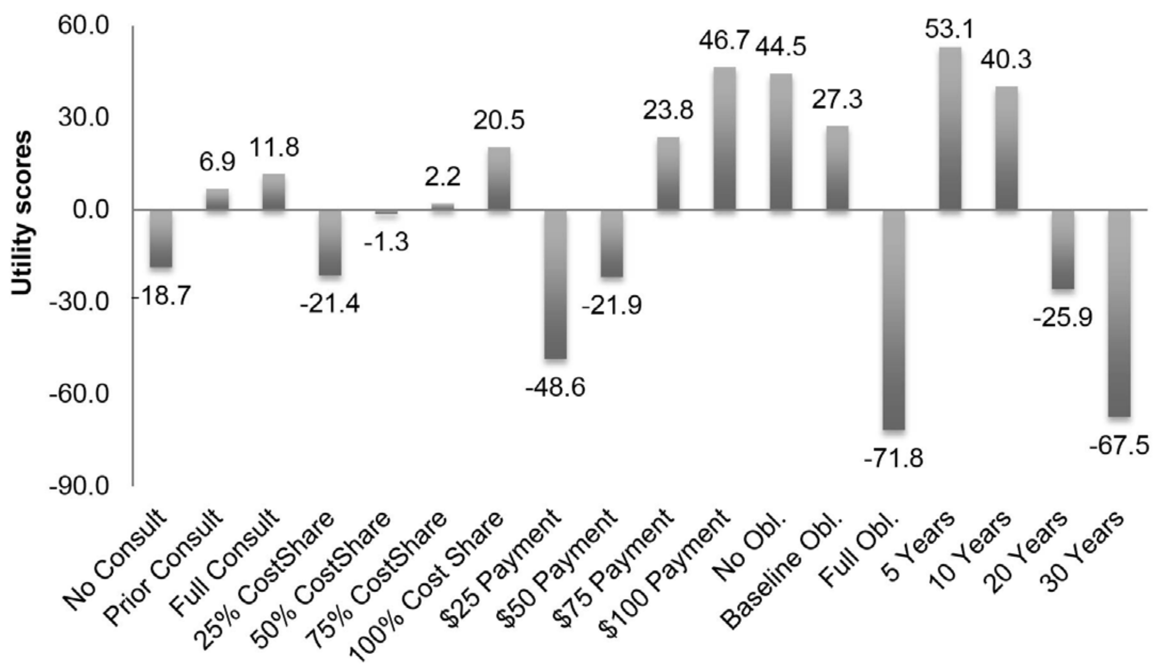

Figure 2—Utility scores for choice-based conjoint (CBC) attributes.

levels are needed to increase the supply. The modest regulatory demand and still nascent voluntary demand for longleaf ecosystems will probably continue to prompt a slow expansion in longleaf pine establishment and restoration in North Carolina rather than a quantum leap that might be prompted by a program such as the Federal "No Net Loss of Wetlands" policy that was mandated in 1990.

We see several avenues for future research in this arena. First, additional studies may explore the relative importance of longleaf's economic merits compared to loblolly pine for landowners. Possible advantages may include alternative income streams (e.g., pine straw, poles) and higher tolerance of drought, wind, and flooding. Similarly, future research could include a spatial component. Compared to loblolly pine or crops, it provides a different income stream and markets for risk reduction purposes; it may prosper more in droughts or even floods; and it provides broad ecosystem benefits. It also does provide pine straw as well as superior timber and poles, and could thus potentially produce higher returns than managing for loblolly pine (Dickens and others 2012), especially with payments from incentive programs for the first 10 years after stand establishment. If a credit ranking system is developed, setting minimum conservation benchmarks and priorities for selecting the best lands—e.g., large areas, near existing RCW colonies—would be important. Even for more traditional incentive programs, these location and habitat characteristics could be incorporated more in making funding decisions.

Our specific results also can be complemented by knowledge of existing landowner behavior. Landowners have been more than willing to enroll in Farm Bill and State longleaf pine planting programs, and our findings help suggest preferred contract, payment, and assistance factors. While it is anecdotal, it appears that a recent increase in tree planting in the South also has a much larger longleaf pine component than in the past, providing some evidence that these public assistance programs are increasing longleaf habitat.

Other practical factors—such as likelihood that longleaf is harder to plant and manage than loblolly, or that agriculture returns on poor lands have such huge variations and much higher risk—may also have large negative or positive impacts on economic decisions to whether to plant or restore longleaf. Getting the message right, making applications easy, and providing certainty to landowners that any program strings will not escalate all are important factors that could provide fodder for future projects to increase the area and restoration of longleaf pine.

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IMPACTS OF CONSERVATION EASEMENTS ON CONTIGUOUS AND SURROUNDING PROPERTY VALUES

Weiyi Zhang and Bin Mei[1]

We apply the hedonic pricing model in attempt to estimate the values of sampled properties based on the attributes of surrounding conservation easements within the 25 counties of the Metropolitan Atlanta Statistical Area. First, we collected data on all conservation easements in the 25 counties, including their location and owner types. We then randomly sampled 50 land parcels that are currently up for sale in the same counties for parcel prices, sizes, and land types. Recognizing the importance of spatial relationship between conservation easements and the properties for sale, the distance between each property and the nearest conservation easement is calculated based on GPS coordinates. A regression is run to fit this pricing model and finds that there exist negative correlations between the distance from a property to its closest conservation easement and the value of the property. In addition, we also notice that there exists a significant correlation between the land value and the number of conservation easements around each property, namely, the fewer conservation easements in the vicinity where the higher property values are.

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IMPACT OF INSPECTIONS ON COMPLIANCE WITH THE FORESTRY LAW IN PERU

David Solis and Erin O. Sills[1]

Illegal logging is a major concern throughout the tropics. In Peru, the Government has issued timber concessions in over 762,222 km^2 of tropical forest in 2003 and 2004. We quantify and seek to understand the economic rationale for violations of the national forestry law in these concessions. Perhaps the most obvious way to violate the law is to harvest more timber than allowed (and reported) in order to increase revenues. However, based on reports from field inspections carried out by OSINFOR (the Peruvian Forestry Agency) between 2009 and 2014, the reverse is more common in Peru. That is, concession managers routinely report harvesting (and pay taxes and fees for) more timber than can be documented in the field (i.e., more logs are reported than there are stumps in the concession). This may reflect two economic strategies: (1) reducing harvest costs (by using official documents obtained for the concession to transport and sell logs harvested from unauthorized locations closer to roads or markets), and/or (2) increasing revenues (by using the official documents to transport and sell logs of more valuable tree species than available in the concession).

Using field reports from OSINFOR inspections from 2009 to 2014, we quantify the extent of this problem, develop a conceptual framework that predicts where and when it is most likely to occur, and estimate a model for concessions breaking the rules and another for concessions abiding by the rules. In so doing, we assess whether OSINFOR's system of inspections is likely to have reduced illegal timber trafficking. Specifically, we test whether previous inspections by OSINFOR reduce misreporting of timber harvest as discovered in forest concessions during later inspections, by matching concessions being inspected for the second time with similar concessions being inspected for the first time. We argue that differences between these two groups reflect differences in the expected probability of inspections and associated fines for over-reporting timber harvest.

Given data restrictions, we implemented a single difference strategy to estimate the Average Treatment Effect on the Treated (ATET). Using propensity score matching to the nearest neighborhood and kernel matching, we found that field inspection of a concession reduced on average between 1,530 and 1,885 cubic meters of misreported timber harvest that could enable illegal timber trafficking. These results are statistically significant and robust (i.e., confirmed in a linear regression with the matching covariates as controls). In order to quantify the magnitude of the impact, we multiply the smallest estimate of the ATET by the number of field inspections from 2009 to 2014 (table 1). This suggests that in total, 679,320 m^3 of illegal timber trafficking were avoided as a result of field inspections from 2009 to 2014. The annual average legal timber production between 2009 and 2012 was around of 850,750 m^3 (Agriculture Ministry 2014), which means that the total impact (over 6 years) is around 80 percent of one year's legal timber production.

Even though our results indicate that field inspections do increase compliance with the law in timber concessions, thereby potentially decreasing illegal timber trafficking, this does not imply that field inspections eliminate illegal activities in forest concessions. We have only found that misreporting is greater in the control group than treatment group. Misreporting may continue despite

Table 1—Impact of field inspections on illegal timber trafficking in forest concession

Year	Field inspections	Avoided under-reporting or laundering of illegal timber
		m^3
2009	51	78,030
2010	138	211,140
2011	74	113,220
2012	64	97,920
2013	47	71,910
2014	70	107,100
Total	**444**	**679,320**

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field inspections for various reasons: (1) involuntary mistakes in the harvesting process (i.e., failure to harvest authorized trees by new employees), or (2) high demand and therefore high profit margin from documentation that allows transport and trade of illegally harvested trees.

While our results indicate that field inspections attenuate illegal timber activities, there is evidence that illegal timber trafficking has nonetheless been increasing in Peru between 2009 and 2014. One possible explanation is that illegal timber traffickers have found other means to obtain the documents required to launder illegal timber, such as permits for logging in native communities, on private lands, and in local forest. The last instrument has been used intensively by illegal timber traffickers because it permits a group of people to harvest timber (and obtain official documents for transport of that timber), but supervision is limited because it is difficult to identify and locate each member of the group.

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SMALLHOLDER LAND CLEARING AND THE FOREST CODE IN THE BRAZILIAN AMAZON

Stella Zucchetti Schons, Eirivelthon Lima, Gregory S. Amacher, and Frank Merry[1]

Smallholder deforestation is increasingly important to forest loss and government policy. A dynamic land clearing theory of a smallholder who has an unobserved perception of government enforcement is developed and estimated using an endogenous regime selection switching regression method applied to data collected from the same households in 2003 and 2014 within the Transamazon, a period and region in which the Brazilian government claimed to have increased enforcement of the Forest Code regulating clearing of smallholder lots. We show compliance and noncompliance preferences of smallholders lead to a selection problem that must be addressed in any examination of land clearing behavior. We also find that marginalization and transitions to cattle grazing, but not agricultural rents, are major contributors to forest clearance and incentives to not comply with the Forest Code once selection is addressed. Smallholders with smaller lots perceive higher net benefits from not complying. Longer land tenure does not mean protection of forests and rather means greater clearing and greater perceived net benefits from not complying, but use of the forest by a smallholder is a protective signal. Frontiers where land tenures are longer, even with significant out- and in-migration, and those with opportunities for smallholders to transition to more expensive cattle production systems, should be a major focus of enforcement of the Forest Code. Even for smallholders who stay more than a decade, the seeming stability does not guarantee forest protection. Our results suggest that Brazilian Forest Code may be ineffective and require a major re-evaluation.

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COOPERATIVE MANAGEMENT OF INVASIVE SPECIES: A DYNAMIC NASH BARGAINING APPROACH

Kelly M. Cobourn, Gregory S. Amacher, and Robert G. Haight[1]

We use a Nash bargaining framework to examine scope for bargaining in areas where control of the spread of invasive species between adjacent municipalities depends on the employment of costly controls and species-specific parameters. Municipalities bargain over a transfer payment from an uninfested municipality to an infested municipality; this transfer payment compensates the latter to undertake greater control to slow the probability of invasive species spread. These controls require that the infested municipality forgoes nonmarket benefits associated with the host plant species in order to protect nonmarket benefits in the uninfested municipality. We demonstrate that the difference between the bargaining and first-best outcomes depends on the relative bargaining power held by each municipality, the rate at which the probability of spread grows over time, and the efficacy of controls in stemming spread of the invasive. In an application to the problem of emerald ash borer infestation in Minneapolis and St. Paul, MN, we find that when the uninfested municipality has a significant bargaining power advantage over the infested municipality, bargaining may attain the first-best solution. Our results also suggest that under a broad range of parameter values, a short-term bargaining agreement is unlikely to succeed, which suggests a potential role for higher levels of government to play in facilitating long-term bargaining agreements even when the details of those agreements are left to the municipalities to negotiate.

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TRACKING ECONOMIC AND ENVIRONMENTAL INDICATORS OF EXPORTED WOOD PELLETS TO THE UNITED KINGDOM FROM THE SOUTHERN UNITED STATES: LESSONS FOR POLICY?

Puneet Dwivedi[1]

This study estimates the abatement cost of greenhouse gas (GHG) emissions for a unit of electricity generated in the United Kingdom from wood pellets imported from the Southern United States. We assumed that only pulpwood obtained from loblolly pine (*Pinus taeda*) plantations was used for manufacturing exported wood pellets. The use of imported wood pellets for electricity generation could save at least 69.9 percent of GHG emissions relative to coal-based electricity in the United Kingdom. The average unit production cost of electricity generated from imported wood pellets (US \$222.3 MWh-1) was 30.0 percent higher than the unit production cost of electricity generated from coal (US \$171.0 MWh^{-1}) without any price support. In the presence of payments from the established price support mechanisms of Renewable Obligation Certificates (ROCs) and Levy Exemption Certificates (LECs), the unit production cost of electricity generated from imported wood pellets (US \$142.9 MWh^{-1}) was about 16.0 percent lower than the unit production cost of electricity generated from coal. Policymakers should consider 1 MWh of electricity generated from imported wood pellets equivalent to 0.58 ROCs or 0.71 ROCs in the presence and absence of payments from LECs, respectively. This will ensure zero abatement cost and lead to economic efficiency in reducing GHG emissions. However, a more indepth analysis focusing on market risks for power generating companies and other wood pellet supply chains is required before modifying existing equivalency factors for ensuring continuous use of imported wood pellets for displacing coal-based electricity in the United Kingdom.

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SOCIO-ECONOMIC FACTORS BEHIND GLOBAL PROTECTED LAND AREA CHANGES

Nianfu Song and Francisco X. Aguilar[1]

Protected lands play an important role in global processes including climate change mitigation, habitat protection, and overall sustainable development. Periodic changes in protected land area were explored as a function of land, social, and economic descriptors. Explanatory variables and function forms of models were first theoretically derived then simplified by a model selection procedure. Indicators from 136 countries reported by the World Bank over 20 years were included, and models for selected observation intervals were estimated and compared. Econometrically, education level, population, geographic region, agricultural land use, and general national income were found to be associated with land protection level of a country. The models provided prediction tools for the next 5, 10, or 20 years in different scenarios. This study also identified the rate of secondary school enrollment as the most important indicator for the prediction of changes in protected land area.

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DETERMINANTS OF FORESTRY RELATED CAMPAIGN CONTRIBUTIONS TO THE HOUSE OF REPRESENTATIVES

Shaun M. Tanger, Daowei Zhang, and James E. Henderson[1]

In this paper, we examine the determinants of campaign donations from forest interests to Congress. Focusing on the House of Representatives, we estimate the impact of key supply and demand characteristics of the member of Congress' political district in determining the amount and number of campaign contributions received in the election cycle building to the general election. We find that campaign contributions are influenced by a member of Congress' unique attributes in their ability to "supply" legislation to donors, as proxied by margin of victory in the last election, age, important committee assignments, majority party status. Relatedly, certain "demand" side characteristics that in the member of Congress' district influence donation patterns. These can include but may not be limited to the number of jobs coded as forestry jobs, the amount of forest land in the congressional district, and the percentage contribution to total Gross Regional Product that the forest products industry represents among all industries in the district.

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THE PROPOSED SALE OF THE HOFMANN FOREST: A CASE STUDY IN NATURAL RESOURCE POLICY

Frederick Cubbage, Joseph Roise, and Ron Sutherland[1]

Abstract—In January 2013, the North Carolina State University (NCSU) Endowment Fund and Natural Resources Foundation proposed selling the 79,000 acre Hofmann Forest, which a Forestry Foundation at NCSU had purchased in 1934 and used for education, research, and demonstration programs. This proposed sale prompted substantial public and faculty opposition, as well as a lawsuit filed based on the North Carolina Environmental Policy Act (named SEPA). Various factors—including the lawsuit, public protests, media exposure, and a new university strategy in 2015—shifted the university's plan from the outright sale of the Hofmann to retaining ownership of the majority of the property and selling a timber deed to a Timber Investment Management Organization (TIMO) in 2016 in order to ensure conservation over as much as 70,000 acres of the land. This public university policy issue is described here in some detail as a case study.

INTRODUCTION

The first Director of the North Carolina State University School of Forestry, Julius Hofmann, felt that the students in the new program needed a forest to learn on and practice their discipline, and worked tirelessly to acquire a suitable tract of land for the new School that he founded after leaving Pennsylvania. In 1934, he set up a Forestry Foundation as a vehicle to obtain a loan and manage such a property, and bought a massive 80,000 acre Pocosin tract in the North Carolina coastal plain. To quote Hofmann (1933), the property was acquired:

> "…as a forestry laboratory, demonstration area and as a source of revenue to help carry on the forestry education work."
>
> "The Forestry Foundation is to hold this property for the sole interest and benefit of the Forestry Department of State College."

Management of the mostly wetland property proved to be challenging, but the Forestry Foundation and professors at the school slowly began teaching and experiments on the forest, and subsequently Wally Wicks, an industry manager, began to convert some of the natural pond pine and other species to loblolly pine by slowly ditching parts of the swamp, draining it, and converting it to loblolly pine plantations. Forestry students also went to summer camp on the Hofmann through the 1950s, and then later moved to the closer and less rugged Hill Forest in the Piedmont of Durham County N.C. After about five decades of ownership, the Hofmann Forest began to make its first net profits in the 1980s.

In 2008, the Forestry Foundation was merged with the Pulp and Paper Foundation to create the NC State University Natural Resource Foundation (2008), which was: "organized to operate exclusively for scientific and educational purposes in support of the scientific, educational, research, and outreach missions of the College of Natural Resources at NC State University. The Corporation has a strong history and lineage of forestry and forest products support, largely due to the management of the Hofmann Forest, which is recognized as a unique resource and a primary focus of the Corporation since its inception."

Despite the initial mission that focused on the Hofmann Forest, the Natural Resource Foundation soon decided to sell the Hofmann based on the premise that it would gain more revenue for its educational and research support mission from a sale of the Hofmann Forest than it could receive from actually managing the Hofmann. Numerous citizens, faculty, and citizens opposed the sale, and pursued various strategies and tactics to stop the sale and protect the Hofmann for education, research, and conservation in its existing university foundation ownership.

By the late 2000s, the forest began to contribute net revenues of more than $2 million per year for the NCSU College of Natural Resources budget. Timber harvests increased substantially from less than 50,000 tons in 2005

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to more than 200,000 tons in 2010, and then dropped to less than 100,000 tons in 2013 (table 1), providing evidence that the high harvest levels were not sustainable. A complex interaction of harvests from natural pine stands; large investments in regeneration of those stands to convert them to planted stands; an unbalanced age class structure; falling stumpage prices; and more aggressive timber harvesting resulted in the harvest area and volume peak and then decline. The timber harvest levels probably could have been scheduled in a better sustained yield even flow approach, but there is not adequate public data to pin this down, and indeed the Hofmann Forest Management Committee was disbanded during this critical period as well. Regardless, the run up in harvest revenues, College expenses, and subsequent revenue declines may have encouraged the Natural Resources Foundation and NCSU to consider selling the property. The public and faculty were not privy to these deliberations or details of the forest management decisions.

AGENDA SETTING PROCESS

This paper examines a policy process that this issue evolved through, and the current status and resolution of the debate, with the university selling a timber deed to the Hofmann Forest, but still retaining the ownership of the Forest. . To provide some theory for this paper, we adapt the agenda setting process described by Cobb and Elder (1972), Birkland (1988), and Cubbage and others (2017), which starts with an issue being identified, and then various attempts by interest groups who are seeking a different policy to get their issue on the agenda for change (fig. 1). This process applies well to the Hofmann debate, and provides a somewhat dispassionate way to examine what was a contentious debate about the fate of the forest.

In brief, the agenda setting process states than an issue is triggered by some initiator or focusing event, which brings attention to an old policy, or places some new policy on an agenda for action by decision makers. Official university decision makers, such as the North Carolina State University (NCSU) College of Natural Resources (CNR) Dean, the Natural Resources Foundation (NRF), and the Chancellor in this case, were able to get the proposed sale on the NC State University agenda quickly, and without the need for any consultation with external stakeholders or interest groups. Persons and uninfluential groups who then eventually opposed the sale of the Hofmann Forest, such as faculty, students, local residents, or conservationists, then had to build broader coalitions and gain wider public attention in order to have their views considered or to halt the proposed sale.

This paper describes how the interest groups that favored retaining the Hofmann Forest sought to oppose the sale for their stated educational, research, and conservation objectives, and by inference, how NC State University and its investment foundations sought to sell the Hofmann Forest to meet their implied educational, financial, and programmatic objectives. Data and references for this discussion are drawn mostly from NC State and public media, newspaper, and internet sources, which were all that was publicly released, since the NC State University Endowment Fund and its Natural Resource Foundation have continuously claimed that they are a private foundation, and they are not subject to any open records, although they are housed in university buildings and have university emails, phones, and purchase cards. In fact, the administration chose not to issue any specific statements about the sale other than formal university press releases or open letters to the College and the public from the Dean of the College of Natural Resources.

The primary official NCSU public press releases and web postings touted the investment benefits of the sale (Watzin 2013); the limited academic use of the Hofmann Forest (NC State University 2015); and the advantages of a new conservation agreement (Hartman 2015). Opponents of the sale contested these official positions, and indeed unsuccessfully argued that the Forest was public property and subject to North Carolina open records laws. Opponents did make many open records requests and did receive copies of the eventual Hofmann Forest sale contracts and some emails deemed to be public, but all requests for information about the Natural Resources Foundation Board meetings or documents were denied. Their attorneys strongly felt that the North Carolina open records law would apply the Natural Resources Foundation / NC State University leaders, but the estimated cost of $10,000 or more to open a new lawsuit for their records about the Hofmann was too expensive for the opponents to afford.

Table 1—Hofmann forest timber harvest trends, 2004−2013

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Area (acres)	290	430	900	1730	1940	2160	2279	1210	1570	1150
Volume (thousand tons)	23	38	88	134	177	194	201	106	127	97
Tons/acre	79	88	98	77	91	90	88	88	81	84

The 2013 Hofmann Forest Sale Announcement Triggers the Issue

The plans to sell the Hofmann Forest apparently started in 2008, when the original Forestry Foundation was merged with a newly created Natural Resources Foundation (NRF), even though the NRF charter recognized the historical significance and importance of the Forest. Over the next several years the foresters, locals, and conservation group members of the NRF Board were replaced by executives in the wood products and pulp and paper industries. The Board members had official authority to make decisions about financial assets. Under the rules of NCSU Foundation ownership, other public and citizen stakeholders do not have a direct say in such decisions, and thus lacked agenda status during decision making. The Natural Resources Foundation voted at its January 19, 2013 board meeting to invite proposals to purchase the Hofmann Forest. In an announcement released on January 23, 2013, the university focused on potential revenues expected from selling the Hofmann, stating in part that (Watzin 2013):

> I write to let you know that the Natural Resources Foundation Board of Directors has unanimously recommended the sale of the Hofmann Forest in its entirety, assuming price and other considerations can be met, for the specific support of the mission of the College of Natural Resources.
>
> I also want to reassure you that any sale of the Hofmann will be consistent with the values of the College [of Natural Resources], which include retaining the name in recognition of the legacy of the Forest to the College. The goal is to sell the property as a working forest. The College hopes to retain access to the property by faculty and students for teaching and

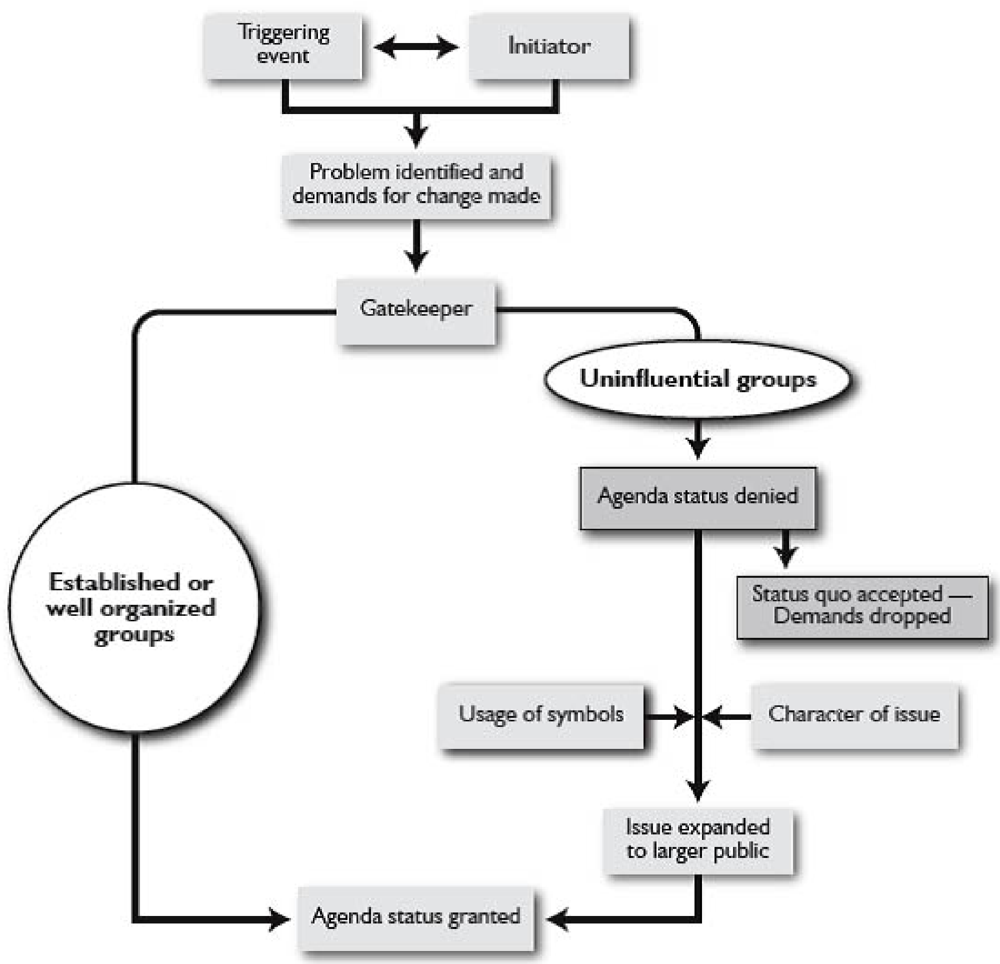

Figure 1—The agenda setting process (Cubbage and others 2017).

> research. My commitment to forestry education, research and outreach as core elements of the programming of the CNR is strong…
>
> The College is currently experiencing significant growth and has strong ambitions. Keeping current programs strong and leveraging new opportunities for the College will only be possible with additional cash flow. A more diversified portfolio of investment could provide a higher and more consistent level of support to the College…
>
> Currently, the primary role of the Hofmann Forest is as an investment, with earnings supporting scholarships and the academic and research programs of the College. It is managed by the Natural Resources Foundation as a commercial forest. Although the Foundation staff has done an outstanding job of managing the Hofmann Forest over the last decade, we are at a competitive disadvantage compared to large commercial operations, which have greater resources to manage in the face of a changing business climate…
>
> The current rate of return from the Hofmann is less than what might be achieved from a diversified investment portfolio.

With the vote to make the sale and its public announcement in on January 23, 2013, the established interests and sale advocates of the NRF Board, the Dean of the College of Natural Resources, and the NCSU Chancellor extended the sale from their private agenda to the broader and more perilous public agenda. The sale decision was made in closed meetings of the NRF Board and the NCSU Endowment Fund Board. These Boards have successfully claimed that as a private 501(c)(3) foundation, their records were exempt from public records requests, as were any of the records of the Dean or Chancellor related to Foundation business. Consequently, opponents had neither access to the process nor records of it, and were forced to try to halt the sale through broader issue expansion strategies.

Subsequent information that was released, however, did indicate that the Natural Resource Foundation actually began seeking buyers for the Hofmann Forest much before there was a public announcement in January 2013. In fact, on October 19, 2012, the Natural Resources Foundation voted to explore and seek if any buyers had a "real and specific interest" in purchasing the forest. Those expressing interest were asked to sign a confidentiality agreement. They were then provided with detailed information about the forest and asked to submit an initial proposal by January 7, 2013. More than 27 expressions of interest were received. So the proposed Hofmann Forest sale began considerably before it was publicly announced, placing opponents at a disadvantage.

The initial and enduring reactions to the public sale announcement by most public, alumni, and faculty were almost completely negative. In the same web site announcing the sale, all the alumni, public, and faculty bloggers expressed opposition to the sale, such as comments excerpted below:

> "The College of Natural Resources is proposing the sale of Hofmann Forest. Does anyone else find this as paradoxical as I do? … I strongly suggest that 80,000 acres of unfragmented woodlands is an irreplaceable NATURAL RESOURCE that should be held for future generations and not sold to the highest bidder. The idea itself is very troubling and in direct conflict with regard to the name of the department proposing the sale. The action being considered is shortsighted, irresponsible and reckless. Once the ink dries and the deal is done, the transaction can never be undone. Despite all assurances, promises and handshakes the land will inevitably be one day dotted with trailer parks, Burger Kings and Dollar Generals. Perhaps the College of Natural Resources should look into offering a course on how to best name a subdivision." (Morton 2013).
>
> "Talk about not seeing the forest for the profit from the trees. I am so disappointed in this decision. Guess they wont be needing any donations anymore." (Cook 2013).
>
> "The message you are sending is that you would rather have the short-term income and distance yourself from the realities of managing one of the largest privately-owned resources in the state than stay committed to teaching that sustainable natural resource management is a viable means for income." (Rudd 2013).
>
> "I can't believe this….. how could the board of trustees sell a donated forest to cover their own agenda in making some new department. Don't sell it!!! Like Mark stated, this really is one of the last

true Natural Resources and this should be treasured, not sold. NCSU, I'm sad to see you spiraling down in both influence and prestige with these sorts of decisions. JUST SO EVERYONE KNOWS< THE ENTIRE FACULTY AND STUDENT BODY IN THE DEPARTMENT OF CNR SAID DON'T SELL IT!" (Anonymous 2013).

> "It is clear the College has strong monetary ambitions; tragic that it has no long term academic or stewardship ambitions… Our stature is integrally linked to the Hofmann. The Hofmann Forest has provided 79 years of teaching, research, and service to students in forestry and natural resources. It is the envy of the rest of the world, as largest living working forest laboratory in existence… Per the Land Ethic of Aldo Leopold (1948), 'A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise.' The sale of the Hofmann would be tragically, monumentally, permanently wrong, violating all the principles and ethics that we espouse as a profession, college, and university." (Cubbage 2013a).

> "I am truly disgusted with the idea and possible impending sale of the Hofmann Forest. By ridding the College of this property you are depriving future students an IRREPLACEABLE opportunity to learn and experience true forestry on such a grand scale. The only beneficiary here is someone's bank account. Dean Watzin, do your students one better, show them how properly managed forests can be steadfast in times of economic uncertainty, rather than dreaming of the shear number of zero's on the winning bidder's check." (Hull 2013).

Internal and External Efforts Expand the Issue

The sale announcement initially left opposing faculty, students, locals, and conservationists in disarray for some time. They tried to appeal to the Dean, to Natural Resource Foundation, and to the Chancellor. The Dean met with faculty and students upon request, but proved resolute in prosecuting the sale, and requests for further meetings eventually petered out. A few faculty in the Department of Forestry and Environmental Resources jointly wrote "reply all" email letters to the Dean in response to periodic College communications about the sale; and specific memos to the Chancellor and the Board of Trustees about the error of making such a sale, with "reply all" copies to the College list serve and NRF Board members as well. In response to the sale opponents, the Department Head of the Forest Biomaterials Department wrote "reply all" comments advocating for the sale.

Further reflecting splits in the College, the Department of Forestry and Environmental Resources faculty voted to oppose the Hofmann Sale, and the Forest Biomaterial Department voted in favor of selling the Forest—perhaps since they never used the Forest, and could receive some proceeds from its sale to build a long-desired new building. Fred Cubbage proposed a resolution via his Senator to the North Carolina State University Faculty Senate to oppose the sale. Cubbage presented the case to the Senate Resources Committee, and attended two Senate meetings to support the resolution. The Provost, the Dean, and the former Senate president spoke against the sale at the meetings. The current Senate president did not let Cubbage speak at the meetings; the Chancellor attended the meeting with the final vote and then left. Discussion by senators was limited, and it did not pass. Cubbage and Joe Roise also wrote and hand delivered letters opposing the sale for all the members of the Board of Trustees and the Natural Resource Foundation Board before two periodic meetings, but they did not receive any responses.

After all the internal appeals to stop the sale failed, the opponents eventually moved to promote external issue expansion both through advocacy campaigns (e.g., symbolic communication) and litigation. The advocacy efforts portrayed the sale as a mistake and highlighted the sale as a shift from investing in education on the forest to investing in Wall Street. Advocacy efforts featured the value of education and research as the mission of the Hofmann Forest and rebutted claims that undergraduate students would benefit most—since they received less than 10% of the net proceeds in scholarships from the Hofmann. They also stressed that the Hofmann was an educational asset, not a financial one (Cubbage 2013a, b), and its immense, irreplaceable conservation value as such a large unbroken natural tract as the Hofmann (Sutherland 2014). External critics of the sale wrote opposing comments on newspaper blogs and letters to the editor opposing the sale. Eventually, a group of core university student leaders, outside conservationists, and a few faculty coalesced to find coordinated ways to oppose the sale, and get the decision to sell the Hofmann Forest reconsidered. In response to the emerging opposition, Chancellor Randy Woodson and Dean Mary Watzin wrote an extensive Raleigh News and Observer (N&O) letter to the editor supporting the sale, stating that their "… obligation to students came first." (Woodson and Watson 2013). Cubbage (2013b) rebutted their arguments in a reply, and stated that NCSU's obligation to students was to teach what we believe and practice what we teach.

Ron Sutherland at the Wildlands Network spearheaded a public relations campaign that included getting support and letters from more than dozen environmental groups to oppose the sale, including the Sierra Club, Izaak Walton League, North Carolina Coastal Federation, Center for Biological Diversity, and Dogwood Alliance, as well as thousands of their members. Initially it was difficult to get the environmental groups engaged in the campaign, because a majority of the Hofmann Forest was already under intensive pine plantation management, and not seen as very pristine. But eventually more and more organizations and individuals realized the conservation value of maintaining this huge tract of uninhabited land for wildlife, and for maintaining the excellent water quality in the three rivers that flowed from Hofmann's expansive acreage.

Seven public protests and rallies were held at NCSU and on the Coast, including one simultaneous event at NCSU and Deppe Park (part of Hofmann Forest) that drew about 100 participants at each location. Also, hundreds of iconic dark green SaveHofmannForest.org (2016) yard signs were placed throughout the state and on most main streets entering the NCSU campus, earning the campaign much-needed public awareness. The Web site itself served as a low-tech location to put position statements and as a reference place for much of the media that was published about the sale. Sutherland developed a high-tech interactive map of the Hofmann Forest that served as a handy public interface for the benefits of the forest (Wildlands Network 2016), as did a Facebook (2016) site. Each of several sale announcements, public protests, and eventual court case hearings generated newspaper and local TV coverage in Raleigh and in Jacksonville near the Forest, which was posted periodically.

In March 2013, Walker Farms, an agribusiness firm based in Illinois, offered $150 million to purchase the forest. Public opposition to the sale was heightened when the firm's secret business plan to convert at least 45,000 acres the forest's 55,000 acres of planted trees and some natural swampland to row crops, commercial development, and subdivisions was leaked to the public (Price 2014). This proposed purchaser and massive development contravened the initial CNR pledge to keep the Hofmann Forest as a working forest, and provoked even broader public opposition to the sale. In fact, the sale contract required only that the remnants of the Forest would bear the name Hofmann Forest and that a plaque honoring an original Hofmann forest manager, Wally Wicks, would be left somewhere on the Forest. Development was not proscribed, and indeed eventually promoted by the new buyer, with assistance from previous plans prepared by the Natural Resource Foundation (Price 2014). Figure 2 shows a snippet of the development plans contained in the business plan—indicating both that most of the Hofmann Forest would be converted to other uses, and that this conversion could earn up to $400 million for the buyers over the next decade, in comparison to their $150 million purchase price (Hofmann LLC 2013).

Public Relations and Advocacy Efforts

The implicit strategy of the sale proponents was to make the sale quietly after meetings and decisions in the closed Natural Resource Foundation meetings, with the subsequent approval of the Endowment Fund of the of the Board of Trustees of North Carolina State University, which included the Chancellor and the Vice Chancellor for Finance of NC State University. One could characterize this approach as a decide-announce-defend (DAD) policy process (Hendry 2004), where an agency makes a decision without public input, and then defends it from opposition so it can be executed. The NRF contended that it is a private organization that does not need comply with laws governing State organizations or open records, and the university supported that stance through its legal office and pursuit of the sale. The NRF on the other hand, and its predecessor the Forestry Foundation, also have successfully claimed that they were State land when it came to paying property taxes, so they would be tax exempt in Jones and Onslow counties (Edmisten 1980).

As one response to the lack of success on getting on the NC State University agenda, about two dozen key environmental, local community, student, faculty, and alumni leaders stayed active for about two years promoting issue expansion to try to reverse the decision. The North Carolina Society of American Foresters voted to oppose the sale, and the Association of Consulting Foresters contributed funds to the environmental lawsuit opposing the sale, as did more than 100 individuals. Issue expansion ultimately created a context so broad that that foresters and environmental activist groups such as Dogwood Alliance and Center for Biological Diversity also cooperated and helped by sending out action alerts to their members in order to protect a planted forest area, for perhaps the first time ever. These alerts led to more than 4000 email and letter requests to Roy Cooper, the Attorney General of North Carolina, and to Dean Mary Watzin, asking them to stop the sale of the Hofmann Forest.

Social media efforts included more than 10,000 signatures on online petitions opposing the sale (I-Petition 2016: 2,214 individuals at http://www.ipetitions.com/petition/cnr-alumni-against-the-sale-of-the-hofmann-forest/); Facebook 2016: 4,980 at https://www.facebook.com/SaveHofmannForest; and 11,877 signatures at MoveOn (2016); (http://petitions.moveon.org/sign/save-hofmann-forest-from). These petitions were ultimately delivered to the NCSU's Chancellor during the largest protest that

COMMERCIAL DEVELOPMENT

There are approximately 10,000 acres that are readily available for commercial development. Jacksonville, NC is one of the fastest growing cities in the United States. The military base is expanding and the need for housing and other essentials will drive demand. The approximately 10,000 acres of land could be converted from timberland and have a potential value of $10,000.00 per acre.

80,000 Acres - Hofmann Forest

PROJECTED IRRIGATED FARM INCOME

Projected Irrigated Figures		Year 1	Year 3	Year 5	Year 7	Year 10
Total Tillable Acres		1,450	20,000	35,000	40,000	45,000
Corn Base Acres	60%	870.0	12,000.0	21,000.0	- 24,000.0	- 27,000.0
Bean Base Acres	25%	362.50	5,000.00	8,750.00	- 10,000.00	- 11,250.00
Wheat Base Acres	15%	217.50	3,000.00	5,250.00	- 6,000.00	- 6,750.00
Corn Average Price Per Bushel		$4.50	$ 4.50	$ 4.50	$ 4.50	$ 4.50
Beans Average Price Per Bushel		$13.60	$ 13.60	$ 13.60	$ 13.60	$ 13.60
Wheat Average Price Per Bushel		$6.25	$ 6.25	$ 6.25	$ 6.25	$ 6.25
		Irrigated Acres				
Average Bushel Per Acre Corn		220	220	220	220	220
Average Bushels Per Acre Beans		70	70	70	70	70
Average Bushels Per Acre Wheat		75	75	75	75	75
Gross Fam Income		$ 1,308,353.13	$ 18,046,250.00	$ 31,580,937.50	$ 36,092,500.00	$ 40,604,062.50
Less Operating Expenses		$ 628,009.50	$ 9,023,125.00	$ 16,737,896.88	$ 19,850,875.00	$ 23,550,356.25
Net Farm Income Before Taxes		$ 680,343.63	$ 9,023,125.00	$ 14,843,040.63	$ 16,241,625.00	$ 17,053,706.25
Farmland Asset Value	$ 6,500	$ 9,425,000.00	$ 130,000,000.00	$ 227,500,000.00	$ 260,000,000.00	$ 292,500,000.00

Note: %

Does not take into consideration commodity price fluctuations.

Does not take into consideration cost of land conversion

Farm Operating Expense Ratio 48% increases to 58%

Figure 2—Excerpt of development plans for the Hofmann Forest made by the Hofmann Forest LLC (2013) proposal.

included students, activists, and professors who marched in to the Chancellor's outer office chanting "No sale, no way, the Hofmann Forest has got to stay."

Dozens of newspaper articles were published about the sale; at least a dozen were editorials opposing it. Google hits on the words "Hofmann Forest" increased from about 13 in 2012 to 574,000 in 2015, and very few contained perspectives supporting the sale. In fact, of all the comments on the web petitions and on the newspaper articles and blogs, only one individual—a former CNR dean—consistently supported the sale of Hofmann Forest, and no more than a dozen or less commenters out of thousands on the petitions or on line supported the sale at all. Ron Sutherland and Fred Cubbage wrote and published many editorials and dozens of newspaper blog comments opposing the sale as well in many on line articles.

In addition, there were many persons among the leaders of North Carolina and at NC State University retired faculty that opposed the sale in principle and stated to the Dean and Chancellor that the sale was harming NC State's reputation. The sale opponents were contacted by some of these policy elites, both first hand, or second hand, and many carried the message of "there has to be a better way" to the Chancellor and the Dean. These elites also were buttressed by many donors withdrawing or refusing to make gifts to the College of Natural Resources and even the College of Agriculture and Life Sciences, or by only making gifts that were very narrowly restricted in order to prevent them from being liquidated or repurposed to other uses. Sale critics were reminded to write to the Alumni Foundation to advocate halting the sale, and indeed many did so on their own volition.

NORTH CAROLINA ENVIROMENTAL POLICY ACT (SEPA) COURT CHALLENGE

While public relations and media efforts to stop the sale generated widespread public support and opposition to the sale, the proponents of the sale largely stonewalled any faculty opposition, newspaper editorials, or written and internet petitions. It was clear that public opinion alone was not apt to reverse the decision to sell the Hofmann. Thus in another strategy to get on somebody's agenda in order to stop the sale, some opponents filed an environmental lawsuit. This included Fred Cubbage as the lead plaintiff, along Ron Sutherland and three other colleagues—another former professor, the former President of the Forestry Foundation Board, and a local Jones County property owner. The suit charged that the sale violated the North Carolina State Environmental Policy Act (SEPA). This lawsuit claimed that the Hofmann Forest was State land, since it had never paid income or property taxes and was part of an NCSU Foundation. The lawsuit contended that according to SEPA, NCSU must perform an environmental assessment before making a sale (Wake County Superior Court 2013). The litigation helped issue expansion by keeping the sale in the newspapers after each of three judicial hearings, and by lending legal credibility to the opposition's case.

In order to pursue a legal course of action, the opponents needed to find a lawyer who supported the principles of opposing the sale of the Hofmann Forest, and believed that there was a strong legal basis that could be won with a court case. Several attorneys that were consulted agreed that the sale of the Hofmann was unwise in principle, and either said they could not take the case because it was outside of their area, or referred the opponents to other lawyers. Two environmental law attorneys were specifically consulted regarding the merits of legal action. While attorneys are reputed to seek cases indiscriminately, they are mandated by the bar association not to take cases that they feel lack merit, and few would want to waste time on indigent or pro bono cases. Both attorneys felt there was sound legal basis for action, and one was available and very positive about the merits of the case as a violation of SEPA. In a conscious, but costly, decision to demonstrate that he did practice what he taught and wrote about conservation and the value of teaching on the Hofmann, the lead author here signed a contract to retain a lawyer and guarantee payment of all the plaintiff's legal costs. Much of the costs were eventually supported through appeals to colleagues, locals, foresters, and environmental groups. The plaintiffs hired one environmental lawyer, who had one part-time assistant. Without subsequent issue expansion attracting additional funds, the plaintiffs would have faced impossibly high costs—about $55,000 in total—and been forced to stop litigation.

The NCSU Endowment Fund as defendants were represented by several lead attorneys from the State Attorney General staff, who argued that the Hofmann Forest was not State land; two from a private law firm representing the NCSU Natural Resources Foundation, and three lawyers from the NCSU legal counsel's office attended the three court hearings. In Fiscal Year 2014, the NC State Natural Resources Foundation (2015) tax return reported about $252,000 on program service legal expenses, versus $2500 in Fiscal Year 2010 (NC State Natural Resource Foundation 2011) before the sale and court case began. As is typically the case when a government entity is the defendant (e.g., lawsuits related to the Endangered Species Act) the State and NCSU legal costs were supported by taxpayers, those of the State of North Carolina in this case. In fact, the university and NRF respondents in the case seemed much more willing to spend time and money on legal costs, perhaps on the presumption that they could bankrupt or at least vastly outspend the contributions from opponents. The private NRF lawyer even charged the attorney for the plaintiffs with a "Rule 11" ethics violation, which while it was handily dismissed—after considerable time and effort by the plaintiff's attorney—probably cost more than $10,000 in added legal fees for the plaintiffs.

The SEPA lawsuit sought equity relief through temporary and permanent injunctions to stop the sale, but they were denied at each of two initial hearings (Wake County Superior Court 2013). The NCSU cadre of attorneys contended that the university's foundations were private organizations and therefore not subject to SEPA, and that the plaintiffs lacked standing to bring the lawsuit. If they lost the case and still wanted to move ahead with a sale, the defendants—the NRF Board and University Endowment Fund—would be required to perform a state environmental assessment (EA) and an EIS if required by the EA.

Temporary Restraining Order and Temporary Injunction Trials

The first petition for a Temporary Restraining Order (TRO) to stop the sale was held in Wake County Superior Court on September, 25, 2013, and heard by Judge Paul Gessner. The plaintiffs argued that SEPA required the respondents to perform an environmental assessment and requested a TRO stop an imminent sale. The respondents claimed that the plaintiffs had no standing to sue; that the Endowment Fund of the Board of Trustees of North Carolina State University was a not a State entity; that SEPA did not apply even if they were a State organization; and that there was no imminent sale. Judge Gessner denied the plaintiffs request for a TRO. He stated that he was sympathetic with the complaint, and that the litigants should go read the Lorax, but did not believe that there was evidence that there was an "imminent" sale, such as bulldozers at the gate, which must be the basis for a TRO.

Within four weeks of the defendants disavowing an imminent sale at the TRO court hearing, NC State University announced that it had signed a contract with a buyer—the agribusiness firm of Walker Farms from Illinois. Subsequent information revealed that Walker Farms owned more than 70,000 acres of farms scattered across the Midwest and South, and was one of the largest recipients of U.S. farm subsidy payments in the country. Based on this new development, the plaintiffs filed a second request in Wake County Superior Court, only for a Temporary Injunction against the sale, which was heard by Judge Shannon Joseph. Judge Joseph was busy, with 21 cases on the docket for the day of the trial in November, and she considered the complex Hofmann case as her third case, which lasted about 2½ hours, much to her chagrin.

The plaintiffs again argued that SEPA should apply for the sale and that an environmental assessment was required to assess potential damage that could be caused by the sale, especially to agribusiness firm that probably would focus on farming and possible conversion to crops. The respondents stated that there was no evidence that major environmental impacts would occur due to the sale. They again said the plaintiffs had no standing to bring the suit; that the Hofmann Forest was not State land; and that even if so, SEPA did not apply in this situation, since the NRF and Endowment Fund were just selling the land and had no responsibility for what happened after the sale. Furthermore, the NRF attorney requested that if the Temporary Injunction were granted, the plaintiffs must post a $150 million bond because they were interfering with a business deal of that amount—a tactic similar to a Strategic Lawsuit against Public Participation (SLAPP), which is sometimes used to kill an environmental lawsuit by bankrupting and intimidating the plaintiffs (Cubbage and others 2017).

State Lands, SEPA, and Standing to Sue

Judge Joseph acknowledged that she was not familiar with SEPA. During the trial, the judge seemed sympathetic to the claim that the plaintiffs would have standing to bring suit, and entertained the premise that the Hofmann was State land. This was at least in part based on a letter from Rufus Edmisten, Attorney General of the State of North Carolina on July 17, 1980 to the attorney for the Jones County Tax Assessor, which said:

> "We are in receipt of a 'auditor's verification request' concerning the above [$51,002.78 Tax Statement to the Board of Trustees of the Endowment Fund, NCSU]. Please be advised that is our position that none of the Amount shown in the statement is due from the Board of Trustees, North Carolina State University or the State to Jones County, since it property owned by the State of North Carolina. Article V, §2 of the Constitution exempts all State property from taxation."
>
> As the Supreme Court observed in the case of "In the Matter of the Appeal of the University of North Carolina" on July 15, 1980, "State owned property is exempt from ad valorem taxation solely by reason of State ownership, regardless of the property's use."

The plaintiffs also provided case law of many federal NEPA lawsuits that did find that public land sales require an EIS, ranging from National Forest land in West to a post office in Pennsylvania. There were no State cases found allowing or denying EIS for the sale of land. The needs for an EIS rest on what is an environmental impact. It is a question of size and scale. Building a house is not large enough to require an EA; nor are small land deals. However, building a subdivision or bridge with federal funds does, and may lead to an EIS or finding of no significant impact (FONSI). Land conversion almost as big as Raleigh surely would require an EA at least, and probably an EIS.

The plaintiffs argued that the UNC system universities all had policies in place for responding to the requirements for SEPA compliance. These policies mostly consisted of a list of activities that would be deemed exempt from EIS preparation—sale of university-owned land was certainly not one of the listed exemptions under NCSU's policy. Thus NCSU would not be exempt from SEPA; the Hofmann sale was monumental in its potential for environmental impact, so SEPA must apply. The State Attorney General lawyers (ironically) argued the Hofmann was not State land; that the university buys, sells, and trades assets, including land, all the time without constraints, and was exempt in its Endowment Fund; and that SEPA did not apply. Furthermore, their sale of the Hofmann would only create prospective actions by future owners, which were not their responsibility, so they were not subject to SEPA.

It is worth noting, however, that in trying to sell the Hofmann, the university/NRF also was reported by the North Carolina Coastal Federation (2013) and then investigated by the Corps of Engineers and EPA for violating Section 404 wetlands dredge and fill permit requirements in its existing management. In 2014, the Corps officially concluded that the Hofmann wetlands management did not meet federal criteria for a Section 404 exemption, and forwarded that information to the U.S. Environmental Protection Agency Region 4 office in Atlanta (Rich 2014). This problem would probably not have come to light without the added scrutiny that the proposed sale generated. After hundreds of thousands of dollars more in consulting fees to determine wetlands status on the Hofmann, the NRF/university did reach a settlement agreement with the Corps of Engineers and EPA, and did have to pay a fine and restore about 100 acres of planted forest back to their original wetlands condition.

These wetlands permit violation issues also probably impeded a rapid sale of the Hofmann to anyone for perhaps a year also, and discouraged the farm business bidder from pursuing a purchase fraught with regulatory trouble, as well with the potential to affect their farm payments on other lands that they owned through the cross-compliance strictures of the Farm Bill. These Farm Bill strictures state that any violations of converting wetlands to dry lands (swampbusting) without an approved farm plan would lead to the loss of all USDA farm payments for all conservation and crop lands on all lands owned by the farmer or farm business. The Walker Farms were among the leading farm payment recipients in the country.

In classic case law regarding standing to sue, the U.S. Supreme Court stated that "the irreducible constitutional minimum of standing contains three elements: (1) an injury-in-fact that is (a) concrete and particularized and (b) actual and imminent, (2) causation, and (3) redressability" (Lujan v. Defenders of Wildlife; 504 U.S. 555, 560 [1992]). So to have federal or State standing, plaintiffs must show tangible, individual harm; show that harm is imminent; and show that legal action can improve the problem. The plaintiffs argued for standing as professors, alumni, conservationists, local residents, and a former Forestry/NRF Board president. The State Attorney General lawyer cited a Smithfield (hog) Farm case, which the court ruled for a narrow construction to prevent environmentalists from having standing. The plaintiffs responded that Smithfield did not apply, because the previous plaintiffs brought suit on general and recreation values. The plaintiffs argued that for the Hofmann, they had specific, tangible, educational, business, and downstream property. Their attorney argued that if they did not have standing, no one in North Carolina would, and the SEPA law would be useless. Judge Joseph seemed somewhat convinced by this, and asked the State Attorney General to rebut the claim, which they could not.

Nonetheless, Judge Joseph also ruled against the plaintiffs and dismissed the lawsuit entirely. The written basis for dismissal was not entirely clear, but in her comments, the judge indicated that the plaintiffs apparently had not proven that the sale of Hofmann Forest would cause irrevocable damage—a criterion often used in some legal decisions. The plaintiffs unsuccessfully argued that the purpose of SEPA was to <u>assess</u> if there would be <u>any</u> damage from a potential action, not prove a priori that there would be <u>irrevocable damage</u>. Since the State attorneys largely dismissed any potential damage from a sale, the adverse impacts argument was not compelling. However, on the very next day, the plaintiffs received a leaked copy of the massive Walker Farm / Hofmann LLC proposals to convert virtually all the planted forest land and more into commercial developments and crops, which clearly would cause massive adverse environmental impacts on the Pocosin wetland and three rivers than ran off the Hofmann, which was the fount of their watersheds.

State Supreme Court

The potential huge impacts of the conversion of the Hofmann to crops, subdivisions, and commercial development on an area about half the size of Raleigh provided a further basis for an appeal to the North Carolina Appellate Court, and the plaintiffs filed such a suit quickly. In a huge surprise, the North Carolina Supreme Court unilaterally reached down and took the case out of the Appellate Court hands, and heard it in a hearing in December 2013. That case limited the attorneys for both sides to 30 minutes of oral arguments, in addition to the more than 500 pages of material presented in District Courts and the transcripts of those trials. The arguments were similar, but the attorney for the plaintiffs added the argument that the State would be better served by performing a 30 page Environmental Assessment than spending large sums in court, with hundreds of pages of testimony, unless they realized that the EA would reveal problems with the sale. The respondents (the State Attorney General lawyers) spent most of the time arguing—with limited success when faced with sharp questions from the bench—that the Hofmann Forest had special non-State status since the deed had a reversionary clause from the Endowment Fund of the Board of Trustees of North Carolina State University to the NRF, which prevented it from being sold without NRF permission (who were the ones who actually initiated the sale).

Soon after the Supreme Court hearing, the proposed sale to Walker Farms and a new purchase partner, a Timber Investment Management Organization (TIMO), fell through. Based on the sale cancellation, the Supreme Court essentially ruled the case moot, and made no decision. This lack of a decision in the end, after hundreds of thousands of dollars in legal expenses, did not support the position of the opponents or the proponents of the sale. Thus if another sale were proposed, opponents could return to court. And the case regarding standing to sue, the Hofmann as State Property, and even SEPA was at least strengthened by having enough merit to be heard by the Supreme Court, which only accepts the most serious and substantive cases in the State.

In addition, the EA would have actually been far shorter, taken less time, been less expensive than their huge legal costs, and indeed be a document that students in the College of Natural Resources are taught to prepare in their natural resource professions. This presumes, however, that the EA would justify such a sale, which opponents indeed did not believe would be the case. Of course, before issue expansion occurred, the perceived options for NCSU were either a quick sale or a lengthier EA/EIS process that could highlight potential environmental problems linked to the sale. The ultimate choice between the EA/EIS process or lengthy and expensive litigation only emerged after issue expansion and agenda status being afforded to the stakeholders opposing the sale.

AGENDA SETTING PROCESS APPLICATION

This issue tracked the Cobb and Elder issue expansion process well. Opponents of the sale were initially ignored, but the issue gained widespread state and even national media attention, largely through the SEPA lawsuit and editorials opposing its wisdom in the Raleigh, Charlotte, and Jacksonville newspapers. A public television special on "North Carolina Now" focused on rare and valuable coastal swamp pocosins (which means "swamp on a hill"), and highlighted the Hofmann Forest as a key piece of this ecosystem. Behind the scenes letters and informal personal contacts with the NCSU Chancellor were made by important North Carolina business executives, NCSU alumni, farm sector representatives, and emeritus professor elites, who reasoned with the Chancellor and CNR Dean that the sale was hurting NCSU's image and fund raising efforts.

The combination of a legal, media, and behind the scenes elite discussions was crucial in keeping this issue on the NCSU and NR Foundation agendas. Opponents were never asked to meet with the decision makers after the issue went to court, but its high visibility apparently affected the sale outcome. Other contributing factors that helped cancel the outright sale to Walker Farms probably included the rapid drop in corn prices, which damaged optimistic crop return scenarios presented in the prospectus. In addition, the shear ambition of Walker's $150 million proposal would then require controversial and massive Section 404 dredge and fill permits for up to 50,000 acres of planted forests. Getting these wetlands clearing permits from the Corps of Engineers and EPA was highly unlikely, and may have further contributed to Walker being unable to secure the financing needed to execute the signed sale agreement.

After the public and media pressure in 2013 and 2014, in March 2015, the Natural Resource Foundation and Endowment Fund and NC State University withdrew the sale. The withdrawal became public in a newspaper announcement, and stakeholders were not consulted. The NR Foundation and College of Natural Resource decision makers committed to managing the forest for research and education purposes and monetizing some parts of the forest, with the help of the Conservation Fund, a group that NCSU contracted with to help the university achieve this compromise solution. In addition, the Dean and Associate Research Dean held several open College of Natural Resources (2016) meetings about the Hofmann, and facilitated a research data collection and mapping effort for the Forest (see go.ncsu.edu/hofmannwebgis). Several NCSU classes continue to use the Hofmann for field visits, and it is a case study focus in the senior natural resource management capstone class. However, for about a year from Fall of 2015 to Fall of 2016, new research projects, large class visits, or local tours on the Hofmann were not allowed by the NRF while it tried to settle on new ownership and monetization strategies, as well develop a new watershed management and regeneration approach to meet the EPA wetland protection mandates.

After a year of efforts, the Conservation Fund did not obtain any permanent solutions, so the College of Natural Resource and the NRF hired their own "Forest Asset Manager" to help monetize the Hofmann. Then in July, 2016, the Dean announced that the NRF had sold a 50-year timber deed to Resource Management Service (RMS), the timber investment management organization (TIMO) that had eventually partnered with Walker Farms, for $78 million. The press release stated that this would provide strong protections for the Hofmann Forest planted forests (Hartman 2016), as well allow for monetization of the agriculture lands and wetland banks on the Hofmann, and offer some prospect of development of land for solar energy.

The final disposition of all the Hofmann Forest lands is not certain, but it appears that the timber deed will help lock in most traditional and forest land uses for its duration of 50 years. There is an escape clause that will allow the NRF/NCSU to buy back up to 8,550 acres of the timber deed at a 25% premium, in case they want to convert it themselves to some more profitable use. On the other hand, the actual owner and their intentions are still a secret—TIMOs just purchase and manage land in a LLC, but don't own it. The university also lost large amounts of good will and up to $800,000 of legal and wetland consultant expenses to try to make the sale, as well as large amounts of foregone alumni and donor good will and contributions. And the Hofmann is less of a shining example of university forest management and education, and instead mostly the financial asset the administration wanted. There have been some attempts by faculty to have projects on the Hofmann, and classes are visiting the Forest again each year. RMS has pledged to allow research and educational visits, but have only one staff person on the Forest instead of five that the NRF had, so will have limited ability for frequent visits. In addition, NCSU teaching and research access is not apt to include full access to management costs and returns from the Hofmann, which has been valuable until 2016. We hope to be able to visit the Hofmann often, but it will be more like visiting a museum than taking pride in the fruits of our own stewardship.

This case not only highlights the process of issue expansion and agenda setting, it also demonstrates the tactics of media use, need for sustained involvement by many diverse interest groups, costs of litigation, agency determination despite opposition, and how university foundations and nonprofit organizations can avoid public scrutiny and perhaps public laws even at State universities for their board appointments, finances, and minutes. NC State University tried to sell the Hofmann Forest quietly in behind the scenes agreements, and limit issue expansion; while opponents tried to expand the issue and attract more opposition. Issue expansion and litigation was possible in this case because ownership was a contested hybrid of private and public ownership and left the door open for oversight under the State Environmental Policy Act (SEPA). SEPA has since been rendered almost toothless by amendments of the North Carolina legislature in 2015, so would not provide as strong a case in the future to oppose a sale. The opponents of the sale needed to employ several strategies to be heard at all—internal and external advocacy, media, direct action protests, the courts, and appeals to elites to intervene on their behalf. NCSU, the NRF, and their administrators made decisions in closed executive sessions, claiming exemption from all public governance laws, never engaged in sincere dialogue with the opponents, and prosecuted their court defense aggressively with considerable no-cost State efforts and at a large NRF expense for their private lawyers. At NCSU, we teach that such adversarial actions could be handled better through collaborative procedures. The CNR actions in 2016 to protect much of the Hofmann Forest with a timber deed and engage faculty and students more on the Hofmann are a step in that direction, and more involvement with conservation groups and local citizens could improve this start.

CONCLUSION

Overall, this contentious process created plentiful ill will on all sides, and generated perhaps only half the maximum amount of money once hoped for by NC State University by making a quick and unilateral sale by the Natural Resources Foundation, which would lead to massive conversion of the Hofmann Forest and development to non-forest uses. In fact, the debate remains sharp enough that it makes us fearful of writing this summary, but it still bears some level of public knowledge as a case of government development objectives versus environmental nongovernment organization (ENGO) and citizen conservation objectives. We have tried to be even handed here, but surely carry some bias as sale opponents in our recounting here. So we do invite readers to seek other information for corroboration if it can be found. The proposed Hofmann Forest sale is a compelling policy case of public or private forest land management issues. We hope that more public information about the issue can inform discussion and that readers can benefit from hearing about the process and draw their own conclusions about the merits of the approaches used by Hofmann Forest sale proponents and opponents, and strategies and tactics used by both sides. The issue also will bear further monitoring regarding issues such as the expenditures of the interest and principal from the sale proceeds; the access and use of faculty, students, and locals to the forest; and the benefits that accrue to local citizens as well as university administrators from the sale. We all will watch these developments with keen interest.

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WILDFIRE TERRORISM RISK ASSESSMENT AND MANAGEMENT: A PILOT STUDY

Jason S. Gordon, Robert K. Grala, Eghbal Rashidi, Hugh R. Medal, Will Leonard, Maxwell Moseley, and Kelsey Seiter[1]

This presentation focuses on pyro-terrorism, defined as the utilization of large-scale fires to attack, intimidate, or coerce a government or civilian population to advance political, social, or religious objectives of a non-State organization. Pyro-terrorism events have been documented in Israel, France, Spain, Greece, and the United States, while a recent Al-Qaeda-affiliated magazine extolled the benefits of pyro-terrorism. This research conducted a two-part pilot risk assessment consisting of a consequence assessment and a likelihood assessment. The assessments involved: (1) a mixed-integer model of the consequences of wildfires with multiple-ignition sites (which is a likely case for pyro-terrorism), and (2) content analysis of Internet-based pyro-terrorism-related data. Although there is little quantitative data on pyro-terrorism, study results nevertheless suggested it to be a significant threat worthy of increased attention. The likelihood assessment reflected strong support systems among terrorists as well as the destructiveness and feasibility of pyro-terrorism. The consequence assessment employed a set of experiments to compare the expected damage caused by a pyro-terror attack with damage caused by a typical wildfire. The model suggested the impact of pyro-terrorism can be at least twice as damaging compared to a typical wildfire. The presentation concludes with several recommendations for national security agencies and future research.

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WILDFIRE RISK ASSESSMENT: EXPERTS' OPINIONS

Robert K. Grala, Hugh R. Medal, Jason S. Gordon, J. Morgan Varner, and Katarzyna Grala[1]

An online survey of 1,637 experts from across the United States was conducted in 2016 to identify a potential role of wildfires in homeland security and best strategies for mitigating such wildfires. Selected individuals were identified based on online directories and included land, fire, and homeland security experts. The online survey questionnaire included questions related to wildfire terrorism, level of wildfire damage, likelihood of wildfire terrorism attacks, preparedness to prevent and mitigate wildfire attacks, and resources needed to prevent and mitigate wildfire attacks. Results will be helpful in identifying potential risks related to wildfires, prioritizing resources needed to prevent and mitigate wildfires as well as developing outreach activities to increase awareness within wildland fire communities of risks associated with intentional wildfires.

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Climate Change and Bioenergy Markets

HYPERCYCLE ECONOMY MODEL OF EXPANDED FOREST AND PULP & PAPER SYSTEM AGAINST ENVIRONMENTAL CHANGE

Zhi-Guang Zhang[1]

A new economic running pattern—hypercycle economy is researched under the background of global climate change, including its basic principles, structure models, operational mechanism, and practical application. First of all, the evolution process of economic running patterns is summarized, which is from "cradle-to-product" in extensive economy, to "cradle-to-grave" in end-treatment economy, and to "cradle-to-cradle" in circular economy. Following the trend of its "green" evolution, a new concept of hypercycle economy is conceived, and its "breeding-to-breeding" structure is described, according to symbiosis theory and hypercycle theory created by Manfred Eigen in the 1970s. Then the thought of hypercycle economy is applied to expanded forest and pulp & paper system (EFPPS). A series of structure models for EFPPS hypercycle economy are established in manner of layer-by-layer expansion in a logical order of core layer of resources chain in pulp & paper subsystem, expanded layer of resources chain in supply chain subsystem, expanded layer of eco-chain in eco-environment subsystem, and expanded layer of value chain in socio-economy subsystem. Thereby, a multinest overall model of EFPPS hypercycle economy is built, and its symbiotic operational mechanism is revealed. Finally, 5R principles, 5R-3C model and its symbiotic operational mechanism for hypercycle economy are founded as theoretical improvement. The study shows that the relationship between industry system and ecosystem can be mutualism in hypercycle economy.

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COMBINING FOREST ECONOMICS AND LIFE CYCLE ASSESSMENT FOR EVALUATING FOREST BIOENERGY: OPPORTUNITIES AND BARRIERS

Caroline Gaudreault, Robert C. Abt, and Reid Miner[1]

Forest biomass from the Southeast United States is expected to play an important role in various renewable energy policies worldwide. In evaluating these kinds of policies, it is important to understand the interaction between policy targets and forest biomass markets, and the effect that this interaction will have on environmental objectives. The consequential approach to life cycle assessment (CLCA) aims at evaluating the environmental consequences of a proposed change in demand for a given product. These consequences can happen within (direct effects) or outside of (indirect effects) the life cycle of the product system under study, meaning that the modeling needs to extend beyond physical relationships typically accounted for in life cycle assessment (LCA) to include market and economic implications of the change analyzed. Early attempts to use CLCA relied on very simple economic models, but the current trend is to integrate the use of sophisticated modeling techniques, for instance partial market or a global general equilibrium models with LCA to estimate indirect effects. This presentation uses the case of the Southern United States region to discuss barriers and opportunities in using economic models with LCA for evaluating the environmental implications of forest bioenergy policies.

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NET CO_2 EMISSIONS EFFECTS OF HOUSING AND BIOENERGY GROWTH SCENARIOS IN THE UNITED STATES

Prakash Nepal, Jeffrey P. Prestemon, David N. Wear, Karen L. Abt, and Robert C. Abt[1]

This study uses a consequential life cycle analysis framework to estimate the change in CO_2 storage and emissions resulting from increased wood use needed to fulfill assumed increased growth in housing and wood energy consumption in the United States. The simulations needed for analyses were achieved with the integrated runs of U.S. Forest Products Module (USFPM/GFPM) and Southern Regional Timber Supply Model (SRTS). A reference scenario is compared with a scenario of high housing growth and high wood energy in terms of carbon storage and emissions in four different carbon pools over 30 years. The projected results are discussed in relation to their implications for use and management of U.S. forest resources to meet the growing demand for traditional forest products, wood energy use, and climate change mitigation.

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UTILIZATION OF LOGGING RESIDUES TO PRODUCE ELECTRICITY BY PRIMARY FOREST PRODUCTS MANUFACTURERS IN THE SOUTHERN UNITED STATES

Raju Pokharel, Robert K. Grala, and Donald L. Grebner[1]

The Kyoto Protocol and Copenhagen Climate Change Conference have set goals for lowering carbon dioxide (CO_2) emissions. Production of woody biomass-based electricity can help lower CO_2 emissions, mitigate climate change impacts, and improve energy security. This study estimated capacity of primary forest products manufacturing facilities (mill) and impacts of mill and procurement related factors on potential utilization of logging residues to produce electricity. A four-contact mail survey was sent to 2,138 processing facilities in 2012. Results indicated that about 70 percent of primary forest products manufacturers utilized woody residues for bioenergy purposes. Pulp paper and paperboard and composite wood products mills were the largest woody residue utilizers. Approximately 11 percent of manufacturers were willing to utilize additional logging residues to produce electricity and, on average, they were willing to pay US$12 per metric ton of logging residues at the gate. Manufacturers reported economically feasible distances for hauling logging residues up to 93 km. Manufacturers with a larger capacity to utilize woody residues were willing to utilize more additional logging residues, pay a higher gate price, and haul logging residues over longer distances. The results will be helpful in formulating future policies related to biomass-based bioenergy production and guiding biomass energy investment decisions.

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DETERMINING IMPACT OF WOOD PELLET PRODUCTION ON WATER AVAILABILITY: A CASE STUDY FROM NORTHEAST OCONEE RIVER BASIN IN GEORGIA

Surendra Shrestha and Puneet Dwivedi[1]

Export of wood pellets from southeastern States is rising. As a result, total acreage of forest lands will most likely increase to meet the growing demand for pulpwood for manufacturing wood pellets. This study explores the impact of demand of wood pellets on potential land use changes and quantifies the impacts of land use changes on the hydrology of a local watershed located in the northeast part of Oconee River Basin in Georgia. Using spatial modeling in ArcGIS, suitable sites for loblolly pine (*Pinus taeda*) plantations were determined. The results of suitability analysis were merged with historical land use change records to determine any potential increases in area under loblolly pine plantation for years 2016, 2021, and 2026. Then, results of land use changes were used as inputs in SWAT model to predict changes in water discharge until 2028 under 10 different land use and climate change scenarios. Our results suggest that changes in land use in conjunction with variable climatic conditions could decrease or increase surface runoff by up to 23 percent and 41 percent and water yield by up to 25 percent and 31 percent, respectively. Results of this study will help in defining economic and environmental performance of wood-based energy products in the overall renewable energy portfolio of the United States.

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EVALUATING REGIONAL IMPACTS OF THE RECENTLY EXPANDED E.U. WOOD PELLET DEMAND

Gregory Latta, Justin S. Baker, and Sara Ohrel[1]

European Union (EU) greenhouse gas (GHG) reduction goals encourage non-fossil energy sources such as biomass and have resulted in a doubling of wood pellets exported from U.S. ports destined for EU power plants over the last 2 years. Depending on how wood pellets are sourced and other production factors, there are potential interactions between increased pellet supply and U.S. forest contributions to domestic GHG reduction goals.

This study uses a spatial model allocating forest biomass from over 150,000 USDA Forest Service Forest Inventory and Analysis (FIA) forest land plots to over 1,500 forest product manufacturing facilities representing 11 intermediate and 13 final solid and pulpwood products. The model determines optimal transportation allocations using fuel costs and locations and is solved annually for the period 2015–2035 with demand shifted by energy prices and macroeconomic indicators from the U.S. EIA's Annual Energy Outlook. We solve the model with and without the recent wood pellet expansion to isolate its impact. Results depicting historic and scenario-specific forest products production are generated. Maps of the spatial allocation of both forest harvesting and related GHG fluxes are presented at the national level, and regional detail is given highlighting changes in the U.S. North, West, and Southeast.

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ECONOMIC ASSESSMENTS OF FARMERS AND LANDOWNERS' WILLINGNESS TO SUPPLY ENERGY CROPS ON MARGINAL LANDS IN THE NORTHEAST OF THE UNITED STATES

Wei Jiang, Michael G. Jacobson, and Katherine Y. Zipp[1]

A major critique of large scale biomass production is competition for land between food and energy crops. A commonly suggested solution is to limit energy crop production to marginal lands. Physical marginality is often used when discussing marginal lands. However, as important is the socioeconomic marginality. This research fills this gap by evaluating farmers and landowners' willingness to supply energy crops on marginal lands. A survey was conducted in the Biomass Crop Assistant Program Area 5 and three energy crops: switchgrass (*Panicum virgatium*), miscanthus (*Micanthus capensis*) and willow (*Salix*) were selected as model crops. A Probit model is applied to evaluate factors influencing decisionmaker's choice on planting energy crops. The initial pre-test results indicate that people are more knowledgeable and willing to plant switchgrass (18 percent) compared with miscanthus (9.5 percent) and willow (9 percent). In addition, land area distribution, age, and bid price are factors that significantly influence people's decision. This socioeconomic analysis is combined with economically marginal land identification using crop growth models and spatial analysis. By combining socioeconomic margin with biophysical margin, we can identify farmers and landowners targeted for energy crops.

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MISSISSIPPI NONINDUSTRIAL PRIVATE FOREST LANDOWNERS' WILLINGNESS TO GROW SHORT ROTATION WOODY CROPS FOR BIOENERGY ENTERPRISES

Anwar Hussain, Ian A. Munn, Stephen C. Grado, Marcus K. Measells, Donald L. Grebner, James E. Henderson, Robert K. Grala, and Randy Rousseau[1]

The long run financial viability of bioenergy enterprises is critically dependent on the smooth supply of woody biomass. This study analyzed factors that influence nonindustrial private forest land owners' willingness to lease their lands for the production of short rotation woody crops (SRWCs) and the share of their land they would divert to them. The data were collected using a contingent valuation survey of a random sample of Mississippi landowners. Econometric results showed that landowner willingness to lease for SRWC production and the fraction of land they would be willing to divert to them were strongly influenced by the lease contract attributes, Mississippi ecoregion, landowners' motives for owning land and landowner characteristics. The mean willingness to accept (WTA) was $69.53 per acre; however, the WTA was differentiated rather than uniform across landowner types, suggesting that bioenergy entrepreneurs may be able to minimize the total cost of compensation. The findings should be helpful to landowners and entrepreneurs interested to engage in bioenergy business enterprises.

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WOOD BIOENERGY AND PRIVATE FORESTS: PERCEPTIONS OF OWNERS IN THE EASTERN UNITED STATES

Donald G. Hodges, Eric C. Larson, James C. Finley, A.E. Luloff, Adam S. Willcox, and Jason S. Gordon[1]

The importance of eastern U.S. private forests can only increase with the continued interest in wood-based energy and the search for nonpetroleum-based alternatives. Part of forecasting the potential of this energy source requires learning more about landowner attitudes toward bioenergy, as well as how landowners might change management strategies in response to bioenergy demands. This paper examines how eastern U.S. private forest landowners view bioenergy and the role of forests in bioenergy development, as well as future forest management plans in light of potential bioenergy production needs. Data for the analysis were obtained through a phone survey of 1,800 private forest owners in States east of or adjacent to the Mississippi River. Landowners were segmented into classes based on ownership motivations and prior management activities. These groups were then used as the basis for assessing differences in attitudes regarding management, bioenergy production, and future forest use activities; and developing some initial conclusions regarding the likelihood of these groups providing wood to meet future energy demands.

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WILLINGNESS TO UTILIZE ADDITIONAL LOGGING RESIDUES TO PRODUCE ELECTRICITY IN THE SOUTHERN UNITED STATES

Raju Pokharel and Robert K. Grala[1]

Woody residues are considered a potential source of alternative energy to reduce fossil fuels dependency and lower carbon dioxide emissions. This study was conducted to determine how changes in mill and procurement attributes affect utilization of woody residues and willingness to utilize additional logging residues to produce electricity in the Southern United States. Data were collected from primary forest product manufacturers administrating a four mail contact survey and regression models were developed to estimate the impacts on utilization and willingness. Results indicated that one third of mills utilized woody residues to produce bioenergy. About 11 percent of mills were willing to utilize additional logging residues to produce electricity, and on average, were willing to pay $12 per metric ton at the gates and haul logging residues for 79 km. Mill capacity, amount of residues disposed out of mill, and availability of logging residues were significant factors in utilization of woody residues. Quantity of residues utilized and disposed, anticipated equipment upgrades, and storage space at the mills were significant factors in improving willingness to utilize additional logging residues to produce electricity. These results will be helpful in developing future policies facilitating bioenergy production from woody biomass.

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PROCUREMENT POTENTIAL FOR UTILIZING LOGGING RESIDUES BY PRIMARY FOREST PRODUCT MANUFACTURES IN THE SOUTHERN UNITED STATES

Raju Pokharel, Robert K. Grala, and Donald L. Grebner[1]

Procurement cost and method have significant importance in developing logging residue as the feedstock for bioenergy in the Southern United States. The study is designed to estimate the procurement potential to recovery logging residues to utilize it for bioenergy in southern forest product manufacturers (mills). ESRI ArcMap Network Analyst was used to estimate the procurement area around each mill depending on existing road networks. Different cost scenarios were used to estimate the transportation cost at different hauling distances. The results indicated that, almost 66 percent of the available residue could be collected for bioenergy if mills recovered residue as far as 15 miles. If mills procure as far as 35 miles, almost 98 percent of the logging residue was available. In a high cost scenario, mills could collect residue as far as 60 miles at the cost of about $15 green ton-1. The results are expected to help identify the spatial availability of logging residues for mills in the Southern United States. The results also help promote wood based bioenergy with estimated costs in recovering logging residue for bioenergy. These results will be helpful in developing future policies facilitating bioenergy production from woody biomass.

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REFINING FOREST SECTOR MODEL OUTPUT TO BETTER EVALUATE LOGGING RESIDUE AVAILABILITY FOR JET FUEL PRODUCTION

Gregory Latta[1]

The Northwest Advanced Renewables Alliance (NARA) is a consortium of university, government, and private industry researchers tasked with demonstrating the conversion of logging residues to biojet fuel in an economic, social, and environmentally acceptable manner. Supply chain logistics are a key aspect in biorefinery viability and thus knowledge of the spatial allocation of logging residues as well as how that allocation may change over time is fundamental. To accomplish this NARA utilizes spatially explicit economic models of forest products markets which balance harvests over time with demand for logs at regional mills. The forest resource supply of these economic models is the individual Forest Inventory and Analysis (FIA) plot on which the simulated logging operations for products such as lumber, plywood and paper products occur. Logging residue availability at the FIA plot is further refined incorporating NARA-derived information regarding the proportion that would be in piles, the distance of those piles from the landings, and the costs associated with extraction and utilization. The combined information regarding current and potential future forest logging residue supply coupled with collection and transportation cost data are used to generate supply cost estimates specific to any desired biorefinery site across Oregon, Washington, Idaho, or Montana.

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Traditional and Non-Timber Forest Product Markers

A STUDY ON REGIONAL DIFFERENCE AND EVOLUTIONAL PATH OF THE FURNITURE INDUSTRY IN CHINA

Jie-Jie Zeng, Ying Nie[1]

In the past 30 years, the majority of China's furniture industries preferred the labor-intensive approach rather than the capital-investment approach to reduce or control the cost of the productions. In recent years, however, the costs of the labor forces and industrial lands have been up dramatically especially in the eastern part of China, which could lead to the geographical migration of the furniture industry among different regions in China depending on their economical characteristics. Therefore, the regional difference and the evolutional path of China's furniture industry have been studied deeply here, and this will help us to learn the possible intrinsic economic mechanism and driving factors that influence China's furniture industry. This research could also be beneficial to other labor-intensive industries in China as well.

Based on data from 1988 to 2013, the Theil index was calculated for the regional difference of the furniture industry in China. We got the following three enlightening results: (1) the regional difference of China's furniture industry has constantly decreased during the period of 1988 to 2013, and this regional difference had shifted from the Intra-regional dominance to the Inter-regional dominance and back to the Inter-regional dominance during the past 24 years; (2) the rising domestic demands have forced the migration of the furniture industry from the eastern to the southwestern of China. In addition, the furniture industry in the east-coastal region is moving to the neighbor inland provinces in order to reduce the cost of production; and (3) the large and multilayered domestic demands of furniture will be there for a long period. The furniture industry in the east-coastal region should take a dominant role in the production chain in China by outsourcing, collaboration, and/or direct migrating of the production line.

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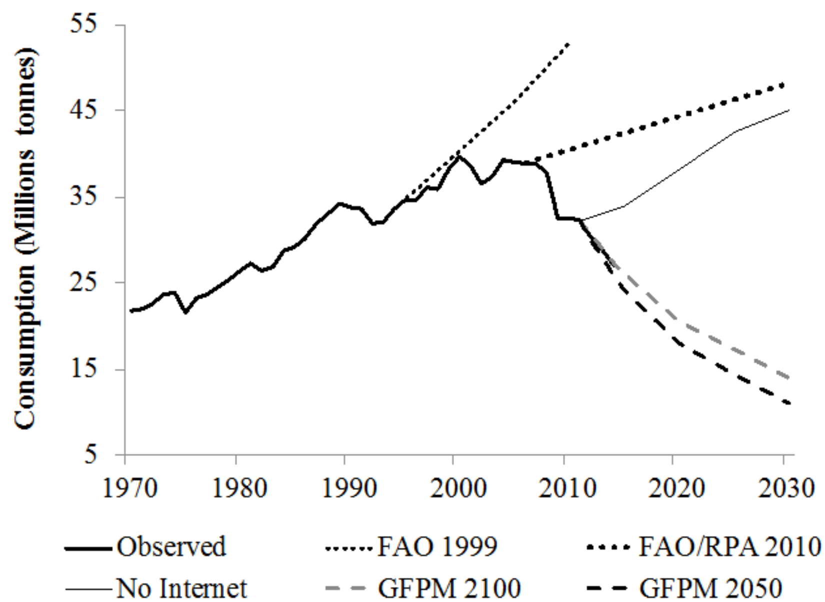
GLOBAL PAPER MARKET FORECASTS TO 2030 UNDER FUTURE INTERNET DEMAND SCENARIOS

Craig M.T. Johnston[1]

The Global Forest Products Model (GFPM) was applied to forecast the effect of increased per capita Internet adoption on the global paper products industry to 2030 under two scenarios: 1) full per capita Internet adoption by 2100, and 2) a more rapid Internet adoption by 2050. Global newsprint consumption is estimated to be 34.2–37.1 million tonnes lower in 2030 than in the U.S. Forest Service 2010 Resources Planning Act report (Buongiorno and others 2012), and the 2010 report (Prestemon and Buongiorno 2012) from the Food and Agriculture Organization of the United Nations (fig. 1). Similarly, global printing and writing paper consumption is forecast to be 76.7–87.1 million tonnes lower by 2030. By including controls for per capita Internet use in the demand equations for print-based media, this article reflects the recent declines in global paper product consumption. Out-of-sample forecasts over a 2-year period indicate global model prediction errors from 0 to 3 percent, depending on the product and exogenous assumptions. The results highlight the importance of considering market evolution in long-term global forecasting, and a failure to account for future rates of Internet adoption will result in an upward bias on paper product market forecasts.



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PRICE LINKAGES BETWEEN SPOT AND FUTURE MARKETS FOR SOFTWOOD LUMBER

Rajan Parajuli and Daowei Zhang[1]

Price discovery is one of the central functions of futures markets. In this paper, we evaluate the relative contributions of spot and future markets to the price discovery of softwood lumber. We estimate a bi-variate vector error correction model using weekly lumber futures and spot prices data from 1980 to 2015, and assess the price linkages and dynamic relationship between lumber futures and spot markets. Our empirical results show that both lumber futures and spot markets play significant roles in the price discovery of softwood lumber. As time to maturity of futures contracts increases, the contribution of the lumber futures market is dominant. However, in certain periods of the United States-Canada softwood lumber dispute, the lumber spot market plays a more dominant role in the price discovery of softwood lumber in the United States.

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IDENTIFYING OPPORTUNITIES FOR GROWTH IN MICHIGAN'S FOREST PRODUCTS INDUSTRY

Stephen Cooke, David Kay, Gregory Alward, and Philip Watson[1]

Abstract—In 2013, Michigan's Governor Snyder proposed increasing the contribution of forest products to the State's economy. The question was asked: which forest product sectors have the highest growth potential? Three economic models are applied to IMPLAN's social accounting data from 2007 to 2013 in this study of the Michigan forest product sectors. The first approach uses contribution analysis to measure a sector's output in its dual roles of bringing and keeping money in the State's economy. Second, a SWOT (strength, weakness, opportunity and threats) analysis measures each sector's changing competitive advantage over time and compared to the U.S average. Third, structural path analysis traces the network of payments as they change hands from the forest product sectors to their destination as labor income for household expenditures. The State could encourage domestic sales of low value-added forest products (e.g., logs, lumber and pallets) and export expansion for the high value-added ones (e.g., furniture and paperboard).

LOOKING FOR OPPORTUNITIES TO EXPAND MICHIGAN'S FOREST PRODUCT MARKETS

In 2013 and 2015, Michigan's Governor Rick Snyder hosted Forest Products Industry Summits to help improve the rural economy of the State. Representatives from industry, Government, finance, and academia identified four goals for the forest product industry. These goals are: 1) to increase forest products economic impact from $14 to $20 billion, 2) to increase their jobs by 10 percent, 3) to increase their export of value-added products by 50 percent, and 4) to encourage industry development regionally (State of Michigan 2016).

One of the consistent themes expressed by Summit participants was the lack of forest product market and supply chain information. This lack of information was viewed as an important "impediment" to making informed decisions on how to best foster the growth of the State's important forest product sectors (State of Michigan 2013). As a result, the Michigan Department of Agriculture and Rural Development, and the Michigan Department of Natural Resources created a request for proposal to answer a set of marketing questions. They asked for help: 1) to identify past and current forest products supply chains, practices, and marketing trends; 2) to identify potential for market growth; and 3) to recommend an integrated sector growth strategy that includes identifying obstacles and their potential solutions. This study focuses on a search for the evolving patterns in the forest products markets—national, regional, and within Michigan. The aim is to identify public policy opportunities that will have the largest beneficial impact for the smallest change.

THE CURRENT SITUATION AND OUTLOOK IN FOREST PRODUCTS

Recent declines in demand for U.S. forest products is attributed to three factors— the recession of 2008, the decline in housing starts, and increased foreign competition in secondary wood products manufacturing (Brandeis and Hodges 2015, Woodall and others 2011).

Regarding supply, the high quality hardwood timber in the Great North Woods of the Northeastern United States and Canada has been favorably compared to oil in Saudi Arabia—as a regional treasure trove (Woodall and others 2011). In the late 19th and early 20th centuries, Michigan's endowment of wood resources was put to good use building the cities of Chicago and Detroit. As the replacement crop of trees grew over the intervening decades, the wood lots became fragmented and the infrastructure such as sawmills and rail lines depreciated. Michigan's economy evolved away from natural resources toward auto manufacturing. Today the sum of the 27 forest product sectors in Michigan represents between 1 and 2 percent of the gross State product (Leefers and others 2013). Currently hardwood growth in Michigan has reached a point in which the growth in harvestable timber supply is threatened by senescence and mortality (Woodall and others 2011).

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NUMBERS THAT BEST DESCRIBE THE PROBLEM

The IMPLAN data set used in this study is a commercially available system of social accounting matrices (SAMs) and accompanying software programs. IMPLAN software includes routines to estimate local purchase coefficients, income-to-output ratios, and other factor relationships. IMPLAN SAM data allow the user to develop input-output models of the economy. These models provide internally coherent information for each sector on its direct effects from exports, its indirect effects from inputs supplied domestically, and its induced effects from local household spending.

In this study, we used these SAM accounting data to create the input-output economic data with which to analyze the economies of the States and the Nation in further detail. To identify important forest product sectors, we assembled hundreds of input-output tables with hundreds of sectors for all the States from 2007 to 2013. These tables were the source of the millions of rows of data that show the sectors with the most promise for increasing output, income, and employment.

CHANGING NUMBERS INTO INFORMATION TO PREDICT OUTCOMES

The three analytic models of economic contribution, competitive advantage, and supply chains determine the opportunities for growth among the forest product sectors. The first approach uses contribution analysis to measure a sector's output in its dual roles of bringing and keeping money in the State's economy. Second, a SWOT (strength, weakness, opportunity and threats) analysis measures each sector's changing competitive advantage over time and compared to the U.S average. Third, structural path analysis traces the network of payments as they change hands from the forest product sectors to their destination as labor income for household expenditures.

Model I—Base and Gross: Bringing and Keeping Money in the State's Economy

With contribution analysis, we can measure the output of a sector in two ways—either as "base" or "gross" output. A sector's gross output is observable. It's the number published by several branches of State and Federal Governments. A sector's base output is revealed only by using an input-output model of the economy. For a given sector, base and gross measures of output are rarely equal. However, the sum of gross and base output for the economy equal each other and the observed. There is no double counting. Economic contribution analysis can generate internally consistent measures of gross and base output, employment and total value added[2] for the sectors of the States and the Nation.[3]

A sector's "base" output is the sum of the domestically produced homogeneous inputs from all sectors brought forth to produce a given sector's output. Base output represents the ability of a sector to bring money into the economy including, but not limited to, export sales. It is also a measure of the current strength of a sector's role within an export expansion strategy of development that broadens the economy.

A sector's "gross" output is a given sector's homogeneous production as an input that contributes to making all sectors' output including its own. Gross output measures a sector's ability to keep money in the economy. It also measures the strength of a sector's role within an import substitution strategy of development that deepens an economy.[4]

These different roles have policy implications. All sectors play both roles of import substitution and export expansion in the economy, but they tend to specialize in one more than the other. Economic contribution analysis identifies each sector's role specialty. Gross and base output analysis tells us which is which and by how much (Waters and others 1999).

Below, in our analysis of competitive advantage, we will use the sectors' shares of gross and base value added as data to track the changes over time and by region to pursue export expansion and import substitution strategies. We will show that increasing the exports of an important keeping sector could be counterproductive if it results in an input bottleneck for an important bringing sector. This possibility appears to exist among Michigan's forest product sectors, a point we will explore further in our analysis of supply chains.

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2 Total value added or simply "value added" is the sum of the returns to labor, capital, proprietors' income and taxes on profits and inputs. The sum of total value added across all sectors equals the gross State product of a State's economy.

3 The sum of the output for States is less than the total for the Nation because of the synergy from the open and closed loop trade multiplier effects for the United States that is not included for individual States. See Round (1985).

4 The size and number of base and gross sectors change over time as the structure of the economy changes. Our research, unrelated to this study, suggests the growth in primarily export enhancing sectors is accompanied by a similar growth or perhaps even greater growth in the import substitution sectors. Because of its deepening effect on the economic structure, import substitution has a greater long-run impact on the economy than comparable increases in exports (Cooke and Watson 2011; Watson and others 2007, 2015).

Results from contribution analysis—We map output onto value added, one-to-one. Using base value added as the criterion, office furniture manufacturing is the most important wood products sector in Michigan. In 2013, this sector had over 3 billion dollars in base value added and 32,000 jobs of base employment (table 1). Office furniture is an important exporting sector, primarily to the domestic U.S. market outside of Michigan. Adding the closely related sectors of institutional-furniture manufacturing and shelving brings the total base value to about 4 billion dollars and 44,000 jobs. The exports from institutional-furniture sector are primarily for the international market.

Paper products, broadly defined, are the other major base value added sectors in Michigan. Paper and paperboard mills along with paperboard containers together create about 2 billion dollars in base value added and 20,000 jobs in base employment. These sectors perform dual but unequal roles of providing exports as well as intermediate inputs to other sectors in the State.

Sawmill, veneer manufacturing, pallets, and commercial logging sectors together make a relatively modest contribution of less than 500 million dollars in base value added and 6,000 jobs in base employment. As we will show in the supply-chain analysis in Model III, these sectors play an important but different role in Michigan's forest products economy as potential input sector bottlenecks.

By comparing gross to base total value added sector by sector, we can now determine which sectors play the roles of primarily money bringing (export enhancing) or money keeping (import substituting) in the Michigan economy. Of the 10 listed in table 1, office furniture, paper mills, paperboard containers, show case & partition, paperboard mills, and institutional furniture are primarily money bringing/export enhancing forest product sectors. The rest—sawmills, wood containers and pallets, veneer and plywood, and commercial logging—are evenly split or primarily money keeping/import substituting sectors. Ideally, we would like to see the low-wage, low-value added import substitution sectors providing inputs for the high-wage, high-value added exporting sectors. This approach both deepens and broadens the economy. This is roughly the pattern we see in Michigan wood products. Michigan is turning its raw forest products into value-added finished wood products and exporting them.

Goal compatibility analysis—With actual measures of gross and base output, employment, and value added, we can see what combination of forest product goals are feasible. Is it even possible to meet all the goals expressed earlier for Michigan's forest product sectors? In table 2, it

Table 1—Michigan's forest products gross and base total value added (TVA), 2013

Sector	Gross total value added		Gross vs. base	Base total value added	
	($million)			*($million)*	
Office furniture	1,662	*40.0%*	<	3,205	42.5%
Paper mills	372	*9.0%*	<	922	12.2%
Paperboard container	444	*10.7%*	<	629	8.3%
Showcase, partitions	219	*5.3%*	<	397	5.3%
Paperboard mills	96	*2.3%*	<	324	4.3%
Institutional furniture	144	*3.5%*	<	297	3.9%
Sawmills and wood pres.	110	*2.7%*	≈	149	2.0%
Wood container and pallets	91	*2.2%*	≈	103	1.4%
Veneer and plywood	55	*1.3%*	≈	101	1.3%
Commercial logging	186	*4.5%*	>	89	1.2%
All other 16 forest products[a]	777	*18.7%*		1,328	17.6%
Total forest products	4,155	100.0%		7,545	100.0%
Grand total	439,363	0.9%		439,363	1.7%

[a] The other 16 forest-product sectors include: boat building, all other paper, reconstituted wood, wood kitchen cabinets, wood windows and doors, sanitary paper products, pulp mills, non-upholstered wood furniture, engineered wood members, stationary products, upholstered wood furniture, prefabricated wood buildings, manufactured homes, forestry services, all other converted paper and miscellaneous wood products.

is proposed that if the 10-percent increase in employment goals is to be met, then a 10-percent across the board increase in value added for all the Michigan forest product sectors would suffice—gross and base. This translates into an addition of $416 million or $755 million in gross and base forest product valued added respectively. How so?

Table 3 summarized the numbers that link a 10-percent increase in gross or base total value added to the same increase in employment. The logic is as follows. From table 1, we know the total value added for both gross and base measures in Michigan in 2013. From these totals, we derived two sets of capacity measures: those linking employment and value added to output, and those linking output, employment, and value added across the gross and base results. For example, we know that if gross employment increases by 10 percent, then output and value added must also increase by the same amount because the ratios of employment to output and total value added to output are constant. To change these ratios is to change the assumptions about the underlying productivity of labor and the size of the share of the returns to labor and capital. Similarly, the relationships between output, employment, and total value added between gross and base results are also fixed ratios. To change these ratios would implicitly change the underlying structure of the Michigan forest products economy expressed as the relative proportions between base and gross sectors. (Perhaps a laudable goal, but not a stated one.)

Therefore, to increase gross employment by 10 percent is to increase base employment by the same percent. Then, the fixed relations among base output, employment, and total value added apply as with the gross measures. Thus, to increase base or gross employment by 10 percent is to increase all the other measures within that metric by the same amount as well. Curiously, if employment increases by 10 percent, then base output (but not gross output as may have been intended) increases to over $20 billion. So arguably, at least two of the four stated goals will have been met by achieving a 10-percent employment increase. The additional goal of a 50-percent increase in value added is inconsistent. A 10-percent increase in gross employment would result in an 18-percent increase in value added measured between metrics as the ratio of additional base to initial gross value added.

We now know which forest product sectors primarily bring and keep money in the Michigan economy. We also know how much a 10-percent increase in gross employment increases value added. But we do not yet know which sectors have the best chance of meeting the goal of increasing employment and value added. That is the job of competitive advantage analysis.

Model II—SWOT Analysis of Changing Competitive Advantage

A SWOT (strength, weakness, opportunity and threats) analysis shows each sector's changing competitive advantage over time and compared to the all States'

Table 2—Michigan's forest products 10-percent across-the-board gross and base value added increase as a way to meet a linked employment goal, 2013

Sector	Additional gross total value added		Additional base total value added	
	($million)		*($million)*	
Office furniture	166	40.0%	321	42.5%
Paper mills	37	9.0%	92	12.2%
Paperboard container	44	10.7%	63	8.3%
Showcase, partitions	22	5.3%	40	5.3%
Paperboard mills	10	2.3%	32	4.3%
Institutional furniture	14	3.5%	30	3.9%
Sawmills and wood pres.	11	2.7%	15	2.0%
Wood container and pallets	9	2.2%	10	1.4%
Veneer and plywood	5	1.3%	10	1.3%
Commercial logging	19	4.5%	9	1.2%
All other 16 forest products	78	18.7%	133	17.6%
Total add'l forest products	416	100.0%	755	100.0%

Table 3—Michigan's forest products gross and base employment, value-added, and output before and after a 10-percent increase in gross employment, 2013

	Metric	Gross	Base	Base		
Measures	Units	Before	After	Before	After	to Gross
Employment	# jobs	47,138	51,852	86,720	95,392	84%
Total value added	$ million	4,155	4,571	7,545	8,300	82%
Output	$ million	14,359	15,795	19,103	21,013	33%
Employment/output	# jobs/$ million	3.28	3.28	4.54	4.54	—
Total value added/ output	$ million/$ million	0.29	0.29	0.39	0.39	—
Additional employment	# jobs	—	**4,714**	—	**8,672**	*18.4%*
Additional total value added	$ million	—	416	—	755	*18.2%*
Additional output	$ million	—	1,436	—	1,910	*13.3%*

Bold numbers indicate additional gross and base jobs created if the gross employment goal is achieved;
Italic numbers indicates the internally consistent impact on the economy measured as the ratio of base additional to gross initial quantities by category.

average. Economic theory suggests that a form of competitive advantage associated with opportunity cost called comparative advantage drives market structure.[5]

> "… Each country will tend to specialize … in the commodity in which it has the greatest comparative advantage; and it will export some of that commodity in exchange for the other country's surplus exports …." (Samuelson 1970).

The idea is to produce what you are relatively good at making (relative to your opportunity cost), export it, and use the money to import what you are not as good at making. But how do you know what you are good at making and when does that change?

We assume that the change in competitive advantage of a sector tracks directly with the change in base or gross value added shares. This approach builds on the work of many (Diewert 1976, Ferguson 1969, Finegold and Soskice 1988, Redding 1996, Scicchitano 2010, Violante 2008). The math is complex,[6] but the logic is simple. If the firms in a sector are increasing their competitive advantage, then the sector's marginal contribution to the state's average wages or value added will increase and show up as a sector's increasing share of total wage bill or value added—over time, between places or both.

By plotting the changes in each sectors' value-added shares by time and place along the *y* and *x* axes, the result is a scatter diagram in the form of a 2 x 2 SWOT analysis. The SWOT format visually conveys the relative distance of the change in value added shares for each sector. The distance from the origin shows the extent of improvement (or lack thereof) in competitive advantage. If the distance is positive (or negative) both relative to the all-states average share[7] (place) and relative to the sector's 2007 share (time), then competitive advantage has strengthened (weakened) (Q1 vs Q3). An improvement over time, but lagging the all-states average, is considered an opportunity (Q2) because continued improvement over time would result in overtaking the all-states average. Conversely, greater distance than the all-states average but less distance over time is a threat (Q4) because continued declines over time would result in falling behind the all-states average as well.

The decision criteria are as follows. The greater the positive change in the share of *base* value added over time and by place, the greater the increase

[5] The concept of opportunity cost is what distinguishes comparative advantage from absolute advantage.

[6] The changes in value added shares conveys both the substitution effect from changing commodity prices and the sector bias from market information about the future direction of a sector (Cook and Kulandaisamy (2010).

[7] All States average value added shares are used instead of the U.S. value added shares because of the multi-regional trade effects that are implicitly expressed in the U.S. value added shares do not appear in the sum of the States' shares that have been calculated individually. The multi-regional trade between States particularly changes the induced effects multiplier for the Nation and make the indirect effects less important. Using the average of the sum of all States value added shares corrects for this difference.

in competitive advantage of the sector's exports. An increase in *gross* value added over time and by place indicates an increase in competitive advantage of the sector's output for import substitution.

Results from SWOT analysis—To determine whether a sector competitive advantage is improving, the base value added shares should be improving both over time—relative to 2007—and relative to the value-added shares for all States in the United States. Of all the forest product sectors in Michigan over the 2011–2013 period, the wood office furniture manufacturing[8] sector stands out for its performance along both time and place dimensions for both export and import substitution (fig. 1) (United States. Executive Office of the President. and United States. Office of Management and Budget. 2002). This is a particularly impressive accomplishment given that only two other States (Iowa and Indiana) have wood furniture manufacturing sectors that show improvements—improvements that only begin to rival those of Michigan. We know from table 4 that office furniture makes up over 40 percent of the base and gross value added in the Michigan forest products. This is good news for the Michigan economy—an important sector that is growing.

Paper, paperboard, and paperboard container sectors also show positive though modest improvements in comparative advantage for import substitution, but falls in the threat quadrant for export expansion (fig. 2). Commercial logging shows modest strength in both exports and import substitution, but ironically this may pose a bit of a problem because logs are a necessary input to all other forest products in the State. Paperboard mills and sawmills both show slight weakness for exporting and import substituting. The plywood and pallet sectors show no change.

Nearly all the changing comparative advantage is attributable to sector bias rather than from the substitution effect associated with changing input prices. The average wages in paper, paperboard, paperboard container and wood furniture sectors are significantly greater than in the other important wood product sectors in Michigan, such as logging. Sector bias that favors high-paying wood product sectors contributes to a high-skill equilibrium economy with sectors producing high-quality, specialized goods and services that require a well-qualified workforce capable of rapid adjustment in the work process and continual product innovation **(Finegold and Soskice 1988)**.

[8] This U.S. industry comprises establishments primarily engaged in manufacturing wood office-type furniture. The furniture may be made on a stock or custom basis and may be assembled or unassembled (code 337211).

The Great Lakes region[9] also reveals (but not shown) that wood office furniture has exporting and import substitution strength like Michigan's. The same is true for the institutional furniture sector as well but by substantially smaller scale of growth. The regional perspectives show the strength for paper mills and paperboard containers is better for import substitution than for export expansion, the same as for Michigan. Again, the concern for the region remains that commercial logging shows more strength as an export than as an import substitute.

In the Southeast region[10] of the United States, the good news is that commercial logging is not a strong exporting sector in the region, but it is threatened as an import substitution sector. The bad news for that region is that it shows no export strength over the 2011–2013 period in any of the 10 forest product sectors discussed for Michigan. The region's only bright spots are the import substitution strength of its paperboard mills and paper mills sectors.

For the United States east of the Mississippi River,[11] forest products for exports are not strong in any of the 10 sectors discussed for Michigan. Exports total value added is greater than all States average for paperboard mills, paper mills, paper board containers and office furniture but decreasing over time, and paper mills remarkably so. This eastern half of the United States has strength in import substitution for the paperboard mills and paper mills sectors only. Commercial logging is threatened as an import substituting sector.

Compared to the Southeast and eastern half of the United States, Michigan and the Great Lake region appear to have a strong export competitive advantage in wood office furniture, commercial logging, institutional furniture, and shelving. There also appears to be opportunities for strong import substitution for the paperboard container, paper mill, institutional furniture, and shelving sectors. This is good news for Michigan because these sectors make up the lion's share of the forest products gross and base value added in the State. But we have not yet determined whether there are any supply chain bottlenecks that could prevent expanding value added in these promising forest product sectors in Michigan. This is the job of Model III.

[9] Great Lakes region includes Illinois, Indiana, Michigan, Ohio and Wisconsin.

[10] The Southeast region is made up of Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia.

[11] East of the Mississippi River includes New England, Mideast, Great Lakes, and Southeast regions.

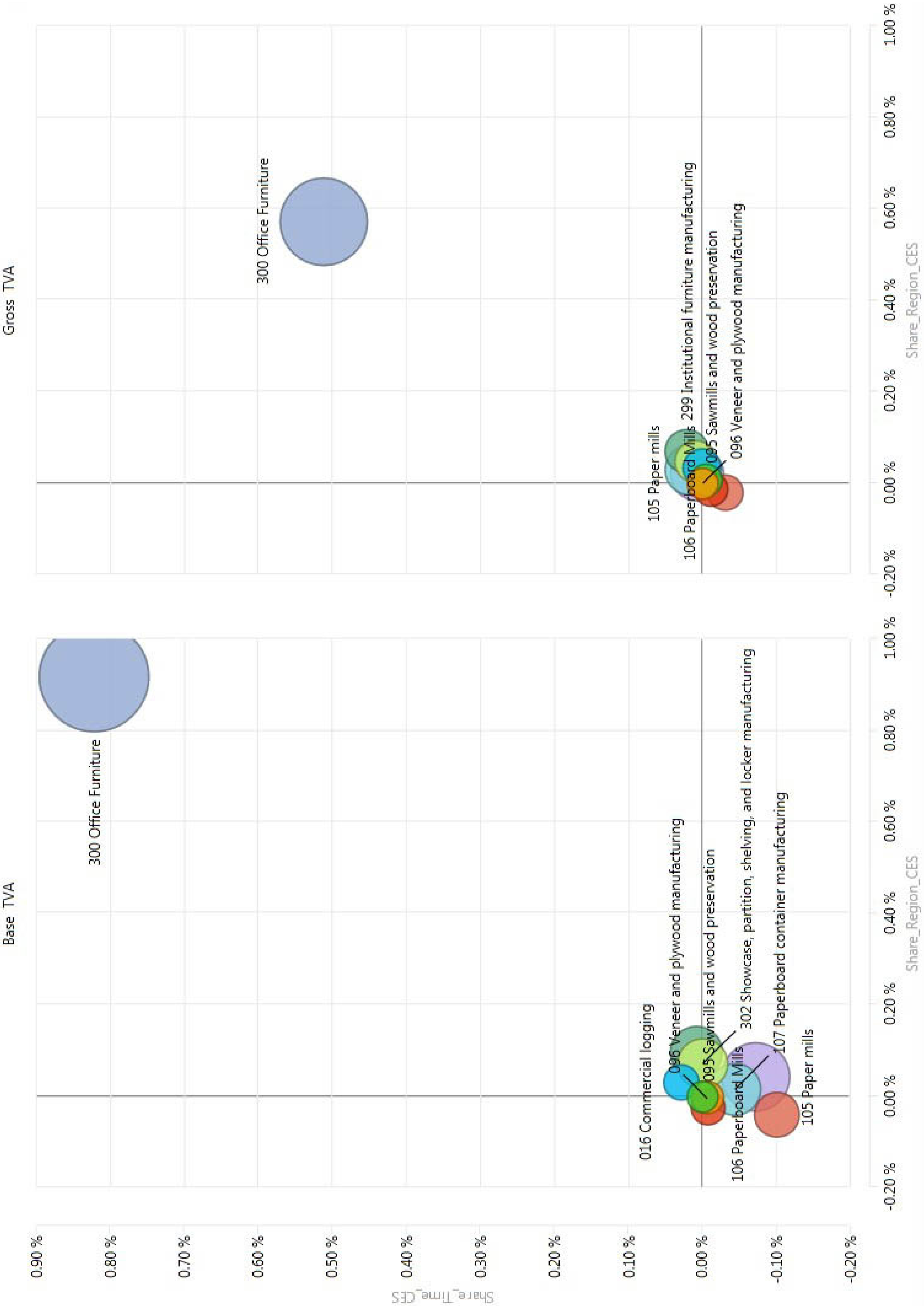

Figure 1—Michigan's change in forest products shares of base and gross value added, 2011–2013 average.

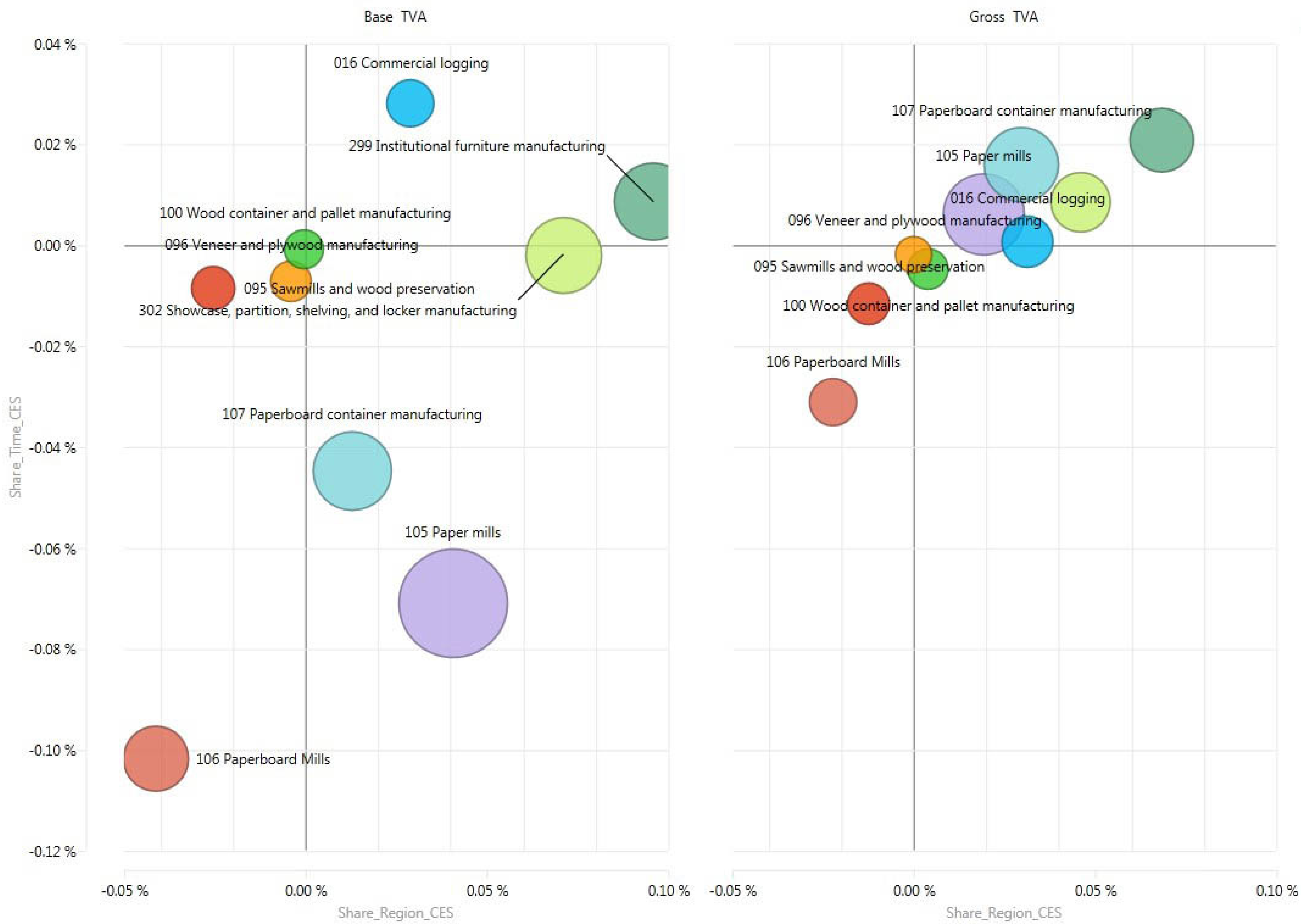

Figure 2—Michigan's change in forest products (without office furniture) shares of base and gross value added, 2011–2013 average.

Table 4—Michigan's and all States' forest products gross and base value added shares, 2007 and 2013

Sector by Year	2013	2007	2013	2007	2013	2007	2013	2007
Place	Michigan	Michigan	All States	All States	Michigan	Michigan	All States	All States
Measure	Base TVA	Base TVA	Base TVA	Base TVA	Gross TVA	Gross TVA	Gross TVA	Gross TVA
Office furniture	42.5%	26.5%	6.1%	4.0%	40.0%	25.1%	5.1%	3.5%
Paper mills	12.2%	16.3%	16.1%	16.9%	9.0%	10.6%	13.1%	11.1%
Paperboard containers	8.3%	8.6%	10.6%	7.8%	10.7%	9.4%	12.6%	9.7%
Showcase, partition	5.3%	6.3%	3.2%	3.6%	5.3%	4.7%	2.9%	2.6%
Paperboard mills	4.3%	7.8%	8.0%	6.8%	2.3%	4.3%	5.5%	4.1%
Institutional furniture	3.9%	4.0%	1.7%	1.5%	3.5%	3.9%	1.3%	1.2%
Sawmills and wood pres.	2.0%	2.2%	5.9%	6.5%	2.7%	3.6%	6.1%	6.3%
Wood container and pallets	1.4%	1.1%	2.2%	1.5%	2.2%	2.3%	2.7%	2.3%
Veneer and plywood	1.3%	1.4%	2.3%	2.6%	1.3%	1.4%	1.9%	2.3%
Commercial logging	1.2%	1.1%	1.8%	3.8%	4.5%	9.4%	5.8%	14.2%
All other 16 forest products	17.6%	24.8%	42.0%	45.0%	18.7%	25.3%	43.1%	42.7%
Total Forest Products	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Grand Total	1.7%	2.0%	1.1%	1.4%	0.9%	1.1%	0.7%	0.9%

TVA = total value added.

Model III—Supply Chain Importance Measured as Betweenness Centrality

Model III begins with a structural path analysis of Michigan's forest product sectors. Defourny and Thorbecke (1984) assert that embedded within an input-output model's induced-effect multipliers, the supply chains of each sector exist. They used a technique called structural path analysis to prove their assertion. Structural path analysis can trace the network of payments as they change hands from the forest product sectors to their destination as labor income for household expenditures.

In our case, the structural path model starts with the technical coefficients of a 52-sector social accounting matrix, in which half the sectors refer to forest products. The model is closed by including the purchases of low and high income households. The structural paths identify the roundaboutness that income generated in a forest product sector takes as it makes its way to household consumption. We apply structural path analysis to 10 important forest product sectors in Michigan to determine the supply chains as revealed by income moving from these sectors to households (Arndt and others 2012, Oshita 2012).

Network analysis builds on the node and path elements from structural paths analysis (Arndt and others 2012, Bastian and others 2009, Gephi Open Source 2015). Highly connected nodes within the network suggest potential bottlenecks in the supply chains for forest products. The criterion for determining the potential bottleneck by a sector in the supply chain is the network-theory measure of "betweenness centrality" (Assenov 2013, Golbeck 2013, West 2001). Betweenness centrality is a measure of the extent of the control a node (in this case, a sector) can bring to bear over the other sectors in an interdependent economy (Assenov 2013). The greater the betweenness centrality of a sector, the greater its potential control over the supply chain—also a measure of a possible bottleneck. Within the forest products marketing chains, some sectors interact between the initial sectors and households more than others. For example, labor is an important intermediary between a sector's generation of value added and household spending. The greater the interaction by a single sector between any two non-adjacent sectors, the greater its betweenness centrality. The greater the betweenness centrality, the greater a sector's potential as a bottleneck in the supply chain.

Results from supply chain analysis—To get an intuitive feel for betweenness centrality, it is helpful to look at table 5. This table presents a 7 x 8 matrix of source by destination for several interrelated forest products. For example, the logging sector (as a source) has several direct sector destinations including sawmills, pallets, veneer, paper mills, and paperboard mills. By way of contrast, the shelving sector (as a source) has one destination—office furniture. It seems reasonable to expect that the logging sector will have a greater betweenness centrality than the shelving sector because more other sectors are dependent on it as an input. So let's see.

In figure 3, the full array of complex source and destination interactions between sectors and institutions[12] are presented in a circular network formation. (The sector and institution acronyms of the node labels are identified in the appendix.) For each node in the circular network, the betweenness centrality is calculated, ranked from high to low, and placed in order starting at "12 o'clock" and moving clockwise. The first five sectors and institutions with the greatest betweenness centrality include labor, logging, capital, proprietors, and sawmills. Three factors (labor, capital, and proprietors) and two sectors (logging and sawmills) hold the greatest potential bottleneck positions to all the forest product sectors in the Michigan forest product supply chain. This is not a particularly surprising result, but it is reassuring to know that Model III found logging to be critically central to the forest product sector. By far, labor is the biggest potential bottleneck in the flow of funds between the forest product sectors and households.

Besides the strong "betweenness centrality" of the important forest product sectors as inputs, there are other key inputs into the forest product exporting sectors as well. These include wholesaling, pallets, veneer, utilities, and other manufactured goods. For example, the wholesale function in forest products relates to the need for "channel masters" to organize the flow of timber from small wood lot owners to the sawmill proprietors.

In a social accounting model of Michigan's economy that includes households, the supply chains that track the flow of funds from the 10 important wood product sectors to households were explored. The definition of "important" is circular. After starting with forest product sectors with high base value added and increases in comparative advantage, e.g., furniture, it was found that other wood products—logging, sawmills, veneer, pallets, and shelving—were also important in the production of wood office furniture and institutional furniture. Similarly, paper and paperboard production are important inputs for manufacturing paperboard containers. In effect, the process has come full cycle in that the focus on base value added and changing comparative advantage leads to the

12 Institutions refers to the non-sector node in the supply chain including labor (FLABR), capital (FCAPL), proprietors (FPRPR), and households (HH_H, HH_L).

Table 5—Michigan's forest products sources and destinations, sector by sector

Source by destination	Office furniture	Instit'l furniture	Paperboard containers	Saw mills	Pallets	Veneer	Paper mills	Paperboard mills
Logging				X	X	X	X	X
Saw mills	X	X		—	X			X
Pallets					—		X	
Veneer	X					—		
Paper mills			X				—	
Paperboard mills			X					—
Shelving	X							

— = the circular own-paths of a sector providing its output to itself, e.g., the pallet sector needing pallets to make pallets.

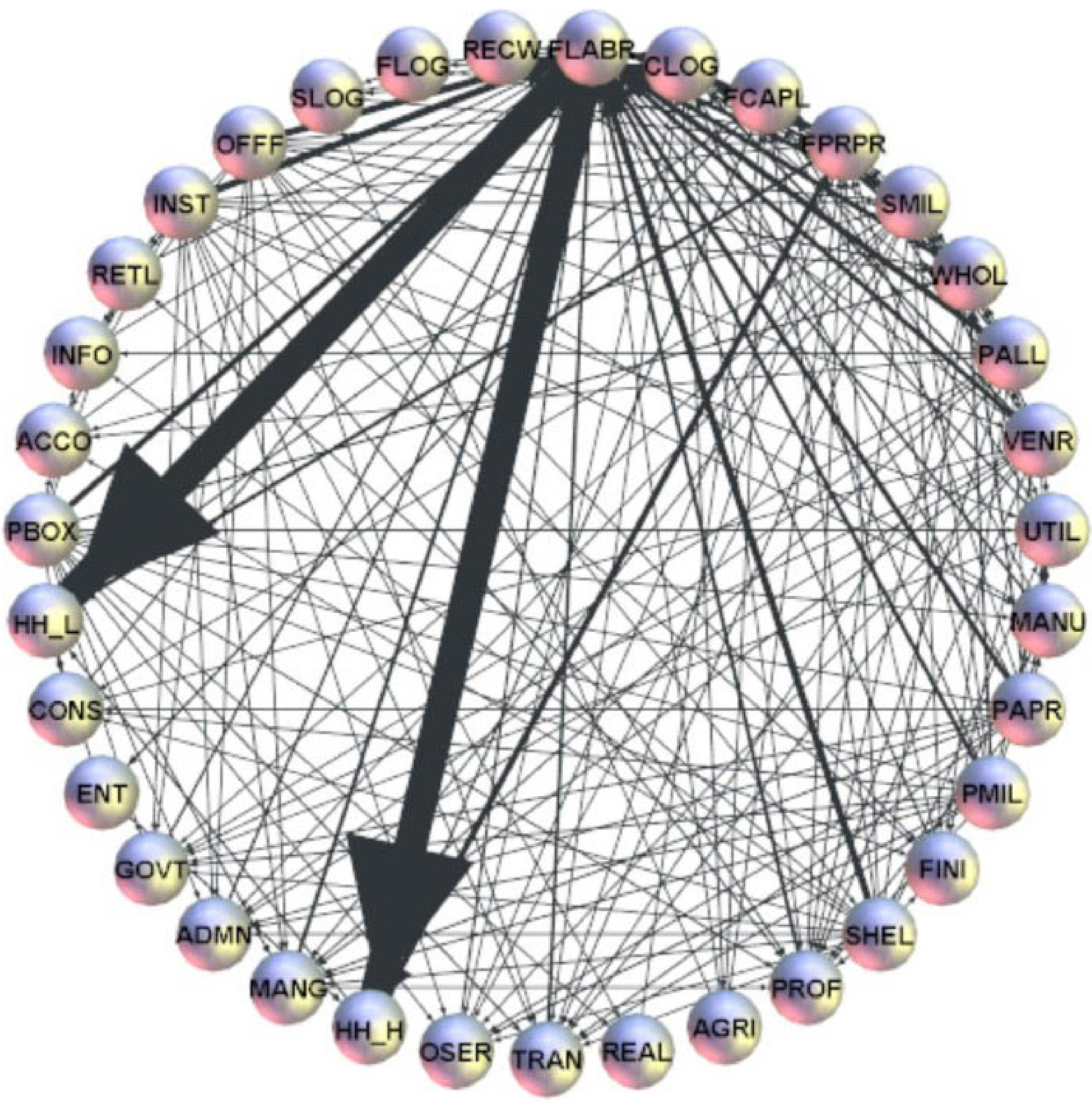

Figure 3—Michigan's circular network of structural paths ranked clockwise by betweenness centrality, 2013.

important role that gross value added forest products play in the supply chain. Their interdependence is complete.

FROM PREDICTIONS TO PRESCRIPTIONS

Taken together, these three models provide insight into the relative importance of sectors that bring and keep money in the economy, their likelihood to improve comparative advantage, and their potential as bottlenecks in the supply chains. What did these models reveal about Michigan's forest product sectors' ability to increase employment by 10 percent and our ability to answer the three questions that motivated this study?

The insights from this study on past and current forest products supply chains, practices, and marketing trends are as follows. Furniture manufacturing—office furniture, institutional furniture, and shelving—are the most important forest product sectors in Michigan. Paper products manufacturing—paper, paperboard, and paperboard containers—are the other major base value-added sectors in Michigan. Sawmill, veneer manufacturing, pallets, and commercial logging sectors together make a relatively modest contribution to value added, but these sectors play an important role in Michigan's forest products economy as key input sectors and, therefore, potential bottlenecks. Together, these 10 sectors make up over 80 percent of gross and base value added of all Michigan's forest products.

The potential for market growth is as follows. The wood office furniture manufacturing sector stands out for its performance along both time and place dimensions for both export enhancement and import substitution—growing in value added share more than any other State in the United States. The office furniture sector alone makes up at least 40 percent of the base and gross value added in the Michigan forest products, so it represents an important sector that is currently growing remarkably. Paper, paperboard, and paperboard container sectors also show positive though modest improvements in comparative advantage for import substitution, but fall in the threat quadrant for export expansion.

An integrated sector growth strategy that includes identifying obstacles and their potential solutions is as follows. If employment across the forest product sectors increases by 10 percent, then base output (but not gross output) increases to over $20 billion.

Generally, the State of Michigan should do things that encourage more export expansion in the high value added sectors and less export expansion from the potential bottleneck sectors. The role of any government is to provide and support education, fund long-run research and development, and maintain the infrastructure. Each of these could help the forest product sectors. For example, the labor supply to the forest product sector in general needs careful attention. Perhaps the State could help recruit and train labor for that sector. Logging is dependent on a road system that allows logs to reach their destinations year round. Research and development can help any sector gain and maintain a comparative advantage. Perhaps additional research and development could help assure that advantage continues. A concern that might prevent this would be issues in key input sectors. These potential bottleneck sectors include commercial logging, sawmills, and pallets. The interdependence among forest product sectors suggests a general strategy of promoting exports for the greater value-added sectors and import substitution for the lower value-added sectors.

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HISTORICAL AND FUTURE HOUSING STARTS

Jeffrey P. Prestemon, David N. Wear, Karen L. Abt, and Robert C. Abt[1]

Forest sector analysts interested in the future of the wood products sector need valid projections of the future of primary consumers of wood, including in the construction sector. We present several alternative models of aggregate, nationwide U.S. single family and multifamily housing starts using quarterly data, 1959-2015. Model fits are generally high, in spite of equation specification simplicity. Monte Carlo based projections generated from the models reveal long-run likelihood distributions of start levels into the future.

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KEY SECTOR ANALYSIS OF WESTERN NORTH CAROLINA FOREST-BASED INDUSTRIES

Laurel Kays, T. Eric McConnell, Robert Bardon, and Dennis Hazel[1]

Abstract—Our objective was to determine the value chain linkages between forestry, forest products manufacturing, and the economy of North Carolina's Appalachian and Foothills region. Key forest-based sectors were identified from the backward and forward linkages contained within the matrix of regional economic multipliers. An input-output model of 32 western North Carolina counties was constructed using IMPLAN. Sector-level transaction data was downloaded to Excel, where the total requirements matrix of economic multipliers was determined. Both the backward linkages (the column sums) and the forward linkages (the row sums) were indexed to their regional averages. A backward linkage index greater than 1.0 indicated a unit change in final demand in forest sector *j* would create an above-average increase in regional economic activity. Forward linkage indexes greater than 1.0 suggested a unit change in all sectors' final demand would create an above-average increase in forest sector *i*. A key sector was one with both indices greater than 1.0. Out of 28 forest-based sectors, 23 sectors had above-average backward linkages; only four had above-average forward linkages. Two industries—Sawmills and Paperboard Container Manufacturing—had both indices greater than 1.0 and were therefore identified as key to the region.

INTRODUCTION

Western North Carolina has abundant forest resources, large portions of which have been identified by the State forest service as high priority for conservation as working forest land (Bardon and others 2010). The mountain region of the State is 76-percent forested, with upland hardwoods such as oaks and yellow poplar accounting for 80 percent of the 5.7 million acres of timberland. These resources and interest in their continuing to be operational timberland mean forest-based sectors have the potential to be a source of much needed regional economic development. By many economic indicators, western North Carolina lags behind the State as a whole. Poverty levels, median household income, and per capita income are all below the North Carolina average and rank very low compared with other regions of the State. Median household income for example, is the lowest across all regions of the State at just 82.5 percent of the State average (Brennan and Cooper 2014). For those looking to combat these issues, identifying key sectors which hold the greatest potential for spurring economic development is crucial. This paper uses backward and forward linkages contained within the matrix of regional economic multipliers to determine forest-based key sectors that could both provide an above-average impact given an overall increase in demand and produce an above-average impact given a sectoral increase in activity.

BACKGROUND AND LITERATURE REVIEW

The concept of key sector analysis is ultimately rooted in the Leontief inverse matrix. Using that matrix, the work of Rasmussen (1956) and Hirschman (1958) established the idea of calculating forward and backward linkages. Forward linkages measure the sensitivity of dispersion (e.g., how a regional change affects a particular sector), while backward linkages measure the power of dispersion (e.g., how a change in a particular sector affects the region). Sonis and others (1996) proposed using these indices together to identify key sectors, with a key sector being one with both a backward and forward linkage greater than one.

The identification of key sectors through forward and backward linkages has many applications, including the investigation of individual sectors (Polenske and Sivitanides 1990) and the analysis of international and regional economies (Humavindu and Stage 2013). Using key sector identification for a regional economy does come with certain issues as summarized by Hewings (1982). These include the fact that indices developed by Rasmussen and Hirschman do not account for unequal variation within sectors or the sectoral contribution to final demand. However despite these issues, the technique remains an accepted and utilized method of regional key sector identification.

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No studies have focused specifically on the underlying structure of the economy of western North Carolina. Those that address the economy of the region have largely focused either on the broad state of the economy through an analysis of public sentiment and census style data (county development information) or on evaluating the impact of a specific event, such as the building of a casino by the Eastern Band of Cherokee Indians (Ha and Ullmer 2007). Our paper will contribute to filling this gap in understanding.

METHODS

An input-output model was constructed for a 32-county region of western North Carolina using the IMPLAN database (IMPLAN LLC 2015). The region of interest extended from the Tennessee border east to approximately Interstate 77 and consisted of 464 active industries. Of the 29 sectors considered forest-based in North Carolina, 28 sectors existed in the region.

Timber income data were customized per Jeuck and Bardon (2015) for the counties, and the model was reconstructed. The *Z* matrix of inter-industry flows was downloaded to Excel. Next, the *A* matrix of direct industry requirements was calculated by dividing the cells of each column by their column total. The Leontief inverse matrix of total requirements, $A^* = (I - A)^{-1}$, was then determined, with *I* being the identity matrix of initial requirements.

Backward linkages for each forest sector were the column sums, , and is equivalent to the forest sector *j* Type I output multiplier. The backward linkages described the total change in the regional economy resulting from a one unit change in final demand for each forest sector *j*. Forward linkages were the row sums, . Each forward linkage described the total change in forest sector *i* resulting from a one unit change in final demand across all sectors in the region.

Two indices developed by Rasmussen (1956) were calculated to assess the potential for key forest sectors being present in western North Carolina.

$$BL_j = A^*_{.j} \Big/ \frac{1}{n}V \qquad [1]$$

$$FL_i = A^*_{i.} \Big/ \frac{1}{n}V \qquad [2]$$

Equation 1 describes the power of dispersion for the backward linkages (BL_j), while Equation 2 describes the sensitivity of dispersion for the forward linkages (FL_i). In both instances, *V* represents the global intensity of the total requirements matrix ($V = 589.054$) and *n* represents the number of sectors ($n = 464$).

Each index describes sectoral linkages relative to the regional average as a benchmark. Above-average changes occur in the western North Carolina economy per unit change of final demand in forest sectors *j* with $BL_j >$ 1.000. Likewise, a unit change of final demand across the region will generate greater than average changes in forest sectors *i* whose $FL_i > 1.000$ (Sonis and others 1996). Key forest sectors are those with both $BL_j > 1.000$ and $FL_i >$ 1.000.

RESULTS AND DISCUSSION

The 32 counties of western North Carolina generated $146 billion in output in 2014, which included $66 billion in value added. Just over 1 million jobs were supported in the region. Sector averages were $273 million in output and 1,870 jobs. Total output in the forest-based sectors summed to $7 billion and averaged $258 million. Forest-based employment totaled 30,330 with an average of 1,083 jobs per sector.

Backward linkages for the forest sectors ranged from 1.113 for Support Services for Forestry to 1.556 for the Sawmills sector. Three sectors in Wood Furniture Manufacturing had the lowest forward linkage of 1.001, while the Sawmills sector had the highest value of 2.253.

The linkages were then indexed to the regional average of 1.270 for key forest sector analysis (fig. 1). Twenty three sectors had $BL_j > 1.000$. Of the five industries with $BL_j <$ 1.000, four were $BL_j > 0.950$. Only one, Support Services for Agriculture and Forestry, displayed what could be considered a weaker backward linkage.

The region's forest sectors did not appear to be strongly forward linked, $FL_i > 1.000$. Only four, Commercial Logging (1.151), Paperboard Container Manufacturing (1.590), Support Services for Agriculture and Forestry (1.694), and Sawmills (1.775), displayed the ability to generate above-average effects given an economy-wide change.

Two industries were found to be key regional forest sectors, Sawmills and Paperboard Container Manufacturing. Only Sawmilling, though, clearly possessed above-average tendencies in both its backward and forward linkages ($BL_j = 1.226$ and $FL_i = 1.775$). Sawmills in western North Carolina utilize higher quality,

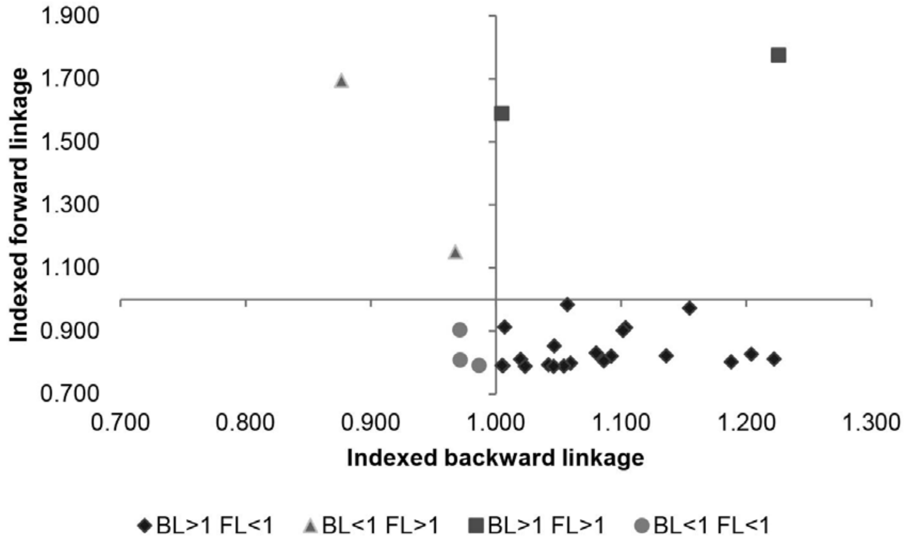

Figure 1—Plot of forest sector forward vs. backward linkages.

Appalachian hardwood sawtimber to produce lumber for the region's wood furniture manufacturers.

Paperboard Container Manufacturing was more sensitive to economy-wide changes (FL_i = 1.590), as its output is used as packaging for the distribution of a wide variety of goods. But, it was not an overly strong source of generating additional spillover effects (BL_j = 1.005). Other sectors that were found to have an above-average linkage in one direction but could not be considered key in the strictest interpretation were Veneer and Plywood Manufacturing (BL_j = 1.155 and FL_i = 0.973), Paper Mills (BL_j = 1.057 and FL_i = 0.984), and Commercial Logging (BL_j = 0.968 and FL_i = 1.151).

The results suggest forest industries in the region are strongly connected to their upstream suppliers. But because the forest industries produce specific goods required by a select few number of sectors, a high proportion of output is exported from the region. This potentially makes the western North Carolina forest sector a significant contributor to the region's export base. In fact, only five industries export less than 50 percent of their output. On the other hand, this reasoning also made it logical to find the forest-based forward linkages were much weaker relative to the regional average.

Key sector analysis can be a valuable tool for developers. However, applying a one size fits all approach to its conclusions would likely be inadequate. Its straightforward application is perhaps best suited for use as a screening tool that provides information for making much more complex decisions. One limitation of identifying key sectors is that it focuses solely on the linkages contained within the total requirements matrix. The results should rather be viewed in context.

The ability to multiply effects across the economy may not mean a great deal if the sector itself is a small contributor in the regional economy. One way to alleviate this is by referencing the absolute size of each industry. Compared to the economy's average output, for example, both of the key sectors identified in this study (Sawmills, \$338 million, and Paperboard Container Manufacturing, \$966 million) had above-average regional sales. By the output criterion, both sectors could indeed be viewed as key.

A more fundamental approach would be to adjust each sector's linkages by their appropriate ratios of exogenous to total output. Properly multiplying the total requirements matrix by the matrix of diagonalized ratios would yield the net backward and forward linkages (Oosterhaven 2004). A forest sector's ability to either actively or passively transmit ripple effects throughout the region would again be evaluated versus a benchmarked value of 1.000. Key sectors would have both net backward and forward linkages greater than 1.000, meaning the economy overall exhibited dependency on forest sector j to generate exogenous change. This approach, though, should still be used in conjunction with a measure of size in order to establish sectoral importance.

SUMMARY

Forest-based sectors in western North Carolina demonstrated overall strong backward linkages, with only five industries showing BL_j < 1.000. Just one of those five showed $BL_j < 0.950$. However, due to overall weak forward linkages, only two sectors, Sawmills and Paperboard Container Manufacturing, were identified as key sectors with both a forward and backward linkage greater than one. Two other forest-based sectors, Commercial Logging and Support Services for Agriculture and Forestry, also showed $FL_i > 1$ due to their providing support for locally grown and harvested timber. It is likely that the overall weak forward linkages in forestry sectors are at least partially due to a high proportion of output being exported from the region to feed select sectors that require such products. Therefore, it is also very possible that forest sectors in western North Carolina are significant contributors to the region's export base.

Key sector analysis is limited as it focuses only on linkages within the total requirements matrix and does not account for the size of a sector's contribution to the regional economy. Further analysis which adjusts sector linkages based on their ratio of final demand/output would provide a more complete picture of the strength of forest sectors in the regional economy. Such analysis would also need to be interpreted with an eye to a sector's overall contribution to the regional economy.

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LABOR MARKET IMPLICATIONS OF CHANGES IN THE DEMAND FOR FOREST SECTOR PRODUCTS

Obed Quaicoe, Jeffrey P. Prestemon, and Luba Kurkalova[1]

The study quantifies the dynamics of U.S. Southeast forest sector employment and wages in the last 40 years, and elucidates the relationship between the sector's employment and demand for the sector's products. Using county-level, 1990–2014 data for eight Southeastern States, we fit a log-linear model of demand for labor. We find that demand for forest sector output, as approximated by the number of issued building permits, has a positive effect on the sector's employment, as measured by the employment per establishment. The effect is statistically significant at a 1 percent level of significance in all States considered except Mississippi, where the corresponding p-value is 0.103. We estimate the elasticity of employment with respect to the number of building permits to be 0.084, 0.189, 0.108, 0.077, 0.051, 0.147, 0.139, and 0.097 for Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, and Tennessee, respectively. The elasticity of employment with respect to wage, as measured by the average weekly wage, is -0.101, -0.176, -0.074, -0.116 for Alabama, Florida, North Carolina, and South Carolina, respectively. As the estimated impact of wage is either positive or not statistically significant for the other four States, current work focuses on alternative model specifications.

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THE PINE STRAW INDUSTRY OF NORTH CAROLINA: A PRELIMINARY CONTRIBUTIONS ANALYSIS

T. Eric McConnell, Clayton B. Altizer, and Bill Pickens[1]

Abstract—Our goal was to determine the economic contributions pine straw processors provide to North Carolina. North Carolina longleaf pine acreage in straw production was estimated using government and university sources. A nonscientific survey provided information on straw prices received ($/bale). A pine straw enterprise budget adapted to North Carolina was bridged with IMPLAN's input-output accounts to develop a complete pine straw industry production function. A single industry contributions analysis was performed, where processors resided in NAICS 1153 Support Activities for Forestry (IMPLAN 19).

North Carolina longleaf pine straw was valued at $34.8 million to the processor, directly accounted for 355 jobs, and generated $17.5 million in value added. Spillover effects were 134 jobs and $14.5 million of value added in other sectors. Total contributions were 499 jobs and $32.0 million in value added. Type SAM multipliers were 1.405 for employment and 1.825 for value added.

INTRODUCTION

Needles of the longleaf pine (*Pinus palustris*) are prized as a mulch by homeowners and communities in the Southeast for their long length, color retention, and durability relative to the other southern pine species (North Carolina Forest Service 2011). Landowners managing longleaf pine plantations can look to pine straw harvesting as an intermediate income opportunity that is compatible with their long-term objectives when practiced responsibly. In cases of extended timber rotations, a significant increase in land expectation value can even be realized (Roise and others 1991). Also, entrepreneurs seeking to participate in pine straw activities can do so at perhaps a more favorable level of investment than that required by other options, such as timber harvesting and sawmilling.

Pine straw's share of the forest economy is not insignificant where its value is tracked. Georgia's annual analysis found pine straw's farm gate value was $79.5 million in 2014 (Wolfe and Stubbs 2015). Direct sales of pine straw in South Carolina amounted to $11.0 million paid to processors in 2015 (Hughes 2015).

Processors make a variety of intermediate and value added payments for capital, labor, energy, materials, and services. To meet the industry's needs, its suppliers also make purchases, so their outputs may ultimately be used as pine straw inputs. Further, employees in the pine straw industry and its supply chain purchase local goods and services in their communities. Each round of spending introduces additional linkages that become increasingly more complex. A full accounting of these transactions can provide insight into the industry's economic contributions to the State.

Pine straw sales in North Carolina exceeded $25 million when last surveyed in 1996 (Hamilton and Megalos 1997). Little, though, is known regarding the State's pine straw industry today. This study's goal was a first attempt at providing that description. Published sources and communications with colleagues and clientele provided us a foundation on which to classify industry spending and sales activities. These data were then used to conduct an analysis-by-parts in the IMPLAN model (IMPLAN LLC 2015). Economic contributions were described as direct, indirect, and induced for employment and value added.

METHODOLOGY

North Carolina pine straw industry contributions were based on the harvesting and processing of longleaf pine straw exclusively. To our knowledge, little to no loblolly pine (*Pinus taeda*) is being raked in in the State, except in possible cases where it occurs in conjunction with longleaf pine. North Carolina longleaf pine timberland acreage on sites capable of producing at least 50 cubic feet/acre/year was obtained from the North Carolina

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Forest Service and estimated to be 350,000 acres. We set a minimum site productivity of 50 cubic feet/acre/year to be considered feasible for straw production.

We determined a percentage portion of North Carolina longleaf pine timberland in straw production by using Georgia as a template. We downloaded estimates contained within the U.S. Department of Agriculture, Forest Service, FIA EVALIDator database for Georgia longleaf/slash pine timberland, which totaled 3.53 million acres. Georgia harvested straw on 626,917 acres in 2014 (Wolfe and Stubbs 2015), or 14.2 percent of the estimated State total available for production. We assumed a likewise 14.2 percent of North Carolina's longleaf pine timberland acres produced straw in 2014, or 49,753 acres.

A nonscientific survey of pine straw producers and field staff with the North Carolina Forest Service provided information on straw production and the prices received by processors in recent years, which suggested a prevailing price of $3.50 per bale (square bales sized 2 cubic feet). This was similar to the earlier report on North Carolina pine straw (Hamilton and Megalos 1997). Production approximated 200 bales per acre, which was within the 10-year average range of production for longleaf pine stands (Dickens and others 2012).

A pine straw enterprise budget adapted to North Carolina was bridged with IMPLAN's input-output accounts to develop a complete pine straw industry production function. An enterprise budget was obtained from Robertson (1992), which provided potential revenues along with an itemized list of costs for a processor. Costs for straw stumpage were not present in Robertson's (1992) budget but were included here. We assumed the total straw stumpage costs were split 25 percent between processor-owned lands and 75 percent for that of all other forest land owners. Prescribed burn costs were eliminated, as our conversations with colleagues and clientele suggested no prescribed burning takes place on the State's pine straw acreage.

A 2014 social accounting matrix (SAM) for North Carolina was constructed using IMPLAN with timber income data customized as described by McConnell and others (2016). Economic multipliers were calculated in $(I - A)^{-1}$ fashion, where I is an identity matrix and A is the matrix of industry direct requirements, and were inclusive of households (Miller and Blair 2009). The costs were allocated to their most appropriate sector following Willis's and Holland's (1997) methodology. They were then converted to a per dollar of output basis to build an industry spending pattern (appendix table A.1). A critical assumption we made at this preliminary stage was that the spending per dollar of output coefficients, or industry direct requirements, was representative of the North Carolina pine straw industry in 2014.

Salary costs for labor from Robertson (1992) were assumed to be split 67 percent between workers and 33 percent for proprietors. This proportion was similar to that found in the labor income accounts for IMPLAN sector 19, Support Activities for Agriculture and Forestry (NAICS 115). We allocated additional income to workers via mileage payments while proprietors earned commissions (Robertson 1992). Land rent here was portioned 85 percent to value added and 15 percent to the farmland rental and leasing sector, which followed Willis's and Holland's (1997) handling of what they considered a bundled input. Margining was applied to ensure all costs to the best of our knowledge reflected producer prices, which is a requirement of the IMPLAN input-output model. We then allowed the industry activity costs plus value added to sum to 95 percent of the total industry spending pattern (Lazarus and others 2002). The remaining five percent was proportionally assigned to the spending pattern for IMPLAN sector 19 with any duplicative sectoral costs eliminated. Merging the two spending patterns provided us a complete pine straw industry production function.

Analysis-by-parts was conducted to determine pine straw industry spillover (indirect and induced) effects. Direct effects were calculated from the enterprise budget and productivity metrics provided by IMPLAN. Processors resided in IMPLAN sector 19, thus all inputs and effects associated with that sector were removed from the analysis to reflect single-industry contributions. Type SAM contributions multipliers were calculated based on the adjusted findings.

RESULTS

Industrial output of North Carolina pine straw processors totaled $34.8 million. Table 1 summarizes the direct effects of the industry as provided by IMPLAN. We estimated 355 full- and part-time jobs generated by pine straw production based on a productivity ratio of $98,000 of output per worker. Full-time equivalent jobs amounted to 305. Labor income totaled $8.99 million, or $25,330 per worker.

The enterprise budget approach to defining pine straw's contributions allowed us to more specifically define the makeup of value added. In addition to labor, a total of $7.8 million was paid to capital. Of that, $1.9 million was land rent, while equipment depreciation totaled $3.6 million. Additional miscellaneous payments, labeled "Other Operational Surpluses" in table 2, were approximately $2.4 million. Taxes amounted to $716,000.

Appendix table A.1—Pine straw industry production function, adapted from Robertson (1992)

Sector costs, IMPLAN code	Description	Coefficient
Inter-industry Direct Requirements		
Straw Stumpage, 3015	Landowners	0.18000[a]
Straw Stumpage, 3019	Processor-owned land	0.06000[a]
Handtool Manufacturing, 3236	Agricultural Small Tools (Producer Margin)	0.01029
Wholesale Trade, 3395	Trade Margins	0.00175
Retail Trade, 3399		0.00101
Air Transport, 3408		0.00001
Rail Transport, 3409	Transport Margins	0.00001
Trucking Transport, 3411		0.00010
Wholesale Trade, 3395	Miscellaneous Supplies	0.06640
Agricultural Equipment Rental, 3445	Equipment Rental	0.00144
Refined Petroleum Products, 3156	Fuel, Oil, etc. (Producer Margin)	0.00744
Wholesale Trade, 3395		0.00062
Retail Trade, 3399	Trade Margins	0.00020
Rail Transport, 3409		0.00002
Water Transport, 3410		0.00004
Trucking Transport, 3411		0.00014
Pipeline Transport, 3413	Transport Margins	0.00008
Insurance, 3437	Insurance	0.02878
Cellular Telephone Services, 3428	Telephone	0.00364
Business and Professional Services, 3515	Advertising	0.00222
Business and Professional Services, 3515	Dues	0.00022
Farmland rental or leasing, 3440	Rent- land, storage	0.00961
Equipment Repairs, 3507	Repairs	0.04318
Pesticides Manufacturing, 3172	Herbicide (Producer Margin)	0.01616
Wholesale Trade, 3395	Trade Margin	0.00553
Air Transport, 3408		0.00022
Rail Transport, 3409		0.00003
Trucking Transport, 3411	Transport Margins	0.00028
Industrial Bank, depository, 3434	Interest	0.00776
State Licenses, 3531	Licenses	0.00022
All Other Sectors[b]	All other costs	0.05000
Value Added Requirements[c]		
Worker Salary, EC	Labor	0.09955
Worker Salary, EC	Mileage	0.10384
Proprietor Salary, PI	Labor	0.04903
Proprietor Salary, PI	Commissions	0.00573
Depreciation, OPTI	Tractor- 50 hp	0.01876
Depreciation, OPTI	Tractor- 24 hp	0.00902
Depreciation, OPTI	Bushhog	0.00556
Depreciation, OPTI	Baler	0.02000
Depreciation, OPTI	Rake	0.00667
Depreciation, OPTI	Trailer	0.00740
Depreciation, OPTI	Pickup	0.03556
Land rent or lease, OPTI	Rent- land, storage	0.05446
Other Operational Surpluses, OPTI	Other	0.06756
Taxes, TOPI	Taxes	0.02056

[a] Coefficients based on costs calculated by the authors.

[b] n = 85, obtained from the IMPLAN 3019 Support Activities for Agriculture and Forestry spending pattern.

[c] EC = Employee Compensation; PI = Proprietor Income; OPTI = Other Property Type Income; TOPI = Taxes on Production and Imports, less subsidies.

Employment and value added are the better indicators of economic performance; therefore, further discussion on pine straw contributions will focus on these values. Spillover effects due to pine straw production totaled 144 jobs and $14.5 million of value added in supporting industries (table 3). Supply chain contributions from the indirect effect provided more value added for the State, while the induced effect generated a greater number of employees (likely due to the higher number of part-time jobs found in the services sectors).

In total, pine straw production in North Carolina contributed an estimated 499 jobs and $32.0 million to gross State product in 2014. Type SAM multipliers for employment and value added were 1.405 and 1.825, respectively. This means that for every 100 jobs in the pine straw industry, 41 additional jobs in other industries were supported. Likewise, for every $1 million of value added generated by pine straw activities, $825,000 of additional value added was contributed to gross State product from supporting industries.

DISCUSSION

The value of pine straw in North Carolina exceeded receipts for 14 agricultural crops in the State (U.S. Department of Agriculture National Agricultural Statistics Service and North Carolina Department of Agriculture and Consumer Services 2015). The $34.8 million received by processors fell between the $11.0 million in sales for South Carolina (Hughes 2015) and the $79.5 million reported by Georgia (Wolfe and Stubbs 2015). The total effects to North Carolina's economy were approximately 500 jobs and $32.0 million of value added to gross State product. The analysis-by-parts was based on defining a full pine straw industry production function, which can be used as a template for analysts seeking to assess other forest industries whose contributions may be aggregated into more miscellaneous sectors.

Table 1—Estimated direct contributions of the North Carolina pine straw industry

Employment	Labor income	Value added	Output
355	$8,991,000	$17,542,000	$34,827,000

Table 2—Direct value added of the North Carolina pine straw industry

Total value added	$17,542,000
Labor	$8,991,000
Capital	$7,835,000
Land rent	$1,897,000
Depreciation	$3,586,000
Other operational surpluses	$2,353,000
Taxes	$716,000

Table 3—Economic contributions of the North Carolina pine straw industry

Contribution	Employment	Value added
Direct Effect	355	$17,542,000
Indirect Effect	59	$8,177,000
Induced Effect	85	$6,299,000
Total Effect	499	$32,018,000
Type SAM Multiplier	1.405	1.825

This preliminary analysis was based on several assumptions requiring further study. One, processing was assumed to occur on sites with at least a moderate degree of productivity (≥ 50 cubic feet/acre/year) in both North Carolina and Georgia. More productive sites may be required to achieve the basal area necessary for optimal straw production relative to costs. Second, the relative proportions calculated from Robertson (1992) for Louisiana were held constant for our study. Management practices in North Carolina may require a different production mix. Further, the absolute values of production costs themselves, particularly equipment, have changed since Roberston's (1992) study. We do not know, though, how this may have impacted the production coefficients and our results. Focus group interviews and/or survey research could provide the information required to define the industry's fixed coefficient production function.

Defining the true contributions of a relatively smaller, rural, and in some instances transient, industry such as pine straw can be problematic. Pine straw harvesting and processing is not specifically spelled out in the NAICS to IMPLAN bridge table. Companies within the pine straw industry could be classified into other sectors, such as those under Forestry and Logging (NAICS 113), depending on their primary output.

We believed harvesting and processing pine straw would be classified in NAICS 115 Support Activities for Agriculture and Forestry (IMPLAN sector 19) because the harvesting and processing of agricultural crops are also grouped under supporting services. We would like to point out that by including pine straw activities under IMPLAN sector 19, and not creating a new column and row, we zeroed out all activities associated with this sector. This could have been an overly conservative approach because some supporting services could have been procured throughout the supply chain by businesses that were not related to pine straw production.

Also, the data utilized when constructing the SAM in IMPLAN are based on Government estimates. We used published information on timber income in the State to augment the ready-made model (Jeuck and Bardon 2015, McConnell and others 2016), but even this information is imperfect as it does not provide a local accounting of nontimber forest products such as pine straw. This study is a first step towards a more inclusive description of timber income in North Carolina.

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THE EFFECTS OF REGULATION AND MACROECONOMIC FACTORS ON SUPPLY AND DEMAND OF WILD AMERICAN GINSENG

Gregory E. Frey, James L. Chamberlain, and Jeffrey P. Prestemon[1]

Wild American ginseng (*Panax quinquefolius*) grows in eastern North America and the root is highly valued as a traditional medicine in Asia. Harvest for international trade has led to American ginseng becoming a species of concern, and is now regulated in the United States. Ginseng harvesting is common among rural poor communities in Appalachia and the Ohio Valley, and prices in excess of $700 per dry pound paid to the harvesters are common. We created a supply and demand model for wild ginseng root to provide evidence related to the sustainability or unsustainability of harvest levels, use of ginseng in times of economic crisis, and the impact of regulation. First, we found that harvest is negatively impacting biological reproduction of the species; that is, lower harvest efforts would allow ginseng to reproduce more freely and actually increase harvest yields. Second, limited evidence supports the idea that increases in unemployment increase harvest. Third, limiting harvest to plants 5 years old or older since 1999 has led to decreased harvests, which is the opposite of what we would predict given the first result above, but could re-equilibrate to a higher level in the future. The potential impacts of other possible regulations are examined.

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Forest Landowners and Ownership Trends

SEGMENTATION OF FAMILY FOREST OWNERS: THE CURRENT APPROACH AND FUTURE DIRECTIONS

Brett J. Butler, Sarah M. Butler, Jonathan R. Thompson, Mary Tyrrell, and Purnima Chawla[1]

Segmentation is a common technique used to separate family forest owners based on various attributes, such as ownership objectives. Using a utility maximization approach, it can be shown that family forest owners exist across financial and amenity dimensions, and these dimensions can be used to segment them into Amenity, Financial, Multiple-objective, and Indifferent categories. A traditional principal components analysis (PCA) and k-means clustering analysis approach was used to segment family forest owners who responded to the U.S. Forest Service's National Woodland Owner Survey. The PCA resulted in two principle components: one labeled amenity and dominated by beauty, nature, privacy, and recreation; and the other labeled financial and dominated by timber, investment, and hunting objectives. Individually, the PCA and cluster analyses proved stable, but the combined analyses were much less stable due to the lack of distinction among groups. Based on a random forest analysis, planning to improve wild habitat, attitude towards keeping woods as woods, concern for heirs, and non-hunting recreational activities most strongly predicted the importance of amenity values; planning to commercially harvest trees, having commercially harvested trees, size of forest holdings, and hunting activity most strongly predicted the importance of financial values.

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IMPACT OF TIMBER PRICE, LOCATION, AND OWNERSHIP ON TIMBERLAND TRANSACTION PRICES IN THE SOUTHERN UNITED STATES

Xiaorui Piao and Bin Mei[1]

Over 350 large timberland transactions in the Southern United States are examined with robust regressions to discover the influence of timber prices, locations, and timberland ownership on per acre transaction prices. The two types of timber prices are South-wide pine and hardwood sawtimber stumpage prices. The 11 Southern States are Alabama (AL), Arkansas (AR), Florida (FL), Georgia (GA), Louisiana (LA), Mississippi (MS), North Carolina (NC), South Carolina (SC), Tennessee (TN), Texas (TX), and Virginia (VA). The five types of timberland ownership are vertically integrated forest products firm (C-Corp), timberland investment management organization (TIMO), timber real estate investment trust (REIT), corporation outside the timber industry, and local government. Results show that only hardwood sawtimber prices have a significantly positive impact on transaction prices. Among the 11 States, NC and SC have positive effects on timberland prices, while AL, AR, LA, TN, TX, and VA have significantly negative effects. In regards to timberland ownership, separate seller or buyer types have no impact on timberland prices, but the combination of seller/buyer types suggests otherwise. When timberland is sold from C-Corps or REITs to TIMOs, or from REITs to firms outside the timber industry, transaction prices are significantly lower.

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WHO OWNS THE TIMBERLAND IN PACIFIC NORTHWEST AND INTERMOUNTAIN REGION?

Jagdish Poudel and Daowei Zhang[1]

Using the U.S. Department of Agriculture, Forest Service, Forest Inventory and Analysis data from 2001 to 2013, we examined the changes in timberland ownership dynamics, land-use conversion and management practices in Pacific Northwest and Intermountain regions. The preliminary results reveal that out of 74 million acres of the total timberland area, public agencies own and manage almost 50 percent, followed by nonindustrial private forest owners whose ownership share is around 28 percent. Furthermore, industrial timberland ownership is about 6.5 million acres. Timberland Investment Management Organizations (TIMOs) and Real Estate Investment Trusts (REITs) own and manage about 4.5 percent and 4.9 percent of the total timberland area respectively.

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SHORT-TERM FINANCIAL PERFORMANCE OF TIMBER REITS AFTER MAJOR STRUCTURAL CHANGES

Wanjing Hu and Bin Mei[1]

Several timber real estate investments trusts (REITs) had significant structural changes in the past 2 years. Weyerhaeuser and Rayonier began spinning off their non-timberland assets and became more focused on timberland management. Weyerhaeuser and Plum Creek proposed to merge to create a $23 billion timber behemoth. In this study, the short-term financial performance of timber REITs after these major structural changes is assessed. Event study and generalized autoregressive conditional heteroscedasticity model are employed to evaluate event-induced abnormal returns, volatility, and volume dynamics. The divestiture announcements had no significant impact on returns, while the merger announcement generated abnormal returns. In most cases, these events also increased asset volatility. There exists a positive correlation between the conditional variance of stock returns and trading volumes for all firms, signaling that they are influenced by the same underlying information flow.

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COMPARING THE FINANCIAL PERFORMANCE OF TIMBER REITS AND OTHER REITS

Xiaorui Piao, Bin Mei, and Yuan Xue[1]

The return and risk characteristics of three types of real estate investment trusts (REITs) in the United States are evaluated by the intertemporal capital asset pricing model (CAPM) and the multivariate generalized autoregressive conditional heteroscedasticity (GARCH) model. The three types of REITs are (1) timber REITs, which focus on timberland management; (2) specialized REITs, which focus on properties that are specialized in a single use; and (3) common REITs, which consist of all REITs except specialized REITs. Results from the intertemporal CAPM demonstrate that REITs behave like procyclical small and value stocks. Results from multivariate GARCH model show that the conditional volatilities of REITs rise more after good news and REITs as a whole respond positively to past shocks. Despite being a part of specialized REITs, timber REITs have large market capitalizations and no excess returns, and are insensitive to recessionary shocks. Timber REITs have the smallest unconditional variance and are most vulnerable to idiosyncratic shocks.

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STAKEHOLDERS IDENTIFICATION OF PLANTATION-BASED FOREST COMPANIES: A CASE STUDY FROM CHINA

Yu Xie, Robert Kozak, Rajat Panwar, Zuomin Wen, Anne Toppinen, and Meike Siegner[1]

Constant investments from stakeholders are the essential conditions for companies to realize their goals and sustainability. Companies perform corporate social responsibilities (CSR) to their stakeholders and make their stakeholder satisfied. Before companies make a stakeholder or CSR strategy, they need to identify their stakeholders. From the relationship of stakeholder and CSR, a 4-dimension Model of stakeholder identification is proposed in this paper. Forest companies have some special characteristics, as well as related stakeholders, especially in plantation-based forest companies. A case study of Chinese plantation-based forest companies with the 4-dimension Model is deducted in this paper and four domestic and multinational forest companies are investigated and compared with mixed quantitative and qualitative methods. The result indicates that: (1) key stakeholders of plantation-based forest companies are listed as employees, governments, local community, suppliers/contractors, customers and forest owners. These stakeholders are all related to the plantation process of forest in the context of Chinese forestry; (2) domestic and multinational companies vary on stakeholder identification, somehow it can be explained by scale of plantation and market region; (3) stakeholders identification of both domestic and multinational forest companies can be affected by the change of policy (tenure reformation of China), the efficiency of forest land usage, and the subsequent timber manufacturing.

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Forest Management

HOW TO SOLVE THE FOREST THINNING PLANNING PROBLEM? A NEW METHOD

Wan-Yu Liu and Chun-Cheng Lin[1]

Appropriate forest thinning is beneficial for continuing forest growing, increasing forest timber harvested, and protecting ecological environments, to achieve cycling and sustainability of forest resources. To lessen effects of global warming, this research will investigate the forest thinning planning problem that takes into account carbon sequestration and emission simultaneously, which were never considered in previous studies. The first improvement in the proposed algorithm is to additionally consider a spatial-operator-based local search scheme, which searches solutions based on the idea that a certain forest block may adopt the same forest thinning schedule with its neighboring forest block. The second improvement in the proposed algorithm is to filter the solution that is the same as the current solution to avoid the time wasted for searching repetitive solutions, when searching a neighboring solution during the algorithm process. To evaluate performance of the proposed methods, this research will do the best to design a simulation scenario to meet practical requirements of real forests, and implement and analyze performance of the proposed mathematical programming method and simulated annealing algorithm. Additionally, the simulation results will be compared with the conventional simulated annealing algorithm, and the statistics theory will be used to test remarkable significance on performance measures.

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FOREST MANAGEMENT UNDER THE GENERALIZED FAUSTMANN FORMULA WITH FOREST TAXATION

Sun J. Chang[1]

Up until this point, the literature on forest taxation has been based on the classic Faustmann formula. In this presentation, the results of incorporating various forms of forest property taxes into the generalized Faustmann formula will be discussed. Furthermore, the impacts of incorporating forest property taxation under the generalized Faustmann formula on the optimal harvest age and tax burden will be examined with case studies of site value tax and net forest productivity tax—the two main forms of forest property taxation in the South. Lastly, we compare and contrast our findings with results obtained under the classic Faustmann formula.

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FOREST ECONOMICS AS AN AGENT-BASED MODEL

Jesse D. Henderson and Robert C. Abt[1]

The Forest Agent-Based Landowner Economy (FABLE) model simulates a market where private forest landowner agents with heterogeneous preferences cast bids using normative decision-making rules. In doing so the model connects two areas of study important to the forest economics literature: (1) market behavior, and (2) behavior of individual forest landowners. The model constructs heterogeneity by separating agents into those who bid based on a valuation of timber and those who bid based on an amenity value. Furthermore, discount rates vary among agents and stand ages are drawn from an empirical age class distribution of North Carolina's southern coastal plain. Model outputs include price, removals, average harvest age and age class structure. A sensitivity analysis on demand curve and amenity value scenarios shows expected economic relationships as exhibited by model outputs and by implicit supply and inventory elasticities. For the majority of scenarios, these elasticity estimates, which are not pre-determined but represent an emergent property of the model, are consistent with empirical estimates. Equilibrium dynamics mimic long wave inventory cycles found historically, rather than simple steady state solutions.

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THE GENETICALLY MODIFIED AMERICAN CHESTNUT TREE AND SURFACE MINE RECLAMATION: MODELING THE POTENTIAL FOR RESTORATION

John Patrick Roberts, Jessica Cavin Barnes, S. Kathleen Barnhill, and Jayce Sudweeks[1]

Once one of the dominant tree species in eastern forests, the American chestnut is now considered functionally extinct, its population decimated by the introduction of a fungal blight in the early 20th century. For decades, scientists and amateurs have worked towards re-establishing the American chestnut in its native range using a variety of approaches, including the development of trees genetically engineered with blight resistance. Historically distributed throughout the Appalachian range, it has been suggested that genetically modified American chestnut (GMAC) trees can help restore former mine sites in the region while simultaneously re-establishing chestnut populations. Given the project's novelty, this paper uses a systems modeling approach to perform a foundational cost-benefit analysis of the use of GMAC trees in reclamation. Our paper integrates a biological model that captures probabilities of survival, growth, and reproduction, with a model that captures the costs associated with reclamation. We then estimate the potential benefits of choosing to use GMAC trees over other species. Using this approach, we are able to demonstrate that there is no extra cost associated with the use of GMAC trees. Additionally, based on historical timber values, GMAC trees have the potential to contribute a valuable monetary resource to former mining regions.

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OPTIMAL FOREST MANAGEMENT WITH SEQUENTIAL DISTURBANCES

Ying Xu, Gregory S. Amacher, and Jay Sullivan[1]

Previous work in forest management under uncertainty has been based on the assumption that landowners face a risk of only one damaging event during any forest rotation, with the main result being that landowners choose shorter rotation ages. These models are universal in an assumption that, should the disturbance arise in a given rotation, the landowner salvages what is possible through a harvest and replants to begin a new rotation. However, a real possibility exists that multiple disturbances may occur in one rotation, with the landowner waiting through the first or even a subsequent disturbance to harvest a stand and begin a new rotation. We develop a new approach that allows consideration of more than one event and allows flexibility in the timing of harvest, where tree recovery and damage may make continuance of the rotation, rather than starting over, a rent maximizing strategy. Thus, we generalize the body of literature beginning with Reed (1984). A Faustmann-Reed type rotation model is developed where the stand can be harvested after each disturbance, or at the rotation age. Results demonstrate that failure to consider these new features leads to suboptimal harvest decisions and suboptimal land rent values. Important parameters are found to be arrival rates of future disturbances and survival proportions and growth rates after each disturbance.

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VALUING DIFFERENT LOBLOLLY PINE PLANTATION REGIMES CONSIDERING TRADITIONAL AND NON-TRADITIONAL PRODUCTS AND MARKET UNCERTAINTIES

Umesh K. Chaudhari and Michael Kane[1]

Planted loblolly pine (*Pinus taeda*) provides sustainable supplies of traditional timber products and increasing bioenergy feedstocks. Planned research uses plantation study data for three sites with stands through age 18. A growth and yield simulator, SiMS, was used to project future growth and yield of stands of various densities and cultural intensities from the Lower Coastal Plain of the United States. Timber price changes according to market demand and supply, and this causes price volatilities. Accurate valuation of timber plantation regimes with traditional net present value (NPV) under such market uncertainties and price volatilities are questioned. Black and Scholes model (Black and Scholes 1973) was used to address this issue, and comparisons were carried out. Financial analysis from both approaches indicate the marginal revenue from higher density plantations of operational regime provides higher financial return than the intensively managed stands in high productivity sites; however, the opposite was true in lower productivity sites regardless of the densities. Bioenergy is the only regime that does not provide any incentive to the landowner; this is because of its low price and the high cost of plantation establishment. Traditional timber continues to be the major driver of a plantation regime, and the combination of both regimes provides the maximum return.

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ASSESSMENT OF PROFITABILITY OF COMPETING LAND USE SYSTEMS: BLUEBERRY PRODUCTION VS. LOBLOLLY PINE PLANTATION IN SOUTHERN GEORGIA

Suraj Upadhaya and Puneet Dwivedi[1]

As the pace of economic development accelerates in countries across the globe, the relationship between land use changes, conservation of natural resources, and socio-economic wellbeing is becoming more complex. Humans have modified their local environment for centuries mostly through land use and land cover changes (LULCCs) to meet needs for food, fiber, and fuel. This is clearly evident in southern Georgia where forest landowners are planting blueberries (*Vaccinum L.*) in place of loblolly pine (*Pinus taeda*) seedlings – an increasing trend which could significantly affect the pulpwood markets in the region. The overall goal of this proposed research is to assess LULCCs in southern Georgia by developing a new analytical approach for sustainably managing a mosaic of agricultural-forest landscapes over time. This project will determine the site suitability of blueberry production and then use the obtained results to project future land cover in this region. Then, a profitability analysis will be done for blueberry and loblolly plantations to determine suitable incentives needed to avoid loss of forest lands. In order to complete the project, advanced remote sensing and GIS techniques will be used. This project's results will inform forest landowners and policymakers about the sustainability of pulpwood markets in the region.

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Economics can affect decisions about forest resource management and utilization, and in turn, the ecosystem benefits received. In a time of market, policy, and climate transformations, economic analyses are critical to help policy-makers and resource managers make appropriate decisions. At the 2016 Meeting of the International Society of Forest Resource Economics (ISFRE), researchers and practitioners addressed these topics in 63 oral, 11 poster, 2 panel, and 2 keynote presentations. Abstracts and full manuscripts are grouped into 8 categories: Economic Impact Analysis, International Trade, Ecosystem Services and Non-Market Valuation, Policy and Governance, Climate Change and Bioenergy Markets, Traditional and Non-Timber Forest Product Markets, Forest Landowners and Ownership Trends, and Forest Management.

Keywords: forest economics, forest product markets, forest resource policy, land owners, resource management.

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