Southern Forest Economics Workers (SOFEW)
2012 Annual Meeting Agenda
Theme: Applied Forest Economics at Work
Host: Hancock Timber Resource Group

Renaissance Charlotte Suites Hotel Charlotte, NC March 19 – 21, 2012

Monday, March 19: Optional Pre-meeting Timberland Tour (confirmed tour participants only)

7:00 AM - 8:00 AM	*Breakfast (Atrium)*
8:00 AM – 8:30 AM	Tour Orientation, Leave Renaissance Charlotte Suites Hotel
5:00 PM	*Return to Renaissance Charlotte Suites Hotel*
3:00 PM - 7:00 PM	*Meeting Registration Open*
Tuesday, March 20	**Annual Meeting**
7:00 AM - 8:30 AM	*Registration and Breakfast (Atrium)*
8:30 AM - 9:00 AM	Introduction and SOFEW Update
	Hancock Timber Resource Group (Host) - Welcome Mississippi State University - SOFEW Update
9:00 AM - 10:00 AM	General Session *(Venice Ballroom)*
	Keynotes: *Applied Forest Economics At Work*
	Court Washburn, Managing Director and CIO, Hancock Timber Resource Group Brooks Mendell, President, Forisk Consulting
10:00 - 10:30 AM	*Coffee Break and Poster Viewing (Florence II)*
10:30 - 12:00 Noon	**Concurrent Sessions**
Session 1A (*Venice I*): *Moderator: J. Prestemon*	Fire: Mitigation, Costs, and Predictive Models
Session 1B *(Venice II):* *Moderator: K. Niquidet*	Timber and Product Pricing Behavior
Session 1C *(Venice III):* *Moderator: S. Petrasek*	Timberland Investment Diversification and Risk
Session 1D(Florence I) *Moderator: B. Keefer*	Forest and Land Use
12:00 Noon - 1:15 PM	*Served Lunch (Atrium)*

1:30 PM - 3:00 PM	**Concurrent Sessions**
Session 2A *(Venice I):* *Moderator: K. Arano*	Economic Valuation of Timber and Non-timber Values
Session 2B *(Venice II):* *Moderator: J. Buongiorno*	Carbon: Mitigation and Market Effects
Session 2C *(Venice III):* *Moderator: M.E. Aronow*	Wood Product Markets in the US: Current and Future Demand
Session 2D *(Florence I):* *Moderator: B. Keefer*	Timber Supply and Pricing
3:00 PM - 3:30 PM	*Afternoon Coffee Break and Poster Viewing (Florence II)*
3:30 PM - 5:00 PM	**Concurrent Sessions**
Session 3A *(Venice I):* *Moderator: S. Petrasek*	Timberland Trends and Pricing
Session 3B *(Venice II):* *Moderator: M.E. Aronow*	Forests Multiple Use and Values
Session 3C *(Venice III)*: *Moderator: S. Grado*	Wood Product Producers – Responding to Consumers
Session 3D *(Florence I):* *Moderator: I. Munn*	Forest Policy and Management
6:00 PM – 7:00 PM	*Reception and Graduate Student Poster Competition (Terrace Ballroom)*
7:00 PM – 9:00 PM	*Sponsor's Networking Dinner (Terrace Ballroom)* Sponsor's Dinner Presentation: The "New" Faces of Timberland Ownership

Wednesday, March 21

8:00 AM - 8:30 AM	*Breakfast (Atrium)*
8:30 AM - 10:00AM	**Concurrent Sessions**
Session 4A *(Venice I)*: *Moderator: N. Poudyal*	Environmental Values
Session 4B *(Venice II)*: *Moderator: TBD*	Community Forestry and Management Outside the US
Session 4C *(Venice III)*: *Moderator: S. Petrasek*	Biomass and Energy
Session 4D *(Florence I)*: *Moderator: P. Dahal*	Forest Management and Investment
10:00 AM - 10:30 AM	*Coffee Break (Florence II)*
10:30 AM - 12:00 PM	**Concurrent Sessions**
Session 5A *(Venice I)*: *Moderator: M.E. Aronow*	Timberland Investment Performance and Risk
Session 5B *(Venice II)*: *Moderator: R. Grala*	Carbon and Forest Management Decisions
Session 5C *(Venice III)*: *Moderator: J. Henderson*	Landowner Behavior
Session 5D *(Florence I)*: *Moderator: F. Cubbage*	Timberland Investment Performance
12:00 Noon	*Meeting Concludes*

DEPENDENCE BETWEEN AREA AND DURATION OF WILDLAND FIRES

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ABSTRACT

Wildland fires can have severe economic and environmental consequences. Two aspects of large wildland fires, area burned and fire duration, were assessed by extreme value statistics in this study. A complete dataset of 64 474 fire records from Mississippi between January 1991 and December 2007 were used in the assessment. Large fires occurred mainly between February and May, in the southeastern region, and started as debris and incendiary fires. Area burned showed more extremal properties than fire duration. A positive but moderate association existed between area and duration of wildland fires. In the univariate analyses, the generalized Pareto distribution with a heavy tail well characterized both the area burned and fire duration. The bivariate extreme value analyses found that the asymmetric negative logistic distribution provided the best fit to the data. The Pickands dependence measure was 0.391 for all the fires combined. The estimated parameter values were used to predict fire return levels by area and duration for different return periods. The techniques adopted in this study can be applied to analogous datasets for other countries. The results of fire patterns and extremal behavior could provide great benefits to forest planning and management.

UNTITLED

Charlotte Ham
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ABSTRACT

National wildfire suppression expenditures are rising with the expansion of the wildland-urban interface, drought and other weather conditions, and vegetation build up. Forecasting wildfire suppression expenditures can be challenging in part due to uncertainties associated with fuels and weather, along with the randomness in frequency and location of ignitions. Another challenge is methodological since the expenditure series may not be a stationary process with a constant mean and variance. In this paper, we will estimate suppression cost models in levels and first-differences for the nine Forest Service regions using data from 1995 to 2009. Then we will predict out of sample, 1977-2011, and compare their forecast performance for predicting spending at the national level. Best models will then be selected for forecasting wildfire suppression expenditures to be used throughout the budgetary process.

Socioeconomic Indicators of Wildfire Arson in the Southeast

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ABSTRACT

There have been many studies in criminology on the effects socioeconomic factors have on crime rates, yet relatively few have concentrated on the timber industry. The research to date varies with change in the dependent crime factor but shows some evidence of increased crime rates as socioeconomic condition worsens. This study focuses on wildfires caused by arson, which accounts for 23% of all wildfires in the southeast. Historical wildfire data from North Carolina, South Carolina, and Georgia was matched with county level socioeconomic data to create a working model to predict wildfire arson rates and risk factor parameters for each socioeconomic variable. The results were added to geospatial data to locate and map high risk areas and provide input data for other timber geospatial risk models.

SERIAL AND POTENTIAL COPYCAT INTENTIONAL FIRES AND THE MAGNIFICATION OF LAW ENFORCEMENT EFFORTS IN SPAIN

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ABSTRACT

Serial and copycat behavior is common in many crime types, particularly arson. Targets may be structures, vehicles, or outdoor vegetation. We report statistical evidence that intentional wildfires in Galicia, a region in northwest Spain containing half the nation's fires, exhibit patterns consistent with serial and copycat behavior. The behavior is identified through significant temporal and spatio-temporal autoregression in daily wildfire occurrences in the 19 forest districts of Galicia, over the years 1999-2006. One consequence of serial and copycat firesetting would be that arrests of individuals responsible for firesetting could have persistent and geographically large impacts. Our results show that an additional arrest of an intentional firesetter in Galicia leads to, on average, a permanent reduction of 140 intentional wildfires in a district, as measured by its temporal autoregressive effects on firesetting. This arrest may also contribute a potential reduction of an additional 24 fires through its spatio-temporal autoregressive effects on firesetting, as measured by effects of the arrest on wildfire occurrences in neighboring and distant districts of Galicia.

Do Forest Products Prices Display Long Memory?

Kurt Niquidet, Ph.D.

ABSTRACT

The behaviour of forest products prices has large implications for forest management and policy. Decisions such as the timing of harvesting and investment in new plantations depend on future price expectations and policy makers often are concerned about the persistence of price shocks for stabilization purposes. Previous research on the topic has been mixed and focused on the question of whether prices are integrated of order one (i.e., have a unit root) and are non-stationary or if they are integrated of order zero and are stationary and mean-reverting. In an effort to understand the price process for two key forest products (lumber and pulp), time series tests were applied to over 40 years of monthly pricing data. Using a modified Dickey-Fuller test, we rejected the null hypothesis of a unit root on most series. However, a separate test also soundly rejected a stationary null hypothesis. Such a finding led us to test whether forest products prices are fractionally integrated, exhibiting long memory. Estimates of the memory parameter (d) for various lumber price series ranged between 0.68 and 0.81 and for pulp it was 0.64. This implies that prices are both mean-reverting (in the sense that shocks die out) and non-stationary.

Spatial price linkage between forest products markets in the South and the Pacific Northwest

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ABSTRACT

The American lumber market has gone through various demand and supply shocks for 40 years, and has been particularly shaped by harvesting restrictions in the Pacific Northwest. Linkage of lumber markets has considerably changed since then, with the most observable alteration in price fluctuation. In this study, the degree of spatial price linkage between the South and Pacific Northwest markets was examined using the threshold vector error correction model and smooth transaction autoregressive model. Estimated results revealed that the two markets are cointegrated, but the degree and direction of spatial price transmission varied by product. Some lumber products made of southern pine gained market leadership over similar products from the Northwest. However, fir products were still influential when higher requirements were set on the products. Results of the smooth transaction autoregressive model showed that when one dimension product is concerned, pine product could maintain relatively higher price for a longer period, but it was not the case for the other two products. As supply and demand of lumber products are affected by various factors, such as environmental protection, housing starts, and also have effect on welfare distribution of market participants, these results provide guidance to understand the dynamics of lumber markets in the United States.

Keywords: price transmission; cointegration; threshold vector error correction model, smooth transition autoregression model

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Introduction

Spatial price transmission among separate timber markets is an important issue. This topic has become more relevant as the timber market stays in recession due to the decline of housing starts since 2006. With the background that almost 20 years has passed since execution of harvesting restrictions in federal forests in the Pacific Northwest, price integration between the South and Pacific Northwest lumber markets needs to be redefined and updated.

It was not until the early 1990s that West Coast changed the role as a quasi-monopolist in lumber market. Figure 1 shows the volume fluctuation related to the production of softwood lumber by regions. The South and West Coast were most important lumber suppliers domestically, with a constant increase in proportion of production volume from the South. At the beginning year when data was available in 1965, West Coast produced 73.05% softwood lumber when compared to only 23.21% produced by the southern region. But at the end of the trend in 2010, production from the West Coast and the South was almost equal, with aggregate production slightly smaller than 45 years ago.

Although lumber production from southern yellow pine and Douglas fir is comparable, , fir products are more preferable in the market. In accordance with Forest Research Notes, the nominal price for Douglas-fir sawlog (#2 sawmill grade) has a relatively stronger correlation (0.7024) with the lumber price collected from Random Lengths (Lutz, 2008). On the contrary, the price of southern pine sawlog is very poorly correlated with the lumber price (0.1114) (Lutz, 2008). With equivalent volumes of production, it becomes a big issue whether the two markets tend to develop more independently with local demand as a major target, or to be more cointegrated with arbitrage activities.

The concept of equilibrium among separate markets can be summarized into the law of one price (LOP) (Enke, 1951; Samuelson, 1952). LOP implies that arbitrage activities can prevent prices of a homogeneous good in different markets from being disparate when considering transfer costs (including transportation and transaction costs). The process of arbitrage depends on the fact that the price gap is able to exceed transfer cost, efficiency of information, and possibility of spatial trade. Arbitrage activities may enhance market efficiency and cause welfare changing among market participants. With some revision, the LOP can also be applied to the relationship between substitutes, as products made of Douglas fir and southern pine.

Although LOP is developed in the 1950s, economists have not reached consensus on this theory. Isard (1977) found explicit evidence against LOP by using disaggregated data for traded goods, which is confirmed by Richardson (1978), Thursby, Johnson, and Grennes (1986), Benninga and Protopapadakis (1988) and others with analysis on different markets. A possible drawback of these studies is a general undervaluation of transaction costs and delivery lags. Therefore, models adopting cointegrations have gained popularity and provided compelling evidence for LOP. For example, Buongiorno and Uusivuori's (1992) examined the LOP for the US pulp and paper exports, Bessler and Fuller's (1993) for regional wheat markets, and Michael, Nobay and Peel's (1994) for international wheat prices.

Since then, economists have begun exploring LOP with a variety of non-linear models, but not until recently have they developed tools, most typically in the form of regime switching models, to depict market dynamics between two divided markets. In general, two categories are always mentioned as regime switching models. One category contains a range of Markov-switching (MS) models wherein regimes are supposed to be determined by exogenous variable. Monte Carlo simulation is always applied to estimate MS models. The others are models with the assumption that regime switching is an endogenous process, such as self-exciting threshold autoregression model (SETAR) by Tsay (1989), threshold vector error correction (TVEC) model by Lo and Zivot (2001), Goodwin and Piggott (2001), and smooth transition autoregression model (STAR) by Terasvirta (1994).

Regime switching model is employed as a tool by empirical studies across economic cycle, finance, energy natural resource economics, agricultural economics, and others. For example, Meyer (2004) adopts TVEC model to estimate the integration of European pig market, and concludes that it is a proper method to examine the existence of "band of non-adjustment" when it is difficult to test models with two different thresholds. Deschamps (2008) adoptes both logic smooth transition (LSTAR) model and Markov switching autoregressive (MSAR) model to estimate factors that can impact the US unemployment. This study concludes that although both models provide very similar pictures, Bayes factors and predictive efficiency tests favor LSTAR model. Most recently, Goodwin et al. (2011) models nonlinearity induced by unobservable transaction costs involved in North American oriented strand board markets by estimating time-varying smooth transition autoregressions (TV-STAR). Empirical results suggest that nonlinearity and structural change are important features of these markets. Price parity relationship has also been proved by TV-STAR, which is consistent with economics theory.

However, few studies have investigated price transmission with regime switching between the northwestern and southern lumber markets. Therefore, the objective of this study is to examine history and trend in price transmission between northwestern and southern lumber markets with supply and demand shocks in the past 40 years, particularly before and after harvesting restrictions executed in the early 1990s. To achieve this goal, three specific problems are concerned: (1) to investigate the extent to which prices in two markets are cointegrated under the situations that they are not perfectly substitutes, and also, transaction costs take a considerable part of the lumber's overall cost; (2) to inspect the deepness and persistence of market shocks and the subsequent recoveries, and the role of arbitrage activity in the process; (3) to further subdivide lumber market by discriminating market dynamics of different lumber products. The results of this research not only provide new information to forest landowners and sawmill owners to reduce asset risks, but also help improving existing policies related to environmental protection and lumber market stabilization.

Regime switching models

Nonlinear time series models are more usually applied to the problem of price transmission compared to linear models. Traditionally, the concept of cointegration is always adopted by economists to describe problem of price transmission. However, there is no unified approach to evaluate market integration, because those studies are generally criticized for their ignorance of transaction cost and efficiency of information (Barrett, 2001; Barrett & Li, 2002), which are actually difficult to be included into econometric models. Therefore, nonlinear time series models, which respect transaction cost as threshold parameter, can be adopted in this study. Specifically, price transmission between timber markets in the South and Pacific Northwest is analyzed by threshold vector error correction (TVEC) model and smooth transition autoregressive (STAR) model.

Threshold vector error correction model

The vector error correction (VEC) model is suitably applied to price transmission of integrated markets where the causality relationship is unidentified. A specification of a VEC model is given in the form of following equation:

$$\begin{bmatrix} \Delta p_t^S \\ \Delta P_t^W \end{bmatrix} = \begin{bmatrix} \alpha_1 \\ \alpha_2 \end{bmatrix} + \sum_{i=1}^{k} \begin{bmatrix} \beta_i^{S,S} & \beta_i^{S,W} \\ \beta_i^{W,S} & \beta_i^{W,W} \end{bmatrix} \times \begin{bmatrix} \Delta p_{t-i}^S \\ \Delta P_{t-i}^W \end{bmatrix} + \begin{bmatrix} \varphi^S \\ \varphi^W \end{bmatrix} [\text{ECT}_{t-1}] + \begin{bmatrix} \varepsilon_t^S \\ \varepsilon_t^W \end{bmatrix} \tag{1}$$

with $\Delta p_t = p_t - p_{t-1}$, a_i are constants; $\varDelta p_{t-i}$ are lagged terms; *ECTs* are deviations; *βs* and *φs* are coefficients; *εs* are residuals. With this equation, price fluctuation of lumber products can be described by constants, lagged terms, and deviations from the long equilibrium.

However, this model is continuous and linear without the assumption of transaction cost, which implies that adjustment rate is constant regardless of the levels and directions of the deviation. This assumption is inconsistent with real reaction in lumber market, so may lead to biased results because of two reasons. On one hand, there is a probable "band of non-adjustment", when the transfer cost is greater than the possible arbitrage profit. On the other hand, price adjustment may occur in only one direction when the powers of the competitors are not balanced, so this equation may not be applicable when price goes beyond certain interval. Thus, error correction model has been developed by simulating transaction cost with thresholds, to estimate the dynamics in different regimes.

According to the two concerns, research on price transmission always assumes model with one threshold, as c_0, when the direction of trade is clearly identified (Balke & Fomby, 1997; Enders & Granger, 1998), or with two thresholds, as c_1 and c_2, when trade might occur toward either direction (Goodwin & Piggott, 2001; Obstfeld & Taylor, 1997). The former one is more preferable when transaction usually occurs in only one direction; the latter one is more preferable when the transactions are bidirectional. Error correction model with one or two thresholds (Hansen & Seo, 2002) is in the form of:

regime 1 $\begin{bmatrix} \Delta p_t^S \\ \Delta P_t^W \end{bmatrix} = \begin{bmatrix} \alpha_1 \\ \alpha_2 \end{bmatrix} + \sum_{i=1}^{k} \begin{bmatrix} \beta_i^{S,S} & \beta_i^{S,W} \\ \beta_i^{W,S} & \beta_i^{W,W} \end{bmatrix} \times \begin{bmatrix} \Delta p_{t-i}^S \\ \Delta p_{t-i}^W \end{bmatrix} + \begin{bmatrix} \varphi_1^S \\ \varphi_1^W \end{bmatrix}$ [ECTt 1]+$\begin{bmatrix} \varepsilon_t^S \\ \varepsilon_t^W \end{bmatrix}$, if $ECT_{t\;1} \leq c_0$ ($ECT_{t\;1} \leq c_1$ for three regimes)

regime 2 $\begin{bmatrix} \Delta p_t^S \\ \Delta P_t^W \end{bmatrix} = \begin{bmatrix} \alpha_3 \\ \alpha_4 \end{bmatrix} + \sum_{i=1}^{k} \begin{bmatrix} \delta_i^{S,S} & \delta_i^{S,W} \\ \delta_i^{W,S} & \delta_i^{W,W} \end{bmatrix} \times \begin{bmatrix} \Delta p_{t-i}^S \\ \Delta p_{t-i}^W \end{bmatrix} + \begin{bmatrix} \varphi_2^S \\ \varphi_2^W \end{bmatrix}$ [$ECT_{t\;1}$] +$\begin{bmatrix} \mu_t^S \\ \mu_t^W \end{bmatrix}$, if $ECT_{t\;1} > c_0$ ($c_1 < ECT_{t\;1} \leq c_2$ for three regimes) (2)

(regime 3 $\begin{bmatrix} \Delta p_t^S \\ \Delta P_t^W \end{bmatrix} = \begin{bmatrix} \alpha_5 \\ \alpha_6 \end{bmatrix} + \sum_{i=1}^{k} \begin{bmatrix} \zeta_i^{S,S} & \zeta_i^{S,W} \\ \zeta_i^{W,S} & \zeta_i^{W,W} \end{bmatrix} \times \begin{bmatrix} \Delta p_{t-i}^S \\ \Delta p_{t-i}^W \end{bmatrix} + \begin{bmatrix} \varphi_3^S \\ \varphi_3^W \end{bmatrix}$ [$ECT_{t\;1}$] +$\begin{bmatrix} \xi_t^S \\ \xi_t^W \end{bmatrix}$, if $ECT_{t\;1} > c_1$, for three regimes only)

For the two-regime model, unidirectional transaction is assumed, with the direction per se examined by the sign of the threshold. For the three-regime model, it is assumed that regime 2 is the "band of non-adjustment". When deviation is between c_1 and c_2, no matter it is positive or negative, prices will respond weakly until deviation goes beyond the band and switches to regime 1 or regime 3. The latter model can also be employed to analyze asymmetric price transmission by examining different thresholds values and other coefficients. Selection between the two models can be done by applying some statistical criterion, i.e., the AIC value when the number of lags keeps constant.

Three steps are followed to estimate a TVEC model. Firstly, given that non-stationary is an important property of time series data, the augmented Dickey-Fuller (ADF) unit root test is applied to confirm this property of the data. Once proven non-stationary, the Johansen method is used to test cointegration between pairs of prices. However, data's nonlinearity may reduce the power of these tests. As the second step, ECM without threshold is estimated by the Johansen method. The number of lags, k, is chosen by minimizing AIC value. Finally, TVEC model is estimated by adopting proper threshold c. The search follows the procedure of Hansen and Seo (2002), and relies on the log determinant of the estimated error covariance matrix to maximize the likelihood.

After c is fixed, statistical significance is calculated with Lagrange Multiplier (*sup-LM*) test or bootstrap method proposed by Hansen and Seo (2002). When *sup-LM* test is used, the cointegrating value is estimated from the linear VEC model. Then, conditional on this value, the LM test is run for a range of different threshold values. The maximum of those LM values will be reported. However, *sup-LM* test can be misleading because the standard cointegration tests can run into considerable power loss, when the alternative is threshold cointegration (as TVEC model), as demonstrated by previous studies (Pippenger & Goering, 2000; Taylor, 2001; Seo, 2006). Therefore, a *sup-Wald* type test has been developed by Seo (2006) to test the null of no cointegration against threshold cointegration. The power of Seo test is significantly greater than the *sup-LM* test, with a residual-based bootstrap proposed, and the first-order consistency of the bootstrap established.

Smooth transition autoregressive model

For some processes, it may be inappropriate to assume that the threshold is sharp; so Teräsvirta (1994) introduces smooth transition autoregressive (STAR) models which allow the autoregressive parameters to change slowly. Following his method, a basic STAR model of order m for U_t is specified as

$$U_t = \alpha_0 + \sum_{i=1}^{m} \alpha_i U_{t-i} + \mathrm{F}(\bullet)\,(\beta_0 + \sum_{i=1}^{m} \beta_i U_{t-i}) + \varepsilon_i,\ \varepsilon_i \sim IID(0, \sigma^2) \qquad (3)$$

where U_t is the log-level of pine-fir price ratio; U_{t-i} is U_t's *ith* lagged term; αs and βs are coefficients. $F(\bullet)$ denotes the transition function; by it is bounded between 0 and 1, the structure of the model can be changed in a smooth manner. With c as the threshold, the model's structure varies depending on whether the ratio is in a peak, (i.e., $U_{t-d} > c$) or a trough (i.e., $U_{t-d} < c$) regime, when d is the delay lag parameter.

In practice, two forms of the transition functions are commonly considered: the exponential specification and the logistic specification, respectively, written as:

$$F(\bullet) = 1 - exp[-\gamma(U_{t-d} - c)^2] \qquad (4)$$

$$F(\bullet) = \{1 + exp[-\gamma(U_{t-d} - c)]\}^{-1} - 1/2 \qquad (5)$$

where γ is slope, and c is threshold, or, location parameter. Equation (4), which is the exponential transition function, has symmetrically bell-shaped distribution around equilibrium level, with c bounded between 0 and 1. The logistic function, which is Equation (5), is asymmetric about c, so local dynamics are not the same for low and high values of involved U_{t-d}. The parameter γ measures the speed of transition between two regimes. Equation (3) and (4) form the exponential STAR (ESTAR) model; and Equation (3) and (5) form the logistic STAR (LSTAR) model.

On one hand, the ESTAR model is slight generalization of the exponential autoregressive (EAR) model of Haggan and Ozaki (1981). It may also be treated as a generalization of a special case of a double-threshold TAR model (Teräsvirta, 1994). On the other hand, both two regime autoregressive model with abrupt transition and linear AR(m) model are nested in LSTAR model (Akram, 2005). The LSTAR model is reduced to a self-exciting threshold autoregressive model with threshold value c, if γ is tremendously large: $F(\bullet) = 0$ for $U_{t-d} \leq c$ but $F(\bullet) = 1$ for $U_{t-d} > c$. Then, the regime switching becomes instantaneous. The LSTAR model is reduced to an AR(m) model if $\gamma = 0$, i.e., $F(\bullet) = 1/2$ for all values of U_{t-d}.

When model fit between the two is considered, ESTAR model is selected when observations are symmetrically distributed on threshold. The reason is that the transition function of the LSTAR model is monotonically increasing, whereas the range of the observation stretches out on both tails of the transition function of the ESTAR model. Otherwise, ESTAR and LSTAR models are close substitutes for each other. Furthermore, an LSTAR model cannot be approximated by an ESTAR model when threshold is *c* is large. To testify which one is more suitable for existing data, Teräsvirta (1994) suggests a sequence of tests to evaluate the null hypothesis of an AR model against a STAR model, and altogether LSTAR model against ESTAR model. The tests are conducted based on the auxiliary regression for a chosen value of *d*:

$$U_t = \alpha_0 + \sum_{i=1}^{m} a_i U_{t-i} + \sum_{i=1}^{m} (b_{1i} U_{t-i} U_{t-d} + b_{2i} U_{t-i} y_{t-d}^2 + b_{3i} U_{t-i} U_{t-d}^3) + \xi_t \quad (6)$$

where ξ_t is the error term. The test of an AR(*m*) model against a STAR model is equivalent to conducting a joint test of:

$$H_0: b_{1i} = b_{2i} = b_{3i} = 0, i = 1,2, \dots m.$$

The value of d can be determined by conducting this test for different values of d in the range $1 \leq d \leq m$. If linearity is rejected for more than one value of d, then the value which brings the smallest P-value of STAR model is chosen. If AR(m) is rejected, appropriateness of logistic transmission function can be tested against exponential transmission function with a sequence of tests related to the auxiliary regression:

$$H_{03}: b_{3i} = 0, i = 1,2, \dots m \ | Reject\ H_0;$$

$$H_{02}: b_{2i} = 0, i = 1,2, \dots m \ | Fail\ to\ reject\ H_{03};$$

$$H_{01}: b_{1i} = 0, i = 1,2, \dots m \ | Fail\ to\ reject\ H_{02}.$$

The null hypothesis is tested against the alternative hypothesis by the F-test. The following decision rules are useful in the determination of LSTAR- or ESTAR-type nonlinearity. After rejecting the H0, carry out the three F-tests above. If the P-value of F-test of H02 is the smallest among the three, select an ESTAR model; otherwise, choose a LSTAR model.

Both ESTAR and LSTAR data can be estimated by conditional least squares following the steps given by Teräsvirta (1994). Considering joint estimation of {γ, c, α, β} is difficult when estimating an ESTAR model (Haggan & Ozaki, 1981), F(•) can be standardized by dividing it with the sample variance of Ut, which makes it easier to select a reasonable starting value of γ. Then a starting value of γ (γ=1 is often adopted) is selected, and the whole set of parameters is estimated by nonlinear least squares. If the algorithm does not converge, estimation can also be carried out by a grid for γ until a satisfactory specification has been found. Similar methodology can also be applied to the estimation of LSTAR model: diving F(•) by the sample variance of Ut, fixing γ and finding the specification of the model.

Data sources

Three pairs of monthly lumber prices are collected from the Rand Lengths Yearbook (Rand Lengths), including two pairs of dimensions, and one pair of stress made of southern pine and Douglas fir, separately. All variables and their names can be found in Table 1. Two pairs of prices start in January 1973, except that of 2×4 random dimension starts two years earlier. As a result of change of statistical criterion, price of 2×4 random dimension terminated at the end of 2010. The remaining two have been updated to the end of 2011. So the final sample sizes for the three pairs of prices are 480, 468, and 468, respectively.

Among the three selected products, kiln dried 2×4 #2 or #2 & btr. random dimension (DIM1) is one of the most commonly used lumber products. Kiln dried 2×10 #2&better random dimension (DIM2) can be regarded as a high-end lumber product. 2×4 #1 random 10/20 stress (STR) is better qualified than dimension 2×4, but is of lower price than dimension 2×10. Furthermore, stress made of fir is green since it can be dried in transportation, but stress of pine should be kiln dried before selling. Products in the same category made of southern yellow pine and Douglas fir are reasonable to be regarded as high-level substitutes when they meet indentical requirements of the same grade. This rule can be slightly violated when particular product is more preferable due to lower percentage of moisture during certain seasons of a year. However, the preference is limit when it is transferred to willingness to pay. So when considering the grades only, dimension 2×4 made of fir is more favored because this category may contain higher qualified products (standard and better) than pine products (#2). Finally, because the process of kiln drying costs time and money, stress made of pine is generally more expensive than the green stress made of fir.

Table 1 Summary statistics for three pairs of lumber prices and their ratio

Item	Sample size	Mean	St. error	Skewness	Kurtosis	ADF test	1st Diff(Δ)
WDIM1	480	271.202	95.386	0.4	0.625	0.59	5.85*
SDIM1	480	274.846	94.638	0.529	0.407	0.61	5.19*
WDIM2	468	327.282	95.454	0.596	0.262	0.72	4.87*
SDIM2	468	313.479	98.788	0.546	0.295	0.32	6.4*
WSTR	468	282.882	91.913	0.389	0.717	0.19	4.99*
SSTR	468	312.271	98.837	0.671	0.353	0.81	4.79*

Note: * indicates that ADF test is significant on 1% degree. Items starting with W and S are prices of Douglas fir and southern pine. DIM1 represents kiln dried 2×4 #2 or #2 & btr. random dimension; DIM2 represents kiln dried 2×10 #2 random dimension; STR is 2×4 #1 random 10/20 stress.

Empirical results

Descriptive statistics

Descriptive statistics for the three pairs of prices are reported in Table 1. Among the three, average price of the fir product is higher than that of pine product when DIM2 is mentioned. Two average prices of DIM1 are almost at the same level, with consideration that average grade for fir product is higher than that of pine product. For stress, average pine price is higher than that of fir; but that is probably because of different techniques of treatment. Furthermore, all six prices are positively skewed and fat-tailed. DIM2 can be regarded as the most standard product among the three categories with kurtosis close to zero. Correspondingly, given that rules for grading are relaxed, prices of DIM1 and WSTR are more extensively distributed.

Price fluctuations in the study period are shown in Figure 1. All three pairs of prices appear to be cointegrated, particularly the two dimension products. Moreover, all prices have gone through a dramatic soaring period around 1993 and began to descend around 2007. The harvest restrictions and the economic recession can be assumed as reasonable explanations for the phenomenon.

Results of unit root test and Johansen test

The ADF test is applied to examine nonstationarity of the prices. The lag length for ADF test is determined by choosing the lowest AIC value. The procedures proposed by Enders (2004) are followed to perform the regression. As illustrated in Table 1, the statistics reveal that unit roots cannot be rejected at the 10% level for all six prices, but all can be rejected at the 1% level for their first difference form. Thus, it can be concluded that all lumber prices are integrated of order one.

Linear cointegration between pairs of prices is examined by using the Johansen test. Results of the Johansen test are shown in Table 2. Six specific tests with trace or eigenvalue, modeling without intercept, with a constant or with a trend variable respectively, are conducted to each pair of prices. The lag length is selected based on the lowest AIC and BIC values. Results have shown that all the three prices of pine products are cointegrated well with those of fir. Thus, unlike conclusions drawn from Yin et al.'s study (2002), results of the Johansen test in this study support Law of One Price instead of geographically separated lumber markets.

Table 2 Results of the Johansen cointegration tests on lumber prices

Pairs of	Johansen λ_{max}			Johansen λ_{trace}		
Prices	Trend	Constant	None	Trend	Constant	None
DIM1	56.803***	55.9***	55.889***	70.15***	65.211***	64.788***
DIM2	41.943***	40.04***	40.014***	56.033***	51.857***	51.795***
STR	25.916***	22.477***	22.413***	31.856***	27.235***	27.1***

Note: Null hypothesis is the rank equals to zero. *** denotes significance at the 1% level. The critical values are from Enders (2004).

TVEC models are estimated series of pine and fir prices. Lag length for each pair of prices is selected by choosing the lowest AIC value of the VEC model, which is one for DIM1 and DIM2, and two for STR. As all the estimations with one threshold produce lower AIC values than those with two thresholds, TVEC model with one threshold is selected, implying that transactions for the three selected products are uni-directional. The Seo and Sup-LM tests are applied synchronously to examine the model fit. Although all three pairs reject null hypotheses of non-cointegration by the Seo test, null hypothesis of AR model cannot be rejected against TVEC model with Sup-LM test when fitting DIM1 and DIM2. However, sup-LM test can be quite misleading because the standard cointegration tests can run into considerable power loss when the alternative is threshold cointegration. Therefore, all three pairs of prices are estimated with TVEC model finally. Results of tests and estimated coefficients are reported in Table 3.

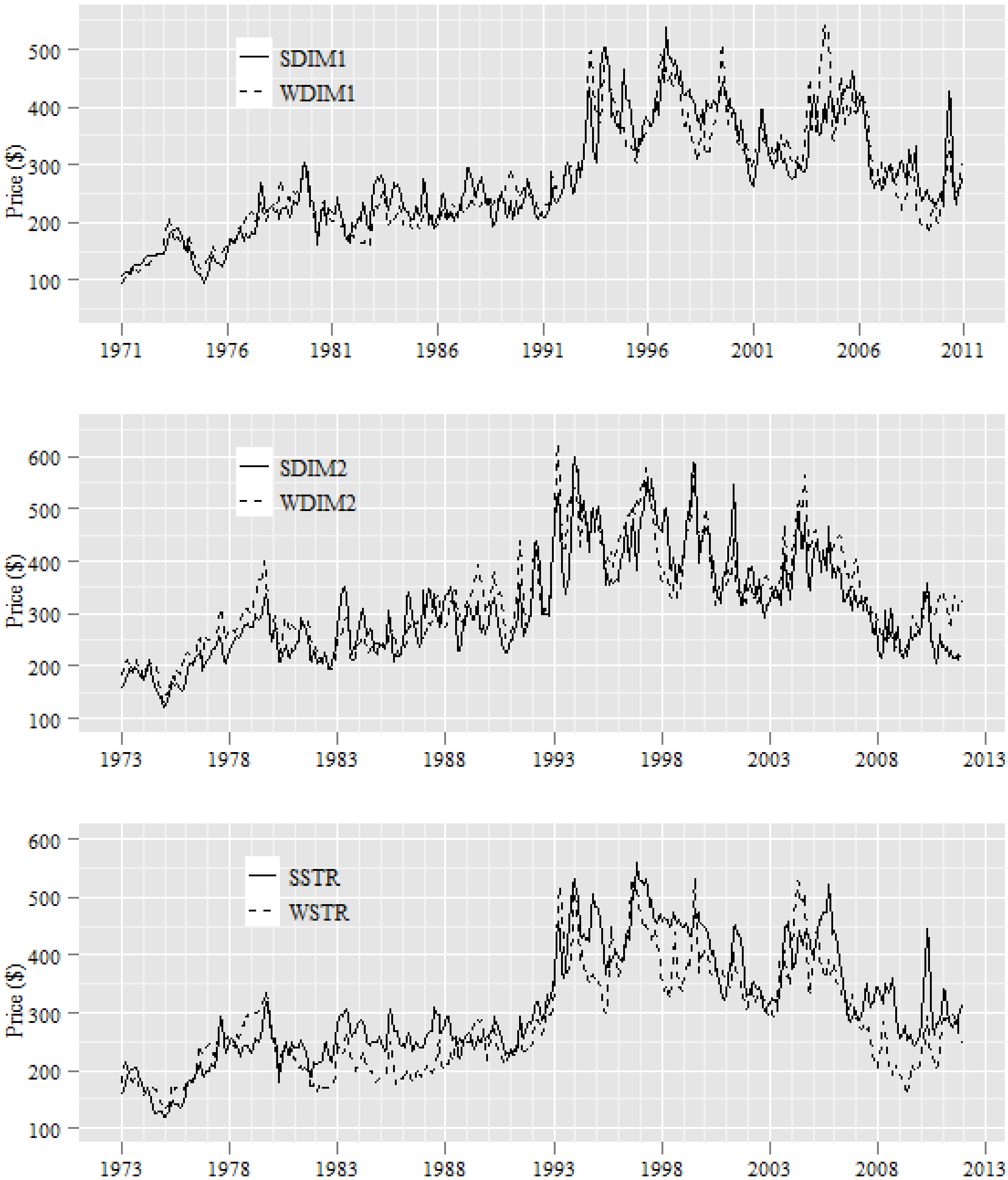

Figure 1 Three pairs of monthly prices of forest products selected from Random Length Yearbook.

Results of TVEC model

Estimated results vary by product. The threshold value is positive when estimating the model with DIM1. But it is negative when the model is estimated with the other two pairs of prices. The signs of the threshold can partially explain that lower regime of DIM1 and higher regime of DIM2 and STR, which can be treated as the "typical regimes", contain more observations than the corresponding regime, which are the "extreme regimes". All the three typical regimes contain the value zero, implying that price of pine product does not differ much from the price of fir product. It can be regarded as a signal that one product is the substitute of the other when one pair is concerned.

Table 3 Results from fitting the TVEC model on lumber prices and involved tests

Item	DIM1		DIM2		STR	
Regime	Low	High	Low	High	Low	High
Lags	1		1		2	
Tests						
Sup-LM	15.241		12.619		25.682*	
Seo Test	68.501***		49.955***		43.852***	
Model fit						
AIC	5391.308		5034.854		5373.974	
BIC	5320.425		4964.402		5270.423	
Coefficients						
φ^S	0.144***	0.26**	0.407***	0.077*	0.404***	0.043**
φ^W	0.01	0.144	0.108	0.07*	0.081	0.048**
α^S	0.002	0.04	0.068**	0.001	0.071**	0
α^W	0.007**	0.055**	0.035	0.002	0.004	0.002
$\beta_1^{s,s}$	0.238***	0.243*	0.045	0.214***	0.552***	0.356***
$\beta_1^{s,w}$	0.019	0.021	0.228	0.01	0.259**	0.086**
$\beta_1^{w,s}$	0.032	0.33***	0.021	0.023	0.177	0.074
$\beta_1^{w,w}$	0.201***	0.538***	0.036	0.288***	0.028	0.356***
$\beta_2^{s,s}$	—	—	—	—	0.044	0.087
$\beta_2^{s,w}$	—	—	—	—	0.317**	0.103**
$\beta_2^{w,s}$	—	—	—	—	0.056	0.048
$\beta_2^{w,w}$	—	—	—	—	0.32*	0.164***
c_0	0.133		0.119		0.186	
Percentage	79.3%	20.7%	21.5%	78.5%	7.5%	2.5%

Note: *, **, and *** denote significance at the 10%, 5% and 1% level, respectively.

The price of pine product has more influence in DIM1 market. Regime 1 for DIM1 is defined as an aggregation of prices with absolute deviation smaller than 13.3% from long-term equilibrium. When $273 is taken as the average price, this percentage is roughly $36. Instead of "non-adjustment band", prices are also adjusted in this regime, but much less responsively, implying that transaction from South to the Northwest is rare in this market. The typical regime contains 79.3% observations, with the remaining 20.7% observations in the extreme regime, where deviation from equilibrium is digested more quickly. Importantly, only are ECT coefficients of southern pine significant for both regimes. It implies that when there is a deviation, it is the pine price that shows reaction and brings market back to equilibrium. Furthermore, taking the significant coefficient from lagged term Δp_{t-1}^S to ΔP_t^W into account, pine price affects fir price in both short and long terms respectively, implying that adjustment in the extreme regime are two times as fast as that in the typical regime.

Transactions in the other two markets are commonly from the South to the Pacific Northwest. There are some other common points shared by DIM2 and STR markets: only the ECT coefficients of pine products are significant in the extreme regime. Adjustment rate in the extreme regime is about five and nine times, for DIM2 and STR, respectively, as large as that in the typical regime. These results imply that the adjustment of pine price is the propulsion bringing market back to equilibrium in the long term. The difference between the two markets is that in the short term, prices of DIM2 tend to be self-evolving, as none of lagged terms from one price to the other are significant in this market. All four lagged terms from fir prices to pine prices are significant when STR market is concerned. As coefficients of terms with one lag and two lags are of equivalent values but opposite signs in typical regime, influence from lagged term in this regime can be ignored. However, fir price reacts more severely in the short term when difference between two prices switches into the extreme regime, implying a more responsive behavior of fir product in STR market. Finally, the threshold for DIM2 is about \$39 (\$320 × 11.9%), and \$55 for STR. So thresholds are similar across the two dimension products with different directions, but it is higher in STR market, suggesting that arbitrage activity in this market is of less propulsion.

Results of STAR model

In this section, regime switching of price transmission between southern and western markets is analyzed with the STAR model. Log form of the pine-by-fir price ratio is regarded as the variable adopted in the STAR model. The AR models are estimated firstly to determine proper number of lagged terms. Lags of 11, 10 and 7 are selected for DIM1, DIM2 and STR, respectively, by minimizing the AIC values. Once number of lags is set, number of delays can be estimated by choosing the smallest P-value of H0 estimated by Equation (6). P-values with different delays from 1 to 10 are reported in Table 4. Delay numbers for the three ratios are 4, 9 and 3. Since auxiliary regressions have been set up, LSTAR and ESTAR specifications can be discriminated as the next step. Results of the group of F tests rooted in the auxiliary regression are shown in Table 5. None of H02 is rejected; instead, H03 is rejected by DIM1, and H01 is rejected by DIM1 and STR, indicating logistic transaction is more suitable when fitting the data of lumber prices. Final estimation of the STAR model is reported in Table 6.

Table 4 P-values of different values of the delay parameter for model fit

Price	P-value of the delay parameter									
Ratio	1	2	3	4	5	6	7	8	9	10
DIM1	0.6226	0.0166	0.0358	**0.0156**	0.2711	0.533	0.3381	0.2093	0.0539	0.1835
DIM2	0.4319	0.4505	0.5382	0.3226	0.6673	0.9895	0.7966	0.2167	**0.0613**	0.0623
STR	0.192	0.0537	**0.0083**	0.0121	0.0155	0.518	0.2652	—	—	—

Note: Bold numbers imply that this is the smallest P-value for selection of delay parameter.

Table 5 Sequential tests for type of nonlinearity on lumber prices

Pairs of prices	F-statistic [p value] H_{03}	H_{02}	H_{01}	Type of nonlinearity
DIM1	1.307 [0.218]	1.524 [0.12]	**2.044 [0.023]**	LSTAR
DIM2	**2.173 [0.019]**	1.399 [0.178]	0.716 [0.71]	LSTAR
STR	1.864 [0.074]	1.275 [0.261]	**2.587 [0.013]**	LSTAR

Note: Bold numbers imply that this is the smallest P-value for selection of model type.

Table 6 Results from fitting the LSTAR model on lumber prices

Ratio of Prices					
DIM1		DIM2		STR	
Item	Estimate	Item	Estimate	Item	Estimate
α_0	0.023**	α_0	0.348**	α_1	0.86*
α_3	0.298***	α_1	1.91***	α_1	0.671***
α_4	0.197***	α_4	0.624**	α_7	0.448**
α_7	0.104*	α_6	0.697***		
α10	0.098*	α_7	0.302*		
		α_{10}	0.869***		
β_0	0.092**	β_0	0.442**	β_4	0.739***
β_2	0.405***	β_1	1.364***	β_7	0.435*
β_4	0.357***	β_3	0.531**		
β_5	0.23**	β_4	1.137***		
β_6	0.208*	β_6	0.695***		
β_{11}	0.246**	β_7	0.549**		
		β_{10}	1.111***		
γ	52.262**	γ	14***	γ	40.092*
c	0.07***	c	0.165***	c	0.124***
ρ_1	0.084	ρ_1	2.108	ρ_1	1.979
ρ_2	0.254	ρ_2	0.057	ρ_2	0.805
AIC	2136	AIC	2136	AIC	2027

Note: *, **, and *** denote significance at the 10%, 5% and 1% level, respectively.

Furthermore, model dynamics can be analyzed with estimated parameters. LSTAR model is appropriate where F = 0 corresponds to the lower regime, and F = 1 corresponds to the higher regime. Briefly, the roots of LSTAR model of autoregressive order m can be calculated by $\hat{\rho}_1 = \sum_{i=1}^{m} \hat{\beta}_i$ and $\hat{\rho}_2 = \sum_{i=1}^{m} (\hat{\beta}_i + \hat{\hat{\beta}}_i)$. Threshold values are of identical signs compared to those estimated by TVEC model, confirming the transportation directions illustrated before. Threshold estimated from the ratio of DIM1 is 0.07. Moreover, coefficients in the lower regime are of comparatively smaller absolute values than those in higher regime, indicating that prices react more responsively in the higher regime. Root in the lower regime is 0.084, comparing to that in the higher regime as 0.254. Therefore, price equilibrium in the lower regime is more stable, or more attractive, than that in the higher regime. This result indicates that when pine price exceeds a certain degree of fir price in this market, adjustment is two times faster. Given that the average of the ratio is only 0.013, threshold value is large. However, 0.254 as a root is not high. Combining the two signs, relatively higher pine price can be tolerated in the dimension 2×4 market.

Situations are slightly different when they come to the markets of DIM2 and STR. Thresholds are negative for the two groups: □ 0.165 for DIM2 and □ 0.124 for STR. When threshold values are negative, lower regime is regarded as the extreme regime; in other words, when pine prices are lower than fir prices to certain extent, regime switching occurs. Also because threshold values are negative, coefficients of lagged terms are unstable in either regime. Thresholds can be revised to be positive if estimation adopts the ratios with fir price divided by pine price, but it is not necessary because values of roots and further conclusions will not be altered by the negative thresholds. Roots in the extreme regime are around 2 for the two products, indicating an explosive behavior when ratios go beyond the typical regime. Root of DIM2 in the typical regime is close to zero, indicating that it is only when fir price exceeds pine price by 16.5% or more that the market tends to adjust toward equilibrium. The results have confirmed that the two markets cannot accept high prices of fir products. However, the much higher threshold and also the reluctance of adjustment in STR market drawn by TVEC model is not supported by the results of LSTAR model.

Figure 2 shows trends in three price ratios and the regime switchings estimated by the LSTAR model. Trends in three ratios are not similar. Firstly, all three ratios go through a peak period from 1980 to the execution of harvesting restrictions around 1994. Secondly, there is a rebounding of pine prices in DIM1 and DIM2markets, which begins in the middle 1990s and lasts for about six or seven years, but this trend is not clearly expressed in STR market. Finally, after 2007, pine prices go beyond fir prices in the DIM1 and STR markets, which is not obviously observed in the DIM2 market.

Considering the lower regime of DIM1 and the higher regimes of the other two are the more stable regimes, stable regime is generally a mainstream under the study period for all the three products, similar to the percentages of lower regimes estimated by TVEC model. When harvesting restrictions are imposed on forests in the West, prices are all in the lower regimes. Therefore, this shock has a deeper and more enduring impact on DIM1 market. Similar explanation can also be extended to the apparent dent in the figure of DIM1 market around 2005, when several hurricanes destroyed hundreds of thousands acres of forests in the South. Last but not the least, when declining of housing starts begins in 2007, only STR market is in the typical regime, so this shock brings more severe and longer feedback in STR market than in the other two.

Discussion

The major objective of this study is to examine history and trend in price transmission between northwestern and southern lumber markets after demand and supply shocks, particularly before and after harvesting restrictions imposed in the forests of Pacific Northwest in the early 1990s. Estimated results have shown three major findings. First, non-linear models fit the data better than linear time series models. Second, prices of pine and fir products are showed to be cointegrated, indicating that lumber market is efficient. Third, pine products have gained some market power from fir products.

Potential nonlinear features of the lumber prices have been explicitly modeled with structural change. Results have shown that the nonlinear models fit the data better than linear models, when estimating spatial price linkage between the South and Pacific Northwest lumber markets. Both TVEC and STAR models indicate that transaction cost should be incorporated into the analysis. This conclusion is also consistent with the considerable portion of transfer cost in lumber price. Moreover, threshold value of one product is positive, but negative for the other two, when conducting estimations with both models. It implies that directions of arbitrage activities are not uniform among the three products, suggesting that transaction cost alone cannot fully explain market dynamics after supply and demand shocks.

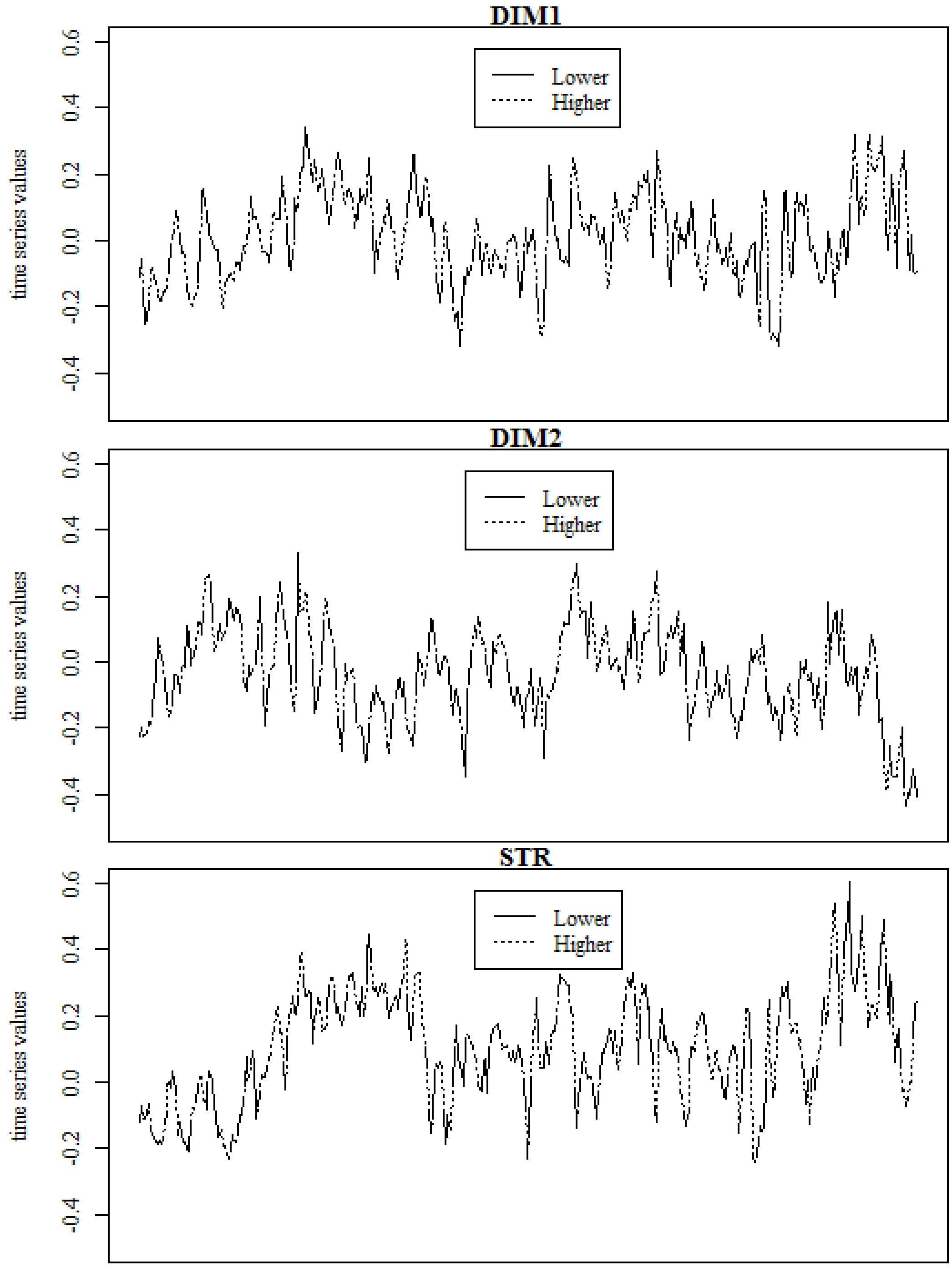

Figure 2 Phase of regime switching of three pairs of prices with LSTAR model.

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PRICE AND VOLUME DYNAMICS OF SECURITIZED TIMBERLANDS

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ABSTRACT

An increasing amount of timberlands have been securitized and available to investors in the form of Master Limited Partnerships (MLPs) or Real Estate Investment Trusts (REITs). In this study, Generalized Autoregressive Conditional Heteroscedasticity (GARCH) and extreme value models were utilized to examine the price and volume dynamics for six firms related to timberland investment. The total standing shares, daily trading volume, and average daily turnover rate for the MLPs was smaller than that for the timber REITs. Both the GARCH and extreme value models revealed a positive return-volume relation, which provided a strong empirical support to the mixture of distribution hypothesis. During extreme market movements, the MLPs had more stable return-volume relation while timber REITs experienced a much weaker positive return-volume association. Asymmetric return-volume relation existed for the MLPs while the relation was quite symmetric for the timber REITs.

ANALYZING RISK IN TIMBERLAND PORTFOLIO ALLOCATIONS: A COHERENT RISK MEASURE APPROACH

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ABSTRACT

The mean-variance portfolio optimization methodology relies on the assumption of normally distributed asset returns and uses the return covariance matrix as the risk measure. However, empirical studies indicate that the normality assumption is frequently not justified, and the covariance matrix of asset returns is likely not the appropriate risk measure. We analyze optimal portfolio allocations to timberland in the U.S. South and Pacific Northwest under the Value at Risk (VaR) and Conditional Value at Risk (CVaR) alternative risk measures and contrast the results with allocations obtained with the mean-variance methodology. The sensitivity of timberland allocations obtained from mean-variance and CVaR portfolio optimization procedures is assessed with re-sampling. Our results show that capital allocations to timberland do depend on the choice of risk measure. However, the differences in timberland allocations are relatively minor and do not impact the majority of institutional investors whose allocations to timberland are small relative to other asset classes.

REDUCING TIMBERLAND PORTFOLIO RISK THROUGH STRATEGIC DIVERSIFICATION

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ABSTRACT

Diversification is one of the most effective tools to manage return risk and volatility in a timberland investment portfolio. With an investor's perspective in mind, a general introductory overview of the topic covers (a) the key sources of timberland risk; (b) the four primary diversification strategies used; and (c) the best method to assess portfolio level risk for a basket of timberland assets.

DERIVATION OF THE TIMBERLAND DISCOUNT RATE AND THE DETERMINANTS OF RISK

Jacob Gorman, Dr. Larry Teeter, Dr. Yaoqi Zhang

ABSTRACT

In a timberland market characterized by a deficiency of information relative to many other types of investments, significant questions remain about the risk of an investment in timberland, both from an appraisal and an investment perspective. In a NPV analysis, or traditional Faustmann approach to deriving land expectation value, the discount rate enters the equation through the denominator in order to appropriately assign a present value to future cash flows. An alternative to thinking of this value as the 'discount rate' is to view it as the 'required rate of return'. This is the return that an investor requires to take on a project or investment. This paper describes an analysis of 400+ sales of timberland properties of at least 5000 acres. Through examination of existing inventories, anticipated future cash flows and a collection of factors related to the location of the properties, we sought to determine the anticipated rates of return necessary to support the sale prices reported for the properties. In addition, econometric methods were used to analyze the determinants of the discount rate. A statistical summary of the results is presented, as well as the methodology and a historical perspective of how the discount rate and timberland prices have behaved over the previous twelve years.

THE SIZE OF FOREST HOLDING/PARCELIZATION PROBLEM IN FORESTRY: A LITERATURE REVIEW

John E. Hatcher, Jr.[1]*, Thomas J. Straka*[1]*, and John L. Greene*[2]

ABSTRACT

In the early nonindustrial private forest (family forest) research literature, size of forest holding was identified as a critical variable impacting the propensity of family forest owners to invest in and manage small forest properties. This literature discusses relationships between size of forest holding and variables like forest owners' financial and asset positions, forest management objectives, use of a forest management plan and professional forestry advice, and use of forestry cost-share funding. Since then, the literature has expanded and now relates to the major problem of forest parcelization. We reviewed this literature for historical themes, technical considerations, and continuing ownership problems, emphasizing the current circumstances of forest parcelization and its historical roots in the size of forest holding problem.

Keywords: size of forest holding, nonindustrial private forest (NIPF), family forest, tract size, parcelization, private noncorporate forest owner

Introduction

There are about 11.3.million private forest owners in the United States; of those, 10.4 million are family forest owners (Butler, 2008). In the recent past, these ownerships were generally called nonindustrial private forests (NIPF). Large amounts of forest industry timberland shifted ownership to nonindustrial owners over the last few decades requiring a shift in definition to capture these family ownerships that tend to be smaller and individually owned.

Butler (2008) classified private forestland owners in the most recent family forest ownership study as industrial, other non-industrial, and family forest. Since most data comes from USDA Forest Service surveys, the definitions of these terms are relevant: NIPF owners are defined as "family and individuals who own forestland and corporations and other private groups that own forestland, but do not own and operate a primary wood-processing facility," This group is a subset of private forest owners," while family forest owners are defined as "families, individuals, trusts, estates, family partnerships, and other unincorporated groups of individuals that own forestland." NIPF owners are a subset of private forest owners and family forest owners are a subset of NIPF owners (Butler, 2008).

Family forests have long been recognized as crucial to maintaining sustainable forests in the United States and crucial to the nation's timber supply (Best, 2002). Early forestry literature calls them small forests (as many of them are small in size; over 60% of family forests are less than 10 acres in size), farm forests (many of the early family forests were parts of farm operations), and eventually NIPFs. The forestry literature now mainly uses NIPF and family forest to identify these forests.

There are regional differences in family forests across the country. This is due to factors like federal forestland ownership patterns, varying silvicultural practices, and mill patterns. Family forests control over a third of the nation's forested land and are important in all regions. These regional ownership patterns control many of the parameters that lead to owners practicing sustainable forest management. For example, in regions with many small family forests, it is more difficult to practice sustainable forestry with tracts containing just a few acres. Plus, the large number of family forest owners means there are a diversity of ownership and management objectives. Encouraging sound forest management has always been a challenge on these family forests. It is important to understand the motivations, limitations, and

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management objectives of family forest owners because they own a large portion of the nation's forestland and account for much of the nation's forest outputs (Majumdar et al. 2009).

Family Forest Ownership

The ownership of small forests has been a fundamental issue in American forest policy since the early twentieth century. The owners of NIPFs, as they were called at the time, were thought to be managing their forests less intensively than other ownership groups and, since they controlled much of the nation's most productive timberland, timber supply problems were likely to result. The NIPF has always been recognized as a critical component of national timber supply; the result of the NIPF not producing its potential contribution of timber would be a severe "timber famine" (Baker, 1933).

For the first few decades of the twentieth century the forestry problem was the concentration of timberland ownership by a few timber barons. Often the practice of these timber barons was to "cut and run". That is, they abandoned cut-over timberland and moved on to other tracts. Eventually this forestland moved into smaller private ownerships. Some of the earliest NIPF research studies concentrated on the growing stock on these smaller private ownerships and used a stocking index to compare management with other ownership classes (Folweiler, 1944; Folweiler and Vaux, 1944; James et al., 1951). While these indexes were arbitrary and did not take NIPF owner motivations and objectives into account, they led to an issue that still continues today: how to encourage better management of these small forests (Straka, 2011).

The forestry problem came down to a choice between federal regulation of private forestlands or some sort of federal-state cooperative effort to encourage improved forest management practices, especially in terms of reforestation and fire protection (Dana and Fairfax, 1980). The Capper Report in 1920 found "the kernel of the problem lies in the enormous areas of forestland which are not producing the timber crops that they should" and urged legislation "which will permit effective cooperation between the Federal Government and the several states in preventing forest fires and growing timber on cut-over lands" (USDA Forest Service, 1920). In 1924, Congress settled the argument with the passage of the Clarke-McNary Act that authorized federal-state cooperation in forest fire protection, tree planting, and forest extension (Cubbage, O'Laughlin, and Bullock, 1993).

A second major USDA Forest Service report in 1933, the Copeland Report, continued to stress timber depletion and exploitation by the private forest owners, but suggested state-federal cooperation and public aid to private forest owners to encourage rational forest management (Dana and Fairfax, 1980). By mid-century, small forest owners were identified as "the heart of the problem" (USDA Forest Service, 1948). Key concerns were the lack of technical knowledge by forest owners and the problem of small average tract size. The picture in 1948 was defined as “largely one of mismanagement, of exploitation on millions of small properties adding up to exploitation on a grand scale” (USDA Forest Service, 1948).

Gradually the NIPF problem was more thoroughly researched and the complexity of the “problem,” if there was one, was realized. The conventional view changed from one of imminent timber supply problems to NIPF owner motivations, rational behavior, and economic expectations (Le Master, 1978; Clawson, 1978; Clawson, 1979). Some researchers even questioned if researchers were properly identifying NIPF owner objectives (Royer, 1980). Considerable research since then has confirmed NIPF owners tend to follow economically rational behavior. Plus, other factors like individual motivations control behavior. All forest landowners are not alike and they have different objectives and views of their land (Schaaf and Broussard, 2006; Davis and Fly, 2010.).

The Classic NIPF Literature

Research on the small landholding or nonindustrial private forest (NIPF) began about 1940. Stoddard (1942) is one of the earliest NIPF landowner studies that mention size of forest holding as a factor that influenced a forest owner’s forest management behavior. Other studies specifically listed size of forest holding as a variable impacting forest management (Barraclough and Rettie, 1950; McMahon, 1964; Porterfield and Moak, 1977; Marlin, 1978; Holmes and Diamond, 1980), but most of the classical NIPF landowner studies measured the quality of forest management with devices like pine stocking index to determine if these important forestlands were being properly managed (Folweiler and Vaux, 1944; James, Hoffman, and Payne, 1951). Great weight was placed on certain forest owner variables in these early studies, like farm ownership, occupation, and education. The studies were simple surveys and little effort was extended to determine which variables exerted the most influence or might be correlated (Chamberlin, Sample, and Hayes, 1945; Poli and Griffith, 1948; Southern and Miller, 1956; Somberg, 1971).

Today parcelization is a major forestry problem that results from urban development and other pressures that decrease forest tract sizes. Size of forest holding concerns were about the same influences of average tract sizes. Size of forest holding was recognized as a factor controlling forest management options; depending on forest owner objectives, forest practices may be limited by these small tract sizes. Stoddard (1942) proposed that perhaps a “centralized operating organization” might be necessary to address “the difficulties of technical direction, marketing, and logging” inherent with small tract sizes. Parcelization as a concept is certainly what he described in 1942: “It should be pointed out that the larger concerns have followed the policy of selling off small parcels after an area has been logged. This practice has resulted in breaking up large forest units into tracts too small for efficient forest management. Many of the small-sized tracts are held for recreational purposes or used as farm woodlands. Nevertheless, the breaking up of larger tracts into many ownerships has tended to render numerous areas into units too small for economic forest operations, even though these units have not been and probably will be put into any other use" (Stoddard. 1942).

These early timber production studies noted that size of forest holding was a critical variable in terms of reforestation of cutover lands and quality of forest management (often measured with a pine stocking index) (Folweiler 1944). Chamberlin et al. (1945) noted that most owners of nonindustrial private forestland found their acreages were too small to adopt forest management practices. Their pine stocking index-based studies found this not to be the case. Similar studies in the same region found size of forest holding to be a key characteristic controlling timber production and that "larger nonindustrial holdings" were in an "appreciably more productive condition than the smaller ones" (Folweiler and Vaux 1944). While not all early family forest owner studies identified size of forest holding as a crucial variable influencing timber production, most did recognize it as a significant determinant of forest management intensity by this ownership group.

Gradually the focus of NIPF research moved from surveys of NIPF landowner characteristics to determining the relationship of these ownership characteristics to forest management practices and landowner behavior. Asset and financial position surfaced as a critical variable. Other variables that were obviously correlated with a forest owner's financial position gained importance: forest owner age, length of land tenure, inheritance of land, and education level. Better asset and financial position equated to better capital availability and, thus, more opportunity to manage the forestland (James, Hoffman, and Payne, 1951;Perry and Guttenberg, 1959; Cole and Smith, 1960; Worley, 1960; Hutchinson and McCauley, 1961; McClay 1961; McMahon, 1964; Fontenot and Marlin, 1974; Kingsley, 1976; Marlin 1978; Birch and Butler, 2001; Leatherberry, 2001).

Tract size or size of forest holding was also a focus of European forestry research in the 1960's and 1970's. Restricted capital for investment was a limitation for forest management on many properties; returns from forest management did not justify the investment in the eyes of many NIPF owners or limited markets for forest products discouraged tree intensive forest management (Zivnuska, 1959). By this time some NIPF researchers were questioning the marginal value of additional research on the subject (Keniston, 1962) and issues like absentee ownership expanded the discussion (Mullins,1960; Quinney, 1962; Noreen and Hughes, 1968) . The NIPF problem remained part of the literature, but it moved beyond the landowner characteristics studies, and many authors questioned the definition of the problem (Preston, 1956; Quinney, 1961; Plair, 1962; Yoho, 1962; Stoltenberg and Gottsacker, 1967). By the late 1970's and 1980's the NIPF problem was even being called a myth (Glasscock, 1978; Gould, 1978; Sedjo and Ostermeier, 1978; Clawson, 1979; Kaiser, Birch, and Lewis, 1982).

Royer (1980), reviewed NIPF research studies and identified the dependent variables used to assess the landowner's performance and noted that the earlier surveys appeared to have been somewhat misleading to policymakers. The dependent variables that were being measured were typically derived as those that were "publicly desirable rather than individually rational levels of performance" (Royer, 1980). Many of the studies in this category focused on psychogenic determinants of landowner behavior, like age, education, race, and occupation, and ignored sociogenic determinants. Not surprisingly, asset or financial position (or a proxy for asset position, like size of forest holding) often was found to be an important determinant of landowner behavior (Duerr, 1948; Clawson, 1957; Row, 1978; Cubbage, 1983; Straka, Wisdom, and Moak, 1984).

As the NIPF problem was being redefined, NIPF research was refocusing on actual management behavior of NIPF landowners. The importance of size of forest holding as a limiting factor in terms of economies of scale available to a forest owner in the establishment, management, and harvesting of timber became more apparent (Cubbage, 1982; Cubbage, 1983; Karppinen, 2005). In addition, size of forest holding is known to be closely correlated with the forest owner's asset position, impacting their availability of capital to invest in and manage forest land (Duerr, 1948; Straka and Wisdom, 1983). A classic study in Sweden (Streyffert, 1957), and other studies in the United States, focused on the effects of tract size (Knight, 1978; Gunter, 1979: Thompson and Jones, 1981; Fecso et al., 1982; Wiersum, Elands, and Marjanke, 2005: Bliss and Kelley, 2008; Zhang et al., 2009). The most recent NIPF studies and reports continue to examine this variable (Butler, 2008; Straka, 2011).

Current Family Forest Literature

The classic NIPF problems still exist today but they are sometimes defined differently. One thing that is certain is that there is a better understanding of their foundations. The family forest continues to be important and modern versions of the same problems constantly surface. Parcelization is a very good example of this. It is the decrease in average family forest tract size as owners gift or sell forest holdings. Multiple heirs might be a reason for parcelization. Urbanization is one of the main causes of parcelization and it is most pronounced at the urban-rural interface. Of course, the fundamental problem is that average tract size decreases and the economies of scale inherent in a larger tract are lost. Also, as forest owners change, oftentimes new owners have different management objectives (DeCoster, 1998; Sampson and DeCoster, 2000; Mehmood and Zhang, 2001; Best, 2002; Germain, Anderson, and Berilacqua, 2007; Moldenhauer, and Bolding, 2009; Haines, Kennedy, and McFarlane, 2011). Surprisingly, parcelization showed up in the classical literature as early as the early 1960's (Schallau, 1962; Schallau, 1965). The use of the word "fragmentation" should not be confused with the more current issue of forest fragmentation which refers to a disruption in the continuity of natural landscapes as NIPF land is divided among more owners or converted to more developed uses (Tyrrell and Dunning,2000). It is possible for parcelization to occur without forest fragmentation as long as the adjoined parcels retain their continuity without major disruption.

Forestry incentives developed as federal and state forest policies shifted to encourage forest management practices on family forests (especially reforestation and fire control). These incentives ranged from cost-share payments, technical assistance, technical advice, and favorable property and income tax policies. Most recipients of cost-share funding were timber-oriented family forest owners (Kluender and Walkingstick, 2000; Megalos, 2000; Stein, 2001; Greene, Straka, and Dee, 2004; Daniels et al., 2010). Cost-share recipients tend to be better educated and have higher incomes than the average family forest owner. Size of forest holding is one of the best predictors of cost-share use (Royer, 1987; Bliss and Martin, 1989; Hyberg and Holthausen, 1989; Lorenzo and Beard, 1996; Amacher, Conway, and Sullivan, 2003; Arano and Munn, 2006). NIPF and family forest owners have been provided additional forest management assistance through education and technical assistance programs. Like other assistance programs, certain landowners tended to receive most of the aid. Forest owners with higher levels of education and income were most likely to receive this type of assistance, and size of forest holding, again, was highly correlated with use of technical assistance (Bliss et al. 1997; Gunter et al., 2001; Kilgore and Blinn, 2004).

Size of forest holding and characteristics related to size of forest holding like occupation, education, and land tenure are positively related to landowner adoption of incentive-based forestry practices (Muench, 1965). One researcher suggested technical assistance would be more effective if it was leveraged through coordinated management of forest ownerships (Cloud, 1966). One problem was that family forest owners were not generally aware of forestry incentive programs and participation rates were not high. A second serious problem was that many family forests were very small and lacked the basic economies of size necessary to implement some forestry practices (Guttenberg, 1950; Redman, 1956; Bethune and LeGrande, 1960; Coutu, 1960; Herrick, 1960). From early on, forestry cooperatives were seen as a means to achieve economies of scale of small forest properties (Aaltonan, Herr, and Barraclough, 1938; Cope, 1943). Various efforts were attempted at locations across the country and the concept is still popular today. Usually its advantages lead to increased technical assistance, better information, and increased (combined) economies of scale (Josephson, 1963; Stoddard, 1964; Dempsey, 1967; Simon and Scoville, 1982; Rosen, Kaiser, and Baldeck, 1989; Sturgess, Zeuli, and Rickenbach, 2004; Hull and Ashton, 2008). Successful applications of forestry cooperative association techniques from other countries have been applied in the United States (Kittredge, 2005).

Current family forest research continues to stress size of forest holding as a key forest owner characteristic that influences forest management on family forests. Even the current family forest literature continues to show size of forest holding to be strongly correlated with many variables related to forest management, especially forest owners' technical knowledge, educational levels, and attitudes towards timber harvesting. These values and attitudes may be linked to the better asset position of these forest owners (Duerr, 1974; Cubbage, 1982; Kuuluvainen, Karppinen, and Ovaskainen, 1996; Butler, 2008).

Over time NIPF and family forest research has focused on timber production foregone due to lack of owner knowledge, insufficient capital, inefficient tract size, or a simple lack of interest (Duerr, 1948; James, 1950; Lord, 1963; McMahon, 1964; Birch, 1996). Consistently, income, education, and ownership objectives were correlated with forest management intensity, harvest and reforestation activities, and the use of cost-share assistance (Duerr, 1948; McMahon,1964; Marlin, 1978; Kaiser, Birch, and Lewis, 1982; Straka and Wisdom, 1983; Eagan, Gibson, and Whipkey,2001;Wicker, 2002; Belin et al., 2005; Butler and Zhao, 2011). While key variables influencing forest management activities by family forest owners are well-known, the relationship between these variables and the controlling variables is less well-defined (Streyffert, 1961; McClay 1961 Turner, Finley, and Kingsley, 1977; Kingsley, 1976; Bliss and Kelly, 2008). Owner income, asset position, occupation, and education are all positively correlated with size of forest holding. On an operational basis, size of forest holding is an easy statistic to obtain. Does size of forest holding exert strong influence on private forest management practices, or is it merely correlated with other variables that exert that influence? Size of forest holding has been shown to be an excellent proxy variable for these other variables (Straka, Wisdom, and Moak, 1984). For example, a professionally-prepared forest resource management plan is highly correlated with timber harvesting and reforestation activities, but also is positively correlated with size of forest holding (McMahon, 1964; Marlin,1978;Williams, Voth, and Hitt, 1996; Eagan, Gibson, and Whipkey,2001; Butler, 2008). There are over 75 years of NIPF or family forest research literature and there has been a consistent family forest problem. That problem is that family forests are a huge proportion of private forestland in the United States and, due to many factors, there are doubts they will produce the forest products that may be required by society. In terms of timber there could be timber supply problems and higher timber prices. Over time the complexity of the family forest and even the "problem" was realized. Perhaps, economically-rational family forest owners should not be producing forest products.

One fundamental relationship became apparent over time; family forests tended to be small and the trend over time was for them to become even smaller (parcelization). Size of forest holding quickly became one of the controlling variables. It apparently had much influence over a family forest owner's ability and motivation to practice forestry. If size of forest holding was not a controlling variable, it clearly was correlated with variables that impacted forest management. The forest parcelization problem is based on the same foundation as size of forest holding as a family forest problem: small forest tracts, lack of economies of scale, and disincentives to practice forestry.

The National Woodland Owners Survey (NWOS) is the official census of forest owners in the United States. It is created and maintained by the USDA Forest Service. The NWOS provides useful information in understanding who owns forestland, the size they own, insight into why they own forestland, and how they manage it, future intentions, owner demographics, and other questions concerning the current state and future state of their forestland (Butler and Leatherberry, 2004). Butler summarized the characteristics of landowners and size of forest holdings in a publication based on the most recent NWOS (Butler, 2008). His summary of size of forest holding relationships includes the following key variables from the NIPF/family forest literature:

- **Land tenure:** as the size of forest holding increases, the length of land tenure increases
- **Land transfers:** as the size of forest holding increases, transferred forestland increases
- **Ownership objectives:** vary by the size of forest holding
- **Timber management objectives:** as the size of forest holding increases, the probability that the owner has timber management objectives increases
- **Leasing:** as the size of forest holding increases, leasing by owners increases
- **Cost-share programs:** as the size of forest holding increases, participation in cost-share programs increases
- **Management plan:** as the size of forest holding increases, the percentage of owners with a management plan increases
- **Management advice:** as the size of forest holding increases, the likelihood of an owner seeking management advice increases
- **Absentee ownership:** as the size of forest holding increases, the percentage of absentee ownership increases

Parcelization

The NWOS does a good job of summarizing key family forest/size of forest holding relationships. The NIPF/family forest literature supports the survey results and from the prior discussion more relationships could be identified. Our point is that this valuable prior research can be applied to the related problem of parcelization today. Forest parcelization ensures that size of forest holding will remain a central concept in family forest management. It is the current term for the small tract problem and urbanization is keeping the problem visible. There is a rich body of NIPF and family forest research literature and tract size relationships are destined to continue to be a focus of this research.

Parcelization has been incorporated into the general forestry literature. Often authors mention a size of forest holding article when discussing the background of parcelization, but often they seem unaware of this connection. Sampson and DeCoster (2000) suggested the need for management strategies for small parcels and questioned what parcelization might do to conservation easement agreements. This is an early example of an excellent discussion of parcelization that touches on many aspects of the size of forest holding problem without ever mentioning that earlier version of the problem.

There are many parcelization articles from the turn of the century that introduce the current version of the parcelization problem (Harris and DeForest, 1984; Shands, 1991; Wear et al., 1999); Best, 2002; Harrison et al., 2002; Rickenbach and Gobster, 2003; Butler and Leatherberry, 2004;. Zhang et al., 2009; Haines et al., 2011; Robinson, 2012). The relationship of parcelization to population increases at the urban fringe or urban/rural interface are many, along with future implications (Vaux, 1982; Bradley, 1984; Macie and Hermansen, 2002; Kline et al., 2004; Nowak and Walton, 2005; Germain et al., 2007).

Creighton et al., (2004) looked at landowner characteristics of urban migrants in Washington state (or new small parcel owners) and analyzed the implication of variables like occupation, income (household and investment), management objective, and social responsibility. They also clearly define the differences between forest fragmentation and forest parcelization. Cleaves and Bennett (1995) in a SOFEW paper discussed unit, parcel, and ownership elements of holding size. They defined parcels as separate units in the ownership unit and noted that smaller ownerships have a greater variety of harvesting and silvicultural problems. Their article was technically not on parcelization, but shows that size of forest holding was still considered a problem as the parcelization problem was developing.

Mehmood and Zhang (2001) is one of the best examples of the interaction of parcelization and size of forest holding. They looked at "causes of parcelization in the existing literature," then, with minor exceptions, examined little of the size of forest holding literature. Their definition of parcelization was large landholdings shifting to smaller landholdings and they expected the process to lead to timber supply problems. They almost redefined the traditional NIPF problem in defining parcelization. They anticipated an increase in harvesting and transaction costs and a greater diversity of landowner objectives (less likely to include timber harvesting and forest management). Factors impacting parcelization were the same ones impacting size of forest holding: land tenure (as death rate increases, so does parcelization), taxes (increased taxes lead to increased parcelization, urbanization (increased urbanization leads to parcelization), income (as income increases so does parcelization), uncertainty (as environmental friendliness increases, so does uncertainty over ability to harvest timber and to perform other forest operations), and cost-share programs (forestry incentives make timber growing more profitable and less likely). All of these relationships could have been determined from a review of the family forest literature.

Other authors cover parcelization in the general context of the size of forest holding problem. Bliss (2003) describes the two fundamental shifts leading to parcelization: changes in the structure and pattern of private forest ownerships and changes in the social values of the United States as it changes from rural to urban to suburban. He does define the traditional NIPF problem of poor forest management on family forests, leading to poor forest productivity, and the unpredictable behavior of family forest owners. Other researchers see the implications of parcelization as increased harvesting costs, increased prescribed burning costs, increased regulation, cost-share funding shifting to urban areas, and general forest operations limitations (Kittredge et al., 1996; Zhang et al., 2004; Moldenhauer and Bolding, 2009; Moss and Hedderick, 2012). The general idea is that small parcel size increases production cost per unit in harvesting operations, plantations, and general forest management. This means timber supply is generally positively correlated with parcel or holding size.

Conclusion

About 75 years of research literature has developed around the NIPF or family forest problem. It has centered on the quality and intensity of management practiced on family forest lands, the behavior and motivations of family forest owners, and the implications for timber supply and forest sustainability. Gradually the motivations of these forest owners were shown to be economically rational. It is the nature of forest property to become parceled over time. Larger forest holdings are divided into smaller ones as estates are apportioned or development takes place. Clearly, population increases are leading to urbanization and increased parcelization at the urban/rural interface.

The issue of parcelization has been in the literature for about twenty years and has become a major issue in the last ten years. It has attracted research. Often, the background size of forest holding problem that is well-researched is not part of the foundation for current parcelization studies. We show the relationship between the size of forest holding and parcelization and alert forest economists to this historical body of knowledge.

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Timberland Dirt: An Analysis of Regional Land Value Changes for Large Timberland Transactions Over the Past Decade

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ABSTRACT

Over the past decade, prices for southern-pine timberland have increased substantially while a regional pine sawtimber price index lost about one-third of its value. Over the same time period, in contrast, northern-hardwood timberland prices were up only modestly while hardwood sawtimber prices ticked down slightly. The purpose of this paper is to investigate these different trends, with a focus on bare-land value trends in the respective regions.

Land values have increased in both regions, but at much different paces. We will review the implied hurdle-rate change for each region given the change in timberland price per acre and timber price per unit. In addition, we will track the price trends relative to capital flows into the two regions. Other potential explanatory factors to be discussed include regional market developments for woody biomass, regional forestry productivity improvements, and regional prices associated with an alternative land use: cropland.

The 2010 RPA Forest Assessment: Outlook for US Forest Conditions

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ABSTRACT

The RPA Assessment provides a snapshot of current U.S. forest and rangeland conditions and trends on all ownerships, identifies drivers of change, and projects conditions 50 years into the future. The RPA Assessment includes analyses of forests, rangelands, urban forests, forest products, carbon, wildlife and fish, outdoor recreation, wilderness, water, and the effects of climate change on these resources. This presentation provides an overview of forest condition forecasts for the United States organized by region. Forest forecasts account for socioeconomic change, driven primarily by land use dynamics, timber market activity (linked to the Forest Products analysis), climate change, and natural aging and successional dynamics. Findings provide insights into the comparative effects of these different vectors and analysis of multiple scenarios provides a range of plausible futures for the nation's forests.

Economic Impact Analysis of Tree Festivals: The Case of the National Cherry Blossom Festival, Washington D.C.

Kathryn Arano and Jinyang Deng

ABSTRACT

Tree related festivals or events are often part of the economic development strategy and image enhancement for both large cities and small towns. The National Cherry Blossom Festival (NCBF) in Washington D.C. has attracted over a million visitors and has contributed over $400 million annually in total economic impact for the city. This economic impact comes from visitor spending on a variety of activities and attractions related to the festival, including the Cherry Blossom trees. However, the main attraction of the festival is the viewing of Cherry Blossom trees. This paper therefore examines the economic impact of NCBF directly attributable to the Cherry trees. Direct economic benefits of trees in this study refer to the proportion of a visitor's actual spending that is directly attributable to the presence of trees. A visitor may be attracted primarily or partially by a tree festival to a city. Accordingly, the visitor's spending on lodging, foods, shopping, etc. should be primarily or partially attributed to the tree festival. Using the portion of festival spending directly attributable to the presence of Cherry Blossom trees in the festival, economic impact of these trees were estimated using IMPAN. Results indicate that the total economic impact of the festival attributable to trees range between $127.66 million-$135.81 in sales, 952-1,012 in added jobs, and $77.47 million-$82.41 million in value added, depending on the visitor estimate used in the analysis.

The Economic Value of Mangroves: A Meta-Analysis

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The Economic Value of Mangroves: A Meta-Analysis

Abstract: This paper presents a synthesis of the mangrove ecosystem valuation literature through a meta-regression analysis. The main contribution of this study is that it is the first meta-analysis focusing solely on mangrove forests, whereas previous studies have included different types of wetlands. The number of studies included in the regression analysis is 44 for a total of 145 observations. We include several regressions with the objective of addressing outliers in the data as well as the possible correlations between observations of the same study. We also investigate possible interaction effects between type of service and GDP per capita. Our findings indicate that mangroves exhibit decreasing returns to scale, that GDP per capita has a positive effect on mangrove values and that using the replacement cost and contingent valuation methods produce higher estimates than do other methods. We also find that there are statistically significant interaction effects that influence the data. Finally, the results indicate that employing weighted regressions provide a better fit than others. However, in terms of forecast performance we find that all the estimated models performed similarly and were not able to conclude decisively that one outperforms the other.

Keywords: wetlands; meta-regression analysis; nonmarket valuation

1. Introduction

Occurring at the intersection of land and sea within 30° of the Equator, mangrove forests thrive in coastal zones characterized by desiccating heat, choking mud, and salt levels that would kill most plants [1]. Nevertheless, mangrove ecosystems are among the most productive and biologically complex ecosystems on the planet and provide us with a myriad of essential ecosystem services [2–5]. Mangroves provide pivotal support to commercial fisheries acting as nursery, breeding, spawning and hatching habitats for offshore fisheries [6–8] and exporting organic matter to the marine environment, producing nutrients for fauna in both the mangroves themselves and in adjacent marine and estuarine ecosystems [9]. Mangroves also play a crucial role in shoreline protection, where they serve as natural barriers, dissipating the destructive energy of waves and reducing the impact of hurricanes, cyclones, tsunamis and storm surges. Several studies have documented that regions with intact mangroves were exposed to significantly lower levels of devastation from cyclones than those with degraded or converted mangroves [6,7,10,11]. Mangroves play a significant role in stabilizing fine sediments, contributing to shore stabilization and erosion control [3,9]. Additionally, mangrove forests are often a rich source of timber, fuel wood, honey, medicinal plants and other raw materials [7,9]. Finally, they attract ecotourists, fishers, hunters, hikers and birdwatchers providing a valuable realized or potential source of national income.

Despite the vital ecosystem services they provide, mangroves are threatened worldwide. In many parts of the world they are rapidly being converted to salt evaporation ponds, aquaculture, housing developments, roads, ports, hotels, golf courses, and farms. In South and Southeast Asia, where 41.4% of the world's mangroves occur [12], shrimp farms are being established on sites previously occupied by productive mangrove swamps [3]. Mangrove trees are also under exploitative pressure in areas, such as Indonesia, for their resources such as timber, fuel wood, and charcoal in addition to being cleared for agricultural purposes [13–15]. The mangroves that survive conversion are often threatened by oil spills, chemical pollution, sediment overload, and disruption of their sensitive water and salinity balance [1].

One reason mangrove forests are threatened is the public-good, non-market nature of many of the ecosystem goods and services they provide [16,17]. Due to the difficulty in estimating the value of the non-market ecosystem services, intact mangrove forests are often undervalued in benefit cost analyses of conservation versus other commercial land uses. Properly accounting for the multiple services provided by mangroves is necessary for making efficient choices between developing mangroves and management alternatives that entail more conservation and less conversion and exploitation of mangroves [14]. Developing accurate estimates for the value of intact mangrove forests is also needed for assessing damages from events such as oil spills. Oil spills, especially large-scale ones, have potentially devastating effects on mangroves, the flora and fauna sheltered by them, and the ecological services they provide [18]. Accordingly, mangroves are ranked among the most sensitive of shoreline regions in the Environmental Sensitivity Index (ESI) of the National Oceanic and Atmospheric Administration (NOAA), which measures how sensitive an area of shoreline would be to an oil spill [19].

The worldwide decline of mangrove forests has instigated a wide range of efforts to estimate the economic value of mangrove ecosystems [3,20–24]. Numerous studies have attempted to value mangrove ecosystems and their services in a wide range of geographic regions using a variety of valuation methods. Furthermore, there have been several meta-analyses conducted with regards to wetlands values in general [17,25–29]. However, to the authors' knowledge, there has been no attempt to undertake a mangrove-specific meta-regression analysis aimed at identifying underlying factors that affect annual per hectare mangrove values. Several studies have assembled data related to mangrove valuations conducted by other studies [16,30] without incorporating a regression component in the analysis while others have sought to identify a quantitative relationship between mangrove habitat area and shrimp production [31–33]. Therefore, the objective of this paper is to present a mangrove-specific meta-analysis examining the factors that determine mangrove economic valuations.

The rest of this paper is organized as follows. Section 2 reviews the different methods used to value the ecosystem services provided by mangroves. Section 3 provides an overview of the methodology used in the analysis. Data and summary statistics are presented in Section 4. Section 5 includes the estimation results and discussion followed by conclusions in section 6.

2. Mangrove Ecosystem Services and Valuation Methods

As noted above, mangroves provide a wide range of vital ecosystem services, which have an equally wide range of value. Economists generally decompose the total economic value of ecosystems into direct use, indirect use and non-use values. Direct use values refer to consumptive and non-consumptive uses that entail direct physical interaction with the mangroves and their services [34] such as outputs of fish, fuel wood, recreation, and transport. Indirect use values include regulatory ecological functions [34], which lead to indirect benefits such as flood control, storm protection, nutrient retention, nursery grounds for different species, and erosion control. Nonuse values include existence and bequest values of mangroves [3]. Table 1 summarizes these services, as well as the methods most commonly used in their valuation.

Methods for valuing ecosystem services vary depending on the nature of the service. For ecosystem functions that produce marketable goods and services, prices are used in several alternative methods. The first is the production function approach (PF), which is based on the notion that the ecological function is an input to the production process and its value is measured by its effect on the productivity of marketed outputs [35]. PF measures the value as the change in consumer surplus (CS) and producer surplus (PS) that result from the change in the quantity or quality of the environmental good [17,36]. The net factor income approach (NFI) measures the value of the environmental service as the change in PS by subtracting the cost of other production inputs from total revenue of the marketable good. The market prices (MP) method assigns the total revenue derived from the marketable goods and services as the value of the ecosystem service that generated them. However, MP estimates are often upward biased since the cost of other production inputs are neglected [17].

Table 1. Ecological mangrove functions, economic goods and services, types of value, and commonly applied valuation methods.

Ecological function	**Economic goods and services**	**Value type**	**Commonly used valuation method(s) ***
Flood and flow control	Flood protection	Indirect use	RCM MP
Storm buffering/ sediment retention	Storm protection	Indirect use	RCM PF
Water quality maintenance/nutrient retention	Improved water quality	Indirect use	CVM
	Waste disposal	Direct use	RCM
Habitat and nursery for plant and animal species	Commercial fishing and hunting	Direct use	MP NFI
	Recreational fishing and hunting	Direct use	TCM CVM
	Harvesting of natural materials	Direct use	MP NFI
	Energy resources	Direct use	MP NFI
Biodiversity	Appreciation of species existence	Non-use	CVM
Carbon sequestration	Reduced global warming	Indirect use	RCM
Natural environment	Recreation, tourism	Direct use	CVM TCM
	Existence, bequest, option values	Non-use	CVM

Source: Adapted from Brander *et al.* [17] who adapt with modifications from Barbier [37,38], Brouwer *et al.* [39], and Woodward and Wui [27]. * Abbreviations represent: market prices (MP), production function method (PFM), travel cost method (TCM), contingent valuation method (CVM), replacement cost method (RCM), and net factor income (NFI).

The contingent valuation method (CVM), currently the only method available to assess nonuse values, has been used for measuring both large discrete and marginal changes in ecosystem goods and services. CVM involves the use of surveys to elicit responses from people about their maximum willingness-to-pay (WTP) or willingness-to-accept (WTA) for hypothetical changes in environmental quality. The welfare measures estimated using the CVM are compensating and equivalent surplus [17,40,41]. Travel cost (TC) models are used to assess the recreational value of an ecosystem, such as evaluating the losses occurring from beach closures after oil spills [42]. The main idea behind the use of travel costs to assess the recreational demand of a site is that they act as implicit prices since an individual would have to incur these costs in order to complete the visit [39,43]. The use value of a recreational site is the sum of the total WTP of all individuals using that site [44]. TC measures the change in CS.

The replacement cost method (RCM) assumes that the value of the ecosystem service is equal to the cost of replacing it with a manmade alternative. Freeman [39] argues that three conditions must be met for the RCM to accurately estimate the value of the service. First, the manmade alternative must be the least costly method of replacement. Second, the service provided by the alternative must be of equivalent quality and magnitude. Third, individuals must be willing to incur this cost to replace the service if the natural resource is destroyed. Since replacement costs are not based on consumers' demand over ecosystem services, the RCM is not expected to provide accurate measures of CS and PS [17].

3. Methods

The goal of this paper is to use meta-analysis to assess the factors that potentially have a role in determining the annual per hectare value of mangrove forests. The most prominent advantage of meta-analysis is that it overcomes the problem of researcher subjectivity that characterizes literature reviews, whereby researchers often subjectively decide which studies to include and set aside others that they consider to be "weak". Instead, meta-analyses provide a statistical framework that incorporates evidence from the entire literature in a way that enables superior summarization and interpretation. Consequently, hundreds of meta-analysis applications have been carried out in the last few decades in the medical and social sciences [45,46].

Meta-regression analysis (MRA) is particularly useful for the purpose of examining the findings of empirical studies in economics. MRA involves a dependent variable drawn from each study, in addition to independent variables that encompass the range of factors underlying differences among the studies such as method, design and data [45,46]. Following Woodward and Wui [27], Brander *et al.* [17], Ghermandi *et al* [29] and Chen [28], we estimate the base semi-logarithmic model of the following form in matrix notation:

$$\ln(y) = c + X_m\beta_m + X_v\beta_v + X_d\beta_d + \mu \tag{1}$$

where c is the constant term, the dependent variable is the natural log of the annual per hectare mangrove values in 2010 US$, the β vectors represent the vectors of coefficients of the respective X matrices and μ is the vector of residuals, assuming well-behaved error terms. The independent variables encompass study characteristics, X_v, mangrove characteristics, X_m, and GDP per capita, $X_{d,}$. Variable definitions and summary statistics are displayed in Table 2.

Table 2. Variable definitions and summary statistics (in US\$ ha^{-1}·yr^{-1}).

Variable	Definition and units	Mean (St. dev.)	*N*
Study characteristics [b]			
Average value	Baseline category. [a] It depicts when the value is taken as an average over the entire area of mangroves.	0.74 (0.44)	108
Marginal value	1 if the value was calculated per hectare and 0 otherwise	0.260 (0.44)	38
Publication year	Year of publication	2000 (7.13)	146
MP	Baseline category [a]	0.411 (0.494)	60
Static PF	1 if a static production function was used and 0 otherwise	0.014 (0.117)	2
Dynamic PF	1 if a dynamic production function was used and 0 otherwise	0.068 (0.253)	10

Table 2. *Cont.*

Variable	Definition and units	Mean (St. dev.)	*N*
Study characteristics [b]			
Other regressions	1 if other regressions were used and 0 otherwise	0.034 (0.182)	4
NFI	1 if the net factor income method was used and 0 otherwise	0.192 (0.395)	28
RC	1 if the replacement cost method was used and 0 otherwise	0.212 (0.410)	31
CV	1 if the contingent valuation method was used and 0 otherwise	0.068 (0.253)	10
Mangrove characteristics [c]			
Area	Area of the mangrove site in logarithm form	8.65 (2.937)	146
Local	Baseline category		
Global	1 if exports or the contribution of foreign visitors represents a significant portion of value and zero otherwise		
Thailand	Baseline category [a]	0.219 (0.415)	32
Asia (excl. Thailand)	1 if in Asia but not Thailand and 0 otherwise	0.514 (0.502)	75
Middle East & Africa	1 if in the Middle East and Africa and 0 otherwise	0.075 (0.265)	11
Americas	1 if in the Americas and 0 otherwise	0.123 (0.33)	18
Other continent	1 if in Fiji or Micronesia and 0 otherwise	0.068 (0.253)	10
Protected	1 if site is designated as RAMSAR or provided any other legal protection by the state and 0 otherwise	0.486 (0.502)	71
Fisheries	Baseline category [a]	0.349 (0.478)	51
Forestry	1 if a forestry product and 0 otherwise	0.24 (0.43)	35
Recreation	1 if tourism, recreation, or research and 0 otherwise	0.096 (0.295)	14
Coastal protection	1 if coastal protection and stabilization or flood control and 0 otherwise	0.197 (0.40)	29
Carbon sequestration	1 if carbon sequestration and 0 otherwise	0.048 (0.214)	7
Nonuse	1 if a nonuse value and 0 otherwise	0.041 (0.199)	6
Water & air quality	1 if water and air purification or waste assimilation and 0 otherwise	0.027 (0.164)	4
GDP per capita	GDP per capita in logarithmic form	6.71 (2.345)	146

[a] Baseline category refers to that which is excluded for each categorical variable in order to avoid perfect collinearity. [b] The category of the TCM was removed since it was represented by only one observation. [c] The observations representing biodiversity, nutrient retention and traditional uses were excluded since each only had one observation.

Several points should be noted concerning the variables used in the model. The log form for area and GDP per capita produced better fitting models. The use of the continent dummy variables should capture location effects on mangrove values. The choice of Thailand to be the baseline category was based on the distribution of observations among the continents. Asia accounts for about 73% of the observations, while the rest of the continents are somewhat similar in the number of observations making them unlikely candidates for being the excluded category, since each accounts for only a small percentage of the overall dataset. In Asia, Thailand accounts for nearly a third of the observations, making it the largest contributor to our dataset. Alternatively, breaking Asia into the country level would generate more variables than would be appropriate given the total number of observations.

Consequently, we ran an *F*-test between the two models excluding Asia as a whole in one and excluding only Thailand in the other. We were not able to reject the null that the two models are not significantly different. Unlike other studies pertaining to wetlands in general, we have not included the latitude and longitude coordinates of the location of each site because unlike wetlands, which are geographically dispersed, mangroves predominantly occur in tropical regions and hence do not exhibit as much geographic variability [47]. The publication year is included to capture developments or innovations in valuation techniques, which may affect estimates. The GDP per capita represents the socio-economic conditions of the different countries the mangrove forests are located in.

A noteworthy point on the variables involves the accounting framework of the ecosystem goods and services valuation. Fisheries production is calculated either as a percentage of the total catch of the fish landings that can be attributed to mangroves, or by using a production function of some kind. The value of the fish, as well as that of forestry products, is computed by using market or surrogate prices. Costs of production may then be deducted or not, depending on the available data, resulting in either the MP or NFI approach being used. The value of coastal protection and stabilization is calculated either as the replacement cost of constructing man-made alternatives that would provide the service, the value of the property that may be damaged without the service, or the value attached by the community to the service. Tourism and recreation are computed as the revenues that accrue to the community by visitors, either local or foreign. Carbon sequestration is calculated as the product of the carbon sequestration rates in the site being valued and a global price of carbon, taken from a source such as the World Bank reports. Nonuse values are always assessed through surveys aimed at soliciting individuals' willingness-to-pay (WTP) for the existence, bequest, or option values of mangroves. A factor that may impact the magnitude of valuation is whether a significant part of the good or service is exported to a foreign market or whether the contribution of foreigners to values such as tourism is large. The categorical variable *Global* captures this factor.

The joint production of ecosystem services as well as the ecological health of the mangroves may also impact mangrove valuations. It is widely recognized that there are intricate relationships and tradeoffs between ecosystem services [48–50]. For example, the over-harvesting of mangroves for timber leads to high, unsustainable rates of deforestation that in turn, negatively impact the productivity of other services such as providing nursery and breeding grounds for fisheries. Even though the mangroves are generally harvested or cleared in all the studies we have covered, we have not found studies that explicitly value this tradeoff between different goods and service in mangroves. Some studies such as Ruitenbeek [14], Ong and Padilla [51] and Gammage [52] examine alternative management strategies that involve focusing on one service or another. For each strategy, they compute the potential value of the fisheries and/ or forestry values given certain assumptions. However, in this analysis, we have included only the values that represent the status quo and not potential values.

Even though the health of mangroves is expected to greatly impact their productivity, the ecological status is not always evident in the primary studies. To our knowledge there have been no attempts to monetarily quantify the loss in ecosystem services associated with deterioration in mangrove function performance. Possible exceptions could be Sanchirico and Mumby [53] and Sanchirico and Springborn [54], who used the percent of mangrove cover as an indicator of mangrove availability. Insofar as a reduced cover percent could be construed as compromised health, these papers can be considered as incorporating mangrove health in determining ecosystem service values. However, the two papers did not offer quantitative values per unit area of mangrove forest.

We estimate three separate regression models. In the first model, we use ordinary least squares (OLS) with robust standard errors [55]. In the second, we deal with the issue of the potential presence of outliers in the data by running a robust regression [56,57]. Finally, in the third model, we address the issue of the likely correlation between observations of the same study (the majority of the studies used in the analysis provide more than one estimate). We employ a method commonly used in the literature [29,58,59], giving each study the same weight by assigning each observation a weight equal to the inverse of the number of observations included in that study [60]. Since a comparison of the first two models reveal that the outliers present in the data have an effect on the results, the weighted regression is also estimated with the robust procedure used in the second model. In section 5, we report the results of the weighted model only since it generally provided the best fit. We report the results for the base OLS and robust models in the supplementary material.

4. Data

We compiled a total of 73 studies encompassing 352 observations of mangrove ecosystem service valuations of either monetary or physical quantities (e.g., cubic meters of timber or tons of fish). The list of studies is provided in supplementary material that is available upon request. The studies included journal articles, project reports, book chapters and 'grey literature'. Care was taken to avoid double counting valuations that were benefit transfers from other studies in our database. For estimates reported by the same author(s) in different studies, the oldest study was used, when possible. Every effort was made to obtain the primary studies where mangrove valuations are reported. However, whenever that was not possible, the valuations were taken from the citing study, and both the original and citing studies were referenced [61].

The data is described in two ways: quantities and values, both of which are expressed per hectare per year ($ha^{-1}\cdot yr^{-1}$). In the former, we describe the ranges of mangrove productivity of goods for which physical quantities were specified in the primary studies. The number of observations of physical quantities was 114 and their summary statistics are presented in Table 3. In the latter, only the values that are used in the regression analysis are included and are summarized by service and by valuation method.

Selecting and standardizing the values for the regression analysis entailed several steps. First, studies that reported only physical quantities but not monetary valuations were dropped, as were all observations with missing values. Some observations were reported on a per household basis, not per unit area and hence were also excluded from the analysis. Additionally, due to the inconsistencies between studies, we aggregated detailed estimates to make studies more comparable. For example, some studies report valuations for aggregate fisheries, while others break them down into fish, shellfish and shrimp, or fish and invertebrates. To overcome this, we aggregated all fishery-related goods into "aggregate fisheries". Reports of total economic valuations for the whole mangrove ecosystem were not used since they include different environmental services, which in turn entail different valuation methods. Accordingly, these estimates are not conductive to assessing the factors that affect annual per hectare mangrove value.

For standardizing valuations, we follow Woodward and Wui [27] and Brander *et al.* [17] in using country GDP deflators and PPP conversion factors taken from the World Development Indicators to convert all values to US dollars. Another issue was that some studies reported marginal values while others reported total or average values. Costanza *et al*. [62] assert that average productivity is more appropriate for the evaluation of large areas, while marginal values should be used in assessing small area values. We followed Brander *et al.* [17] and assumed that marginal and average values are equal, *i.e.*, that mangrove values exhibit constant returns to scale. We later include area as well as a categorical variable to denote whether average or marginal values were reported as explanatory variables in order to examine the returns to scale of mangrove area.

The final number of studies included in the analysis was 44 for a total number of 149 observations. The observations span 18 countries in Asia, the Americas, the Middle East and Africa. We created the variable ‘other continent’ to represent Fiji and Micronesia. The methods of valuation employed in our dataset include market prices, replacement cost (including costs avoided and maintenance costs avoided), net factor income, travel cost, and both static and dynamic versions of the production function approach. Several other production function models have been used, namely, the Schaefer-Gordon model, the Leontief production function, the Pauly and Ingles production function as well as a scaling model [63]. In the following analysis, we group the latter four production function models, into one variable, “other regressions”.

To allow more consistency with the definitions used in the valuation studies, we categorize the ecosystem services included in the dataset differently than in previous wetland meta-analyses. The services are: (1) fisheries, which depict the value of fish and shellfish supported by mangrove forests, including support as nursery and breeding grounds, (2) forestry, which includes timber, fuel wood, charcoal, and other forestry products, (3) recreation, which includes tourism and research expenditures, (4) storm protection and coastal protection and stabilization, (5) carbon sequestration, (6) nonuse values, including option, bequest and existence values, (7) water and air purification as well as waste assimilation, (8) nutrient retention, (9) biodiversity and (10) traditional uses from hunting, fishing and gathering. The last category includes a value that incorporated elements of both forestry and fisheries without segregating them into separate values and so was listed as a separate category.

Table 3. Quantities of goods provided by mangrove forests ($ha^{-1}\cdot yr^{-1}$).

Variable	Obs.	Mean	Std. Dev.	Min	Max	Median
Fish, shellfish, molluscs (Kg) *	29	539	748	10	2,500	126
Shrimp (Kg)	22	146	119	6	349	109
Timber (Kg)	3	5,976	6,658	289	13,300	4,340
Timber (m^3)	13	6	4	1	13	5
Fuel wood, charcoal (Kg)	6	5,140	11,393	6	28,370	511
Fuel wood, charcoal (m^3)	7	102	102	2	230	92
Carbon (Mg)**	34	5.27	15.41	0.02	90.5	1.69

* Two observations also include shrimp. ** Mg = metric ton = 10^6 g.

Table 3 shows that all goods are quantified in Kg., while timber, fuel wood and charcoal are further quantified in some studies in terms of m^3. In describing the productivities, we aggregated fish and shellfish together, but left shrimp separate since studies often focus on shrimp because of its higher value. It is not feasible to compare productivities across services because of their heterogeneity. Fisheries, either on-shore or off-shore, that depend on mangroves produce an average of 539 Kg·ha^{-1}·yr^{-1} of fish and shellfish and 146 Kg·ha^{-1}·yr^{-1}of shrimp. These averages lie within the value ranges found by other studies [16,64]. Mangrove forests produce on average 5,976 Kg ha^{-1}·yr^{-1} of timber and 5,140 Kg ha^{-1}·yr^{-1} of fuel wood and charcoal. The forests further sequester an annual mean of 5.27 Mg of carbon ha^{-1}·yr^{-1}. All medians are lower than the means, indicating skewed value distributions. However, some services are much more heavily skewed with long right tails, such fish and shellfish, carbon, and timber (Kg).

Figure 1 shows the distribution of observations by location. The observations are significantly concentrated in Asia [65]. The reason for this may be partly because mangroves in South and Southeast Asia account for 41.4% of the world's mangroves [12]. Another reason may lie in the motivations behind many of the studies, which were to carry out a cost-benefit analysis of converting mangroves to alternative uses, such as shrimp aquaculture, or to quantify the cost of overexploiting mangroves for extractive purposes. We expect that these uses of mangroves are relatively more prevalent in Southeast Asia than they are in North America or Africa and the Middle East. Evidence of this may be found in Brander *et al.* [17], who employ 80 wetland studies comprising 215 observations, over half of which are concentrated in North America. When examining the distribution of observations in their study according to type of wetland service, we find that the number of amenity and recreation observations account for a significantly larger proportion of total observations than in our study (see Table 4). Accordingly, we may infer that the study location affects the type of ecosystem service being evaluated [66].

Figure 1. Distribution of observations by continent.

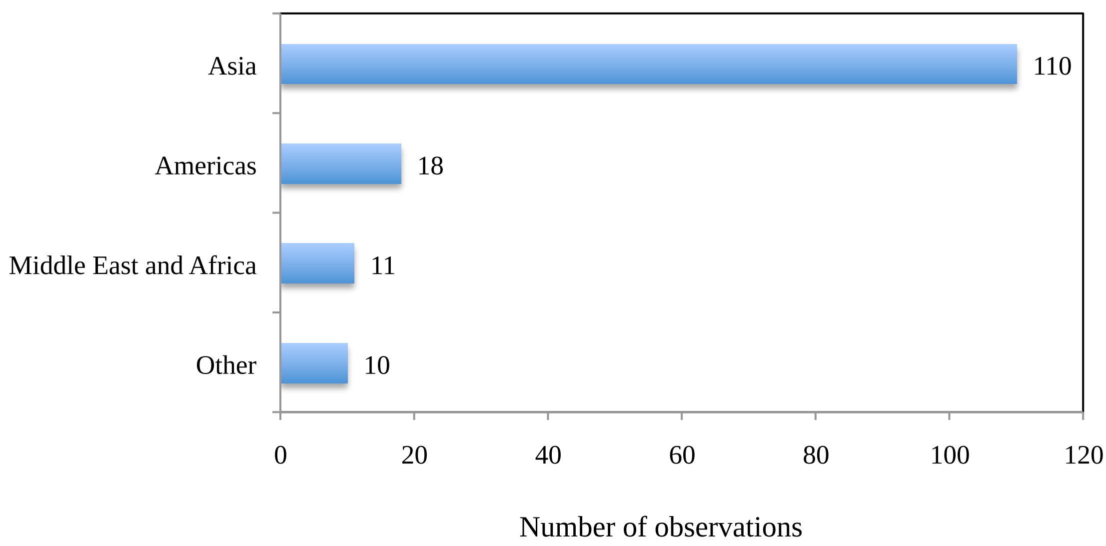


Table 4 presents summary statistics for valuations by type of service. The observations representing total economic values, and which have been excluded from the analysis, lie in the range of \$2,772 to \$80,334 US\$ ha^{-1}·yr^{-1} with a mean of \$28,662 US\$ ha^{-1}·yr^{-1} and a median of \$3,847 US\$ ha^{-1}·yr^{-1}. This indicates a heavily left-skewed distribution, a characteristic that is also found among per hectare values distributed according to type of service and method of valuation (see Tables 4 and 5, respectively). As is evident in Table 4, the highest average service value is forestry ($38,115) followed closely by recreation and tourism ($37,927), while the lowest is nutrient retention ($44). However, due to the highly skewed nature of the data, the medians portray a different picture. Nonuse values have the highest median by a large margin ($15,212), followed by purification and waste assimilation services ($5,801) and coastal protection ($3,604). Hence, indirect use and nonuse values have higher medians than direct use values.

Table 4. Summary statistics for mangrove valuations by type of service (in US$ $ha^{-1}\cdot yr^{-1}$).

Service	Obs.	Mean	Min	Max	Median
Fisheries	51	23,613	10.05	555,168	627
Forestry	35	38,115	18.00	1,287,701	576
Coastal protection	29	3,116	10.45	8,044	3,604
Recreation & tourism	14	37,927	1.74	507,368	1,079
Nutrient retention	1	44	-	-	-
Carbon sequestration	7	967	39.89	4,265	211
Nonuse	6	17,373	3.77	50,737	15,212
Biodiversity	1	52	-	-	-
Water and air purification/ waste assimilation	4	4,748	12.43	7,379	5,801
Traditional uses	1	114	-	-	-
Total	149				

Values are significantly more diversified when categorized according to method of valuation, as can be seen in Table 5. The highest average value is given by production functions other than static and dynamic ($257,905), followed by MP ($31,990) and CVM ($10,691) while the lowest values are provided by the dynamic PF ($209).

Table 5. Summary statistics for valuation observations by method of valuation (in US$ $ha^{-1}\cdot yr^{-1}$).

Method	Obs.	Mean	Min	Max	Median
Static PF	2	2,975	120	5,830	2,975
Dynamic PF	10	209	10	1,334	53
Other regressions	4	257,905	4,377	555,168	236,037
Market prices	62	31,990	2	1,287,701	768
Net factor income	28	1,545	18	11,341	342
Replacement cost	32	3,390	12	8,044	3,889
Contingent valuation	10	10,691	4	50,737	1,082
Travel cost	1	8,094			
Total	149				

Figure 2 and Figure 3 present the valuations based on services and valuation methods, respectively. The boxes represent values from the 25th to the 75th percentiles, and the line markers in the bars depict medians. The error bars identify the adjacent values, which are the most extreme values within

1.5 interquartile range (*iqr*) of the nearer quartile (*iqr* = 75th quartile − 25th quartile). The *y*-axis is on a log scale and outliers that lie outside the error bars have been excluded. In Figure 2, the number of excluded observations for the services was: fisheries (3), forestry (4), tourism and recreation (1), and carbon sequestration (1). In Figure 3, the excluded observations are: dynamic PF (2), MP (6), and NFI (4). In Figure 2, three services with only one observation have been excluded. They are: biodiversity, nutrient retention and traditional uses of hunting, fishing and gathering. As Figure 2 shows, there is moderate overlap between values of different services. As was shown in Table 4, nonuse values have the highest median and are also the most widely dispersed. Purification and waste assimilation services follow in terms of values while the rest of the services lie in a somewhat similar range.

Figure 2. Distribution of mangrove valuations by type of service (in US\$ ha^{-1}·yr^{-1}).

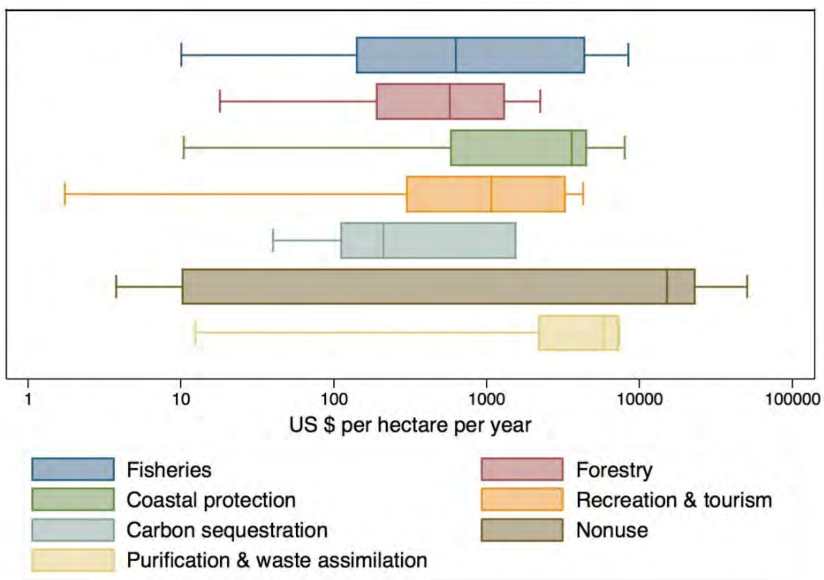
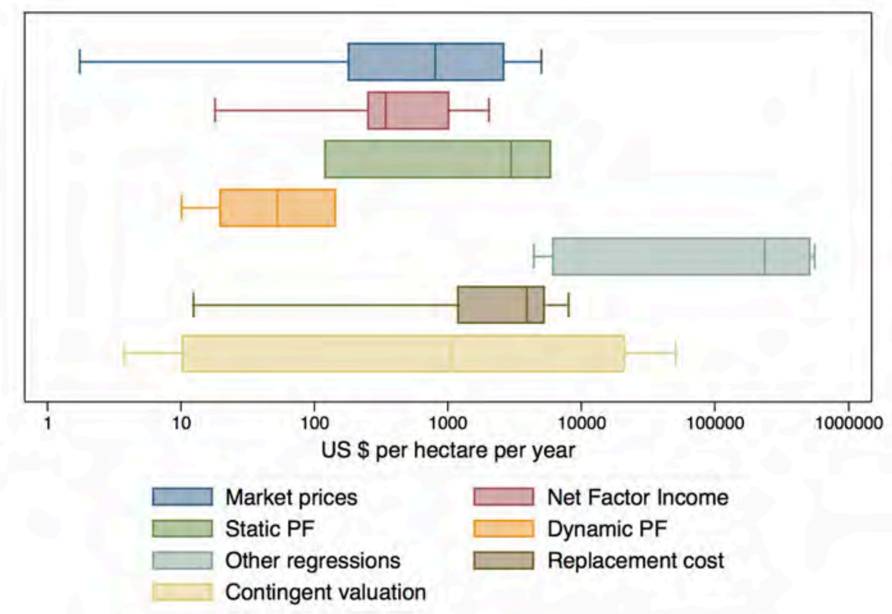


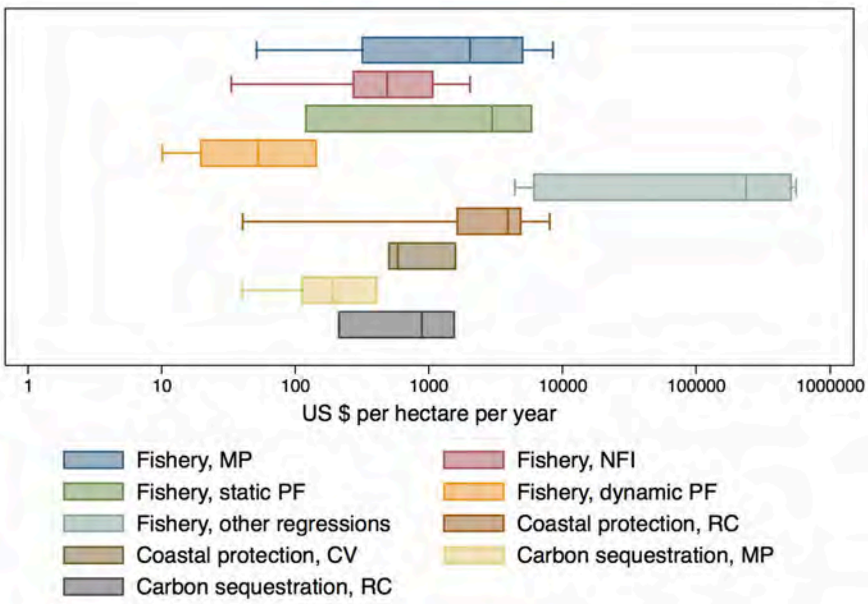
Figure 3. Distribution of mangrove valuations by method of valuation (in US\$ $ha^{-1} \cdot yr^{-1}$).



In Figure 3, the distribution of values confirms the information conveyed in Table 4. It is evident that "other regressions" provide the highest values, while the dynamic PF method gives the lowest median. However, not all valuation methods are used for all services, which is bound to influence the way values are distributed across valuation methods. For example, CVM is the only method that measures nonuse values, while MP and NFI are used when valuing forestry products. In Figure 4, we plot the distribution of values according to services and valuation method. We chose only those services for which more than one method was used in valuation, and for which each method has at least two observations. In this way, comparability between valuation methods becomes more feasible.

The methods used in valuing fisheries are MP, NFI and all types of production functions. Two methods were used to value coastal protection and stabilization, namely RC and CVM, while both the MP and RC methods were employed to measure the value of carbon sequestration. Comparing the first five boxes shows that MP values are slightly higher than those of NFI but do not differ significantly from static PF methods, though the latter are more dispersed. The dynamic PF gives lower values than other methods, while other regressions provide higher estimates. Values reported for coastal protection and stabilization are higher when the RC method is used than CVM. Similarly, the RC method generates higher values compared with MP in carbon sequestration valuations.

Figure 4. Distribution of mangrove valuations by service and method of valuation (in US$ $ha^{-1} \cdot yr^{-1}$).



5. Results and Discussion

The total number of observations estimated in the model is 145. Results of the weighted robust regression are displayed in Table 6 and labeled as model 1. The coefficients of the area and GDP per capita, being in logarithmic form, should be interpreted as elasticities. The coefficients of the categorical variables, on the other hand, show the effects of their respective variables on the dependent variable [67,68]. The variable representing publication year is removed due to multicollinearity problems. Additionally, we examine potential interaction effects of per capita GDP with type of ecosystem service. We included interaction terms to the model depicting the cross effects of the different services with GDP per capita (the interaction term of fisheries was excluded due to multicollinearity problems). The results are displayed in Table 6 as model 2. The number of observations flagged as gross outliers in models 1 and 2 were 2 and 3 observations, respectively.

Table 6. Estimation results [a].

Variable	Model 1	Model 2
Marginal value	−1.066 ** (0.491)	−1.274*** (0.4)
Static PF	−0.437 (1.019)	−0.328 (0.802)
Dynamic PF	1.148 * (0.682)	1.344 ** (0.544)
Other regressions	3.705 *** (0.871)	2.880 *** (0.704)
NFI	−0.618 * (0.327)	−0.614 ** (0.264)
RC	−0.791 (0.881)	3.103 *** (0.819)
CV	−2.421 (1.944)	4.199 *** (1.532)
Log (area)	−0.0774 (0.056)	−0.018 (0.0463)
Global	0.674 * (0.377)	−0.278 (0.311)
Asia (excl. Thailand)	−0.833 * (0.427)	−0.0462 (0.355)
Middle East & Africa	1.043 (1.008)	2.175 *** (0.804)
Americas	−0.581 (0.635)	0.197 (0.533)
Other continent	0.977 (0.896)	0.941 (0.73)
Protected	0.845 ** (0.37)	0.520 * (0.304)
Forestry	−0.455 (0.342)	0.294 (0.412)
Recreation	−0.263 (0.766)	−0.00449 (0.732)
Coastal protection	2.059 ** (0.949)	−5.492 *** (1.062)
Carbon sequestration	1.342 ** (0.543)	−3.123 *** (1.064)
Nonuse	5.809 ** (2.266)	6.403 ** (2.533)
Water & air quality	3.027 ** (1.502)	7.869 (11.19)
Log (GDP)	0.866 *** (0.0794)	0.792 *** (0.0664)
Forestry_GDP per capita		-9.72×10^{-5} ** (4.06×10^{-5})
Recreation_GDP per capita		-2.07×10^{-5} (2.79×10^{-5})
Coastal protection_GDP per capita		0.000563 *** (0.00013)
Carbon sequestration_GDP per capita		0.000288 *** (8.37×10^{-5})
Nonuse_GDP per capita		−0.00119 *** (0.00023)
Water & air quality _GDP per capita		−0.00204 (0.003)
Constant	−0.0787 (0.101)	−0.0881 (0.081)
No. of observations	143	142
Adjusted R^2	0.6	0.7
F	45.85***	59.45***

[a] Robust standard errors are between parenthesis and the asterisks *,**,*** depict significance at the 10%, 5% and 1% levels, respectively.

First, we examine the effect of the study characteristics on mangrove valuation and find that both models provide consistent results with regards to statistically significant coefficients. Compared to the method of MP, dynamic and "other" PF, as well as the RC and CVM methods provide higher estimates, while the NFI method generates lower estimates. However, the estimated coefficients of the static and dynamic PF methods should be interpreted with caution since only two studies used each method. This confirms our initial expectations regarding valuation magnitudes as shown in Figure 5, with the exception that the CVM produces higher estimates than the RCM and the rest of the methods. Similarly, Brander *et al*. [17] find that the CVM provides the highest estimates, while Woodward and

Wui [27] find that the RC method produces higher values than CVM. Finally, marginal values are lower than average values, suggesting decreasing returns to scale. This is consistent with expectations in the literature about the relationship between marginal and average values [62]. Even though Brander *et al*. [17] find that marginal values are higher, they do conclude that values exhibit decreasing returns to scale based on area.

As for mangrove characteristics, we find that although the coefficients of area are negative, they are insignificant. Model 1 shows a positive, significant '*Global*' coefficient, indicating that having the product exported or having foreign tourists account for a significant portion of value raises the value more than average. This effect disappears when the interaction terms are included, indicating that the *Global* variable was capturing this interactive income effect. The location variables show that only the coefficient of the Middle East and Africa is significant and positive, indicating higher values than average, consistent with the findings of Brander *et al*. [17]. This result is likely influenced by the particularly high values reported for Egypt, where the area of mangroves is among the smallest in the dataset, which are therefore highly valued.

Furthermore, we find the variable depicting protection to be positive and significant. In contrast, Brander *et al*. [17] find a negative relation between values and being designated as a RAMSAR site. However, a positive effect of protection on mangrove values is expected since protection entails higher productivity, especially with regards to ecological functions such as storm protection and acting as nursery grounds for fish and shellfish.

Considering the effect of the type of ecosystem service on values, the value of fisheries is included in the intercept. The ecological services of water and air quality as well as nonuse values are found to be higher than the value of fisheries, while forestry products and recreation are not significantly different. However, the models provide significant, but opposing results with regards to coastal protection and carbon sequestration. Model 1 provides positive estimates while model 2 produces negative estimates. This can be explained by the interaction terms in model 2, which show positive and statistically significant estimates for both these services. This indicates that the positive estimates in model 1 may have been capturing this income effect. Brander *et al.* [17] and Ghermandi *et al*. [29] find that materials and recreation give lower than average values. Chen [28] and Ghermandi *et al*. [29] also find that water quality has higher than average values. The coefficient of GDP per capita is positive and statistically significant in both models, conforming to the findings of Brander *et al.* [17], Ghermandi *et al.* [29] and Chen [28].

The inclusion of cross effects reveal that service type affects mangrove values not just through the service itself, but also through its interaction with GDP per capita. The estimated coefficients are mostly found to be statistically significant. One might expect that ecological functions would be more valuable in countries with higher GDP per capita and that materials such as fuel wood and charcoal would be more valued in countries with lower GDP per capita, where such services are often used for subsistence purposes in villages. The significant coefficients of interaction terms mostly confirm this since the coefficient of forestry is negative, while those of carbon sequestration and coastal protection are positive. However, the unexpected result was that of nonuse interacted with GDP per capita, which is negative. We attribute this to the high value reported for Egypt, for which GDP per capita is below the average of countries in our dataset, and for which nonuse value is the highest in the dataset. The values reported for Egypt, while high, were not recognized as outliers by the procedure through which outliers were dropped as described in endnote [57].

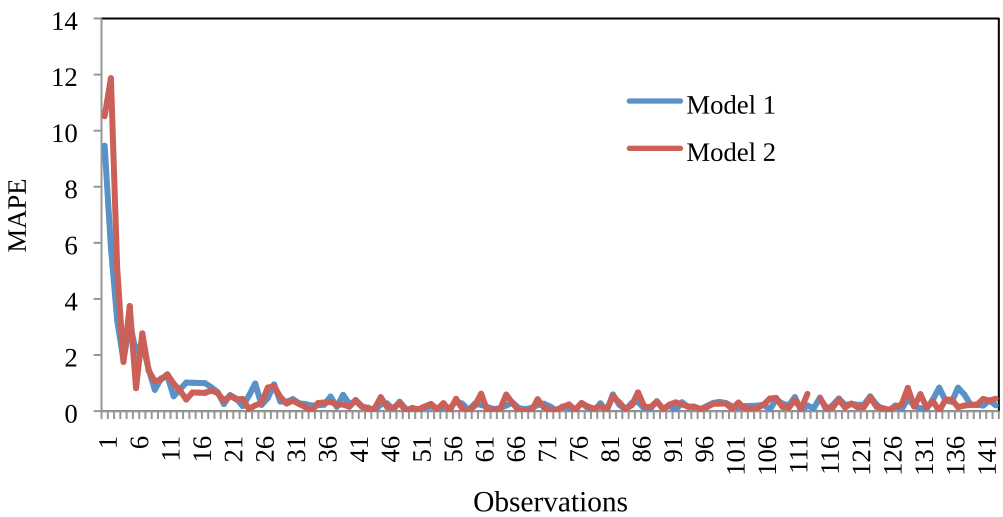
Both models fit the data well as evidenced by the high adjusted R^2. However, the inclusion of the interaction terms has raised the explanatory power of the model.

Since one objective of meta-regression analysis is to provide a value transfer function for benefit transfer exercises, we examine two measures of forecast performance [17]. The first is an in-sample forecast performance measure, namely, the Mean Absolute Percentage Error (MAPE), defined as the mean of $|(y_{obs} - y_{est})/y_{obs}|$. Additionally, as an out-of-sample forecast performance measure, we use a data-splitting technique whereby $n-1$ transfer functions are estimated by iteratively omitting one observation, estimating the model and then applying the resulting estimated parameters to this observation. Comparing the predicted and observed values reveals how well the model performs against the data. The results of both measures are displayed in Table 7.

Table 7. The in-sample and out-of-sample Mean Absolute Percentage Error (MAPE) of the estimated models.

Performance Measure	Model 1	Model 2
In-sample MAPE	0.402	0.35
Transfer MAPE	0.488	0.54

Figure 5. Out-of-sample transfer MAPE while observations are sorted in an ascending order based on annual per hectare mangrove values.



The in-sample MAPE shows that model 2 performs relatively better. Brander *et al*. [17] report a value of 58% and Chen [28] reports values that range from about 13% to 44%, indicating that our models perform relatively well. The out-of-sample forecast analysis, however, shows that model 1 performs slightly better. The corresponding values in Brander *et al*. [17] and Chen [28] are 74% and 42% to 75%, respectively, again indicating that the models presented here perform relatively well. Furthermore, the transfer errors lie well within the bounds reported by Brouwer [37], who reviewed several studies that have attempted value function transfer.

Figure 5 shows the plot of the values of the out-of-sample MAPE while sorting observations in an ascending order based on annual per hectare mangrove values. There are no significant differences between forecast performance among the two models, though both models perform considerably worse in predicting very low mangrove values than higher ones.

5.1. Robustness Checks

As previously mentioned, we estimated an OLS regression with robust standard errors as well as an unweighted robust regression model, the results of which are reported in the supplementary material. There are a few differences among the models. The dynamic PF approach is negative and statistically significant in these models. We attribute this difference to the high concentration of the dynamic PF method observations in one study [69], which reports relatively low values. When these observations are given less weight, their effect is reduced and becomes positive. Another difference is that area, while having a negative coefficient in all models, is found to be statistically significant in the unweighted models, but insignificant in the weighted models. However, the implication is the same, namely that mangroves exhibit decreasing returns to scale. The double-log formulation, however, results in the diminishing effect of area on wetland value as area increases so that the scale effect is minor for large wetland areas [27]. A similar relationship was found by Ghermandi *et al.* [29]. Brander *et al.* [17] and Woodward and Wui [27] find a statistically significant negative relationship as well and their estimates, −0.11 and −0.168 (−0.286), respectively, are similar to ours.

Finally, even though the weighted regressions have fewer explanatory variables and observations, their adjusted *R* squared values are significantly higher than the OLS and robust regression models, indicating a better fit. When comparing the in-sample and out-of sample forecasts, we find that, on average, the unweighted models have a slightly lower forecast error, especially with regards to the out-of-sample MAPE. However, this difference is not large and we conclude that the weighted regressions do reasonably well in providing a benefits transfer function.

6. Conclusions

In this paper, we have provided an overview of the mangrove evaluation literature through a meta-regression analysis, the first in the wetlands literature that focuses specifically on mangrove forests. Like wetland studies, the literature on mangrove economic valuation is diverse in terms of types of ecosystem services, valuation methods, and location and consequently has produced a wide range of values. To assess how study characteristics and mangrove site characteristics have influenced economic valuations, we regressed annual per hectare values on different explanatory variables that encompass characteristics of the studies and the study sites, as well as GDP per capita. Since the data had several outliers, we also ran a robust regression to account for extreme values and weigh them accordingly. In addition, we ran a weighted robust regression (weighing studies equally rather than observations) to allow for possible correlation across observations. Finally, we investigated the cross effects between service type and GDP per capita since each service may be valued differently based on the socio-economic conditions of the hosting country.

According to the weighted robust regressions, we find that employing the CVM and RC methods results in higher values than other methods of valuation, with the CVM being the highest. Other factors that have a positive effect are protection of the site and GDP per capita, the latter being a common finding among previous wetland meta-analyses. In the model without the interaction effects, indirect use and nonuse values are higher than direct use values, with nonuse values the highest. In this model, we also find that having a foreign exchange component in the value results in higher valuations. Including cross effects results in values in the Middle East and Africa being higher than elsewhere, while coastal protection and carbon sequestration have the lowest values and nonuse values the highest. Also, the coefficients of the interaction terms show that coastal protection and carbon sequestration are more highly valued, and nonuse values and forestry are less valued in countries with higher per capita GDP. The unexpected result of the negative sign of the nonuse cross term is attributed to the high estimates reported for Egypt, which has a lower than the average GDP per capita of countries in our dataset. A final result is that mangroves exhibit decreasing returns to scale as evidenced by the fact that marginal value was found to be lower than average value.

We estimated transfer errors of the models to gauge their performance for the purpose of a benefits transfer. The result was that there were slight differences between the models since all transfer errors are between 35% and 54%, a range that is within the lower end of previous estimates in the literature.

A recommendation is that primary studies provide more comprehensive information pertaining to several aspects. The first is the state of the environmental health of mangrove forests. While some studies do make this information known, this is not always the case and like any natural resource, the ecological functioning and economic values of mangrove forests are largely dependent on their environmental health and soundness. The second is the type of management of the resource such as fisheries and forestry, which is not always clarified in the original studies. The yields of fisheries and forests are affected by the form of management [51,64], thereby necessitating the inclusion of pertinent management information in any evaluation study. Finally, we recommend that if papers evaluate physically quantifiable goods, like fish or timber, they include the physical quantities of these goods. This facilitates comparing the productivity of mangrove forests across countries and independently of the method of valuation.

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Saving Elephants and Restoring Paradise: Determine the Cost to Restore Tropical Rain forest in Xishuangbanna, China

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ABSTRACT

The rapid expansion of rubber plantations in Xishuangbanna has devastated the tropical rain forests in Xishuangbanna while the protection of wild Asian elephants has resulted in a steady growth of its population. The reduced habitat for wild Asian elephants has meant increasing conflicts between human and the wild Asian elephants. To reduce such conflicts and develop the wild Asian elephants into an eco-tourism attraction requires the reversion of some rubber plantations back to tropical rain forests. In this paper, we report on the results of a field study to determine the cost of such a reversion in terms of the value of the land and the value of standing rubber trees.

INVESTING IN FOREST CARBON OFFSET PROJECTS UNDER CLIMATE POLICY UNCERTAINTY – A MARKOVIAN FRAMEWORK WITH SIMULATIONS

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ABSTRACT

Forests, as natural carbon sinks, play an essential role in mitigating the impacts of climate change. With the emergence of market-based mechanisms for mitigation, forests can provide tradable carbon offset credits thus generating additional income to forest landowners. Here we explore the economic potential of investing in carbon offset projects through sustainable management under uncertainty in climate policies with a Markov decision process approach combined with simulations. Climate policy uncertainty was modeled as a regime-switching process with two regimes. Regime 1 represented the current policy of voluntary reduction of greenhouse gases and regime 2 future policy of mandatory reduction. Different scenarios were simulated assuming different carbon prices under regime 2 and probabilities of switching from regime 1 to 2. A linear programming model was set up to optimize for the discounted net income from timber and carbon credits of a stand of northern hardwoods. The option value of offset investments increased as the expected carbon price under regime 2 increased. A more certain regime switch represented by a higher probability of switching from regime 1 to 2 also led to a higher option value of offset investments.

CO_2 *MITIGATION BENEFITS AND TIMBER MARKET IMPACTS OF CARBON OFFSET PAYMENT POLICY IN THE UNITED STATES*

Prakash Nepal, Peter J. Ince, Kenneth E. Skog, and Sun J. Chang

ABSTRACT

This study presents carbon dioxide (CO2) benefits potentially achievable over the next 50 years by setting aside portions of the U.S. timberland area for permanent carbon reserve as a result of the implementation of future carbon policy that will allow for forest carbon offset purchases. The actual timberland area entering into the permanent carbon reserve is determined based on the economic principle that a rational landowner will decide to go for a carbon reserve if the present value of carbon offset payments is equal to or greater than present value of timber harvests. The additional CO2 mitigation benefits resulting from such timber set asides is quantified relative to a baseline (business-as-usual) scenario without any policy to purchase carbon offsets. The presentation discusses potential mitigation benefits of alternative hypothetical carbon price levels ($5 and $10 per metric ton of carbon dioxide equivalent (CO2e)), and exogenously projected annual carbon expenditure levels ($1 billion, $3 billion) available for carbon offset purchase. The potential timber market implications of such policy is discussed in relation to available timberland area and timber inventory for conventional timber products, and their impacts on U.S. regional timber stumpage prices.

Private Forest Landowner Greenhouse Gas Mitigation in the Southeast: Where is the Carbon?

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ABSTRACT

In 1995, when Cubbage et al. pondered, "Where is all the wood?", the question was prompted by uncertainty surrounding the future supply of timber in the Southern United States. Here, we ask a similar question about the potential of Southern forests to mitigate greenhouse gas (GHG) emissions. Previous research suggests that if the price of carbon is high enough, afforestation and changes in forest management in U.S. forests could potentially store an additional 1.2 billion tons of carbon dioxide equivalent (tCO_2e) nationwide annually. These projections, however, assume that all forest landowners react the same way to market prices no matter how much land they control or their objectives for owning the forestland. Because a substantial portion of carbon sequestration potential occurs on Non-Industrial Private Forestland (NIPF), the accuracy of these projections depends on how NIPF landowners respond to markets and their ability and willingness to participate in carbon offset programs. To address this key data gap, we use National Woodland Owner Survey (NWOS) and Forest Inventory and Analysis (FIA) data to examine the current distribution of carbon across the South. We link forest condition and landowner demographic and behavioral data to produce a more realistic assessment of the potential for Southern forests to sequester carbon under a variety of carbon offset policy designs. We also examine barriers to NIPF participation in carbon offset programs and offer recommendations for overcoming those barriers.

EFFECTS OF COST-SHARE PROGRAMS ON FOREST MANAGEMENT BY NON-INDUSTRIAL PRIVATE FOREST LANDOWNERS: EVIDENCE FROM THE U.S. NORTHERN REGION

Nianfu Song, Francisco X. Aguilar, Brett J. Butler

ABSTRACT

Cost-share program participation is not a random process, and econometric analyses produce biased results if non-randomness is not corrected. This study used propensity score matching to randomize a sample drawn from the most recent National Woodland Owner Survey dataset for the U.S. Northern region. We investigated drivers for participation in cost-share programs and assessed cost-share program effects on stated future forest management and land use change. Non-industrial private forest (NIPF) landowners or larger areas of land exhibited different functions for cost-share participation compared with owners of smaller areas, and effects of the participation on forest management vary over forest size. Higher levels of education and timber production objectives were positively associated with cost-share participation for owners of all forest sizes. It is estimated that landowners enrolled in a cost-share program are 39% more likely to adopt sustainable and environmental management plans, and 18% more likely to plant trees and practice forest regeneration than other landowners. Cost-share programs were estimated to be correlated to converting non-forest land into forest land, conducting road maintenance and chemical application for improving forest health in the future. Moreover, cost-share program effect on conservation activities was larger for NIPF landowners with less than 1,000 acres than those with larger forest area, implying promoting cost-share participation by forest landowners of smaller size could be more efficient.

THE 2010 RPA FOREST ASSESSMENT: OUTLOOK FOR US FOREST PRODUCTS MARKETS

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ABSTRACT

The RPA Assessment provides a snapshot of current U.S. forest and rangeland conditions and trends on all ownerships, identifies drivers of change, and projects conditions 50 years into the future. The RPA Assessment includes analyses of forests, rangelands, urban forests, forest products, carbon, wildlife and fish, outdoor recreation, wilderness, water, and the effects of climate change on these resources. This presentation describes projections of forest products markets for a set of four IPCC-based scenarios evaluated for the 2010 RPA Assessment. These scenarios account for economic and population growth as well as varied levels of demand for wood for bioenergy. Results show a range of outcomes for US forest products and illustrate the influence of bioenergy demands on the future of forest production and prices.

Analysis of the Economic Impact of Wood-Related Industries on Thirteen Southern States

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ABSTRACT

Wood related industries have long been an important component of southern state economies. While dependence on wood industries continues to decline region-wide, forestry, logging, and wood products, furniture, and paper manufacturing still contribute anywhere from one to five percent of total employment and income for individual states. We present an analysis that combines the use of Python scripting and a dynamic charting environment to describe data sourced from the Bureau of Economic Analysis and our most recent IMPLAN contribution analysis for the wood-related industries in the south. We also identify and compare trends by state and by sector for the period 1990-2010, including the recent economic recession.

A SIMULTANEOUS TIMBER FAMINE AND WALL OF WOOD: THE FOREST ECONOMIST'S DREAM SCENARIO

Karen L. Abt and Robert C. Abt
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ABSTRACT

Though trends vary from state to state, tree planting in the core of southern timber markets over the last decade has declined significantly. During this same time, pulpwood demand has remained strong and bioenergy demand, especially from the EU, is competing for small roundwood. Until housing recovers, the outlook for expanded planting is doubtful. As planting from the CRP surge entered the sawtimber market, lumber demand fell to historic lows. Delayed harvest due to low prices has led to a significant increase in sawtimber inventory which will dampen sawtimber prices after sawtimber demand recovers, which will further delay planting. We evaluate how these factors (a decade of reduced planting, increasing small roundwood demand, low pine sawtimber demand, growing sawtimber inventory) could influence pine markets in the coming decade.

DO SUPPLY AGREEMENTS DAMPEN TIMBER PRICE VOLATILITY?

Pete Stewart
President and CEO
Forest2Market

ABSTRACT

What is the relationship between supply agreements and timber price volatility? Forest2Market and the Wood Supply Research Institute (WSRI) recently teamed up to answer this question. Using its proprietary delivered price database, Forest2Market divided timber sales in its proprietary delivered price database into two groups, sales that were conducted under supply agreement and those conducted on the open market. Forest2Market then divided that data into a series of paired sets based on product type, geography, purchasing facility type, volume and—for sawtimber—diameter at breast height (DBH). A series of statistical analyses of these paired sets produced these findings: supply agreements dampened price volatility for many products in multiple geographies. In his presentation, Pete Stewart will review these results and provide insight into the ways that industry participants can use the findings to improve their profitability, while helping stabilize existing and emerging markets for wood raw materials. The study, "An Analysis of Price Volatility for Wood Products Sold under Supply Agreement v. Wood Products Sold on the Open Market," was commissioned by the WSRI and conducted by Forest2Market.

FOREST INDUSTRY AND FOREST MANAGEMENT RESPONSES TO THE RECENT ECONOMIC DOWNTURN IN THE SOUTHERN UNITED STATES

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ABSTRACT

This study uses forest inventory and analysis (FIA) data, timber product output (TPO) surveys and IMpact analysis for PLANing (IMPLAN) output to quantify the impact the recent economic downturn on the forest product industry and land management practices in the South. This analysis involves comparing recent changes to the pre-downturn trend. Preliminary TPO results reveal that softwood and hardwood total product output fell 22 % and 30% respectively between 2005 and 2009. IMPLAN analysis suggests that the total jobs associated with the wood products industry (direct, indirect and induced employment) fell 20% between 2004 and 2009. Landowners appear to be responding by decreasing final harvest and increasing thinnings and other management practices.

Institutional Timberland Ownership in the U.S. South: Magnitude, Location, Dynamics, and Management

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Auburn University

ABSTRACT

We have compiled an exhaustive list of Timberland Investment Management Organizations (TIMOs) and timberland Real Estate Investment Trusts (REIT) and identified them based on U.S. Forest Inventory Analysis plot-level data. We find that TIMOs and REITs own/manage about 16 million acres or 10% of the timberland in 11 southern states and that they manage these forests in a sustainable fashion. Further, TIMOs and REITs own/manage more forest plantations than other owners and harvest more hardwood than its growth. Most of the timberland owned and managed by TIMOs and REITs, located mainly in the southern coastal plains and piedmonts, were previously owned by industrial forest products firms.

Impact of Timber Sale Characteristics on Harvesting Costs

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Acknowledgements
This research was funded by a grant from the Wood Supply Research Institute. The authors also wish to acknowledge Timber-Mart South, who provided the data used to complete this project.

ABSTRACT

Large changes have taken place in the forest industry in the past decade with record high and low home construction levels, the dissolution of vertically integrated forest products companies, and record high fuel costs. All of these shifts have impacted the timber harvesting workforce. We gathered data on timber sales from across the southeastern United States from 2000 through 2011 to examine what changes had occurred in harvest tract characteristics. Among the trends observed were an increase in average tract acreage and substantial increases in partial harvesting. These data were then used to model harvesting costs in the Auburn Harvesting Analyze, in an effort to determine what trends existed. Little long-term impact to harvesting costs could be attributed to timber sale characteristics.

Keywords: Harvest volumes, acreage, logging

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Introduction

Across much of the country, forestland ownership patterns have shifted dramatically. Lands previously owned by vertically integrated forest products companies have been divested, typically to land management organizations seeking to provide competitive financial returns to company shareholders. Fragmentation and parcelization are viewed as significant long-term threats to the sustainability of the forest industry (Sampson and DeCoster 2000). As the size of ownerships decrease, contiguous stretches of similar forest conditions are feared to become increasingly less common. While this can have substantial ecological implications, it has potentially detrimental economic implications as well. The average size of a harvested tract has a direct impact on the cost to cut and haul timber (Greene *et al.*1997). Twenty acres is viewed by many logging contractors as a threshold of financial viability (Moldenhauer and Bolding 2009). With the level of mechanization and the production potential of most contractors operating in the southern US, tracts of less than twenty acres do not typically afford enough production to dilute the costs of moving the crew onsite. While acreage is often used as an indicator of minimum operable tract size, total and per acre volume are important cost drivers for harvesting operations (Greene *et al.* 1997).

We undertook a project to determine what changes have occurred in the characteristics of harvested tracts since 2000 and what impact they may have had on harvesting costs over the same timeframe.

Methods

Individual timber sale data from across the South were compiled from Timber-Mart South for each quarter from January 1, 2000 through December 31, 2011. Data from eleven states were included (AL, AR, FL, GA, LA, MS, NC, SC, TN, TX, VA), though not all states had timber sale data in every quarter. Timber sale characteristics included sale date, acreage, state, total volume, total sale price, and harvest type, but many timber sale records excluded data in one or more of these categories. Timber-Mart South's primary focus is timber prices rather than harvest tract information, thus many of the reporters share only product prices and volumes, with no way to tie this information to a specific harvested tract (Harris *et al.* 2012). The data were processed using SAS 9.2 to provide a single record for each of the 18,006 individual sales. All product volumes were converted to tons using 2.7 cords/ton, 7.5 MBF (Scribner board rule)/ton, 8 MBF (Doyle Board Rule)/ton, and 6.23 MBF (International ¼ Board Rule)/ton. Individual product volumes were then combined into a total volume per timber sale.

Sales records were analyzed by quarter to provide South-wide average harvest characteristics. The data were split for this analysis into clearcuts and partial harvests, with salvage sales removed from the analysis. Four-quarter moving averages were generated to clarify trends in the data. Medians were generated for quarterly measures of central tendency as means were greatly influenced by large outliers in a significant percentage of the quarters examined. Kolmogorov-Smirnoff tests for normality in the data also verified that more robust estimators were needed than arithmetic means.

The Auburn Harvest Analyzer was adapted to accept inputs of quadratic mean diameter, tract acreage, and volume per acre as variables (Tufts *et al.* 1985). A standard feller-buncher, two skidder, one knuckleboom loader system was used to estimate harvesting costs for crews typical in the Southeastern U.S. (Baker and Greene 2008). All model parameters were held constant except for those values calculated from quarterly sales data. The common inputs by machine are listed in Table 1. Additional assumptions include labor rate of $16.00/SMH, labor fringe expenses of 40% of the base rate of pay, combined interest, insurance, and taxes of 10% of average annual investment, lubrication costs 37% of fuel expense, and off-road diesel costs of $3.00 per gallon.

Table 1. Machine rate cost assumptions by machine.

Machine	Purchase Price	Salvage Value	Economic Life (yrs)	Availability (%SMH)	Fuel (gal/PMH)	Maintenance & Repair (% Depreciation)
Feller-buncher	$205,000	20%	4	85%	8.14	100%
Skidder	$225,000	25%	5	85%	7.77	90%
Loader	$190,000	30%	5	85%	6.29	90%

An array of quadratic mean diameters, tract acreages, and volumes per acre were used to examine the sensitivity of the modeled costs to these three input variables. Quarterly median acreage and volume per acre values from both clearcuts and partial harvests were used to calculate harvesting cost changes for an average logging system based on the changes in observed tract characteristics. To differentiate the average tree size impacts of clearcuts versus partial harvests, quadratic mean diameters of 9 and 7.5 inches were modeled for each harvest type respectively.

Results

The data included a large number of records which excluded information necessary for the analysis. When only sale records including acreage were retained, the dataset included 12,436 individual timber sales, whereas 8,675 records included both volumes and acreages. The distribution of sales records including at least acreage amongst the eleven states is shown in Figure 1. While Georgia had the greatest percentage of records, every state except Tennessee had over 600 sales records in the dataset.

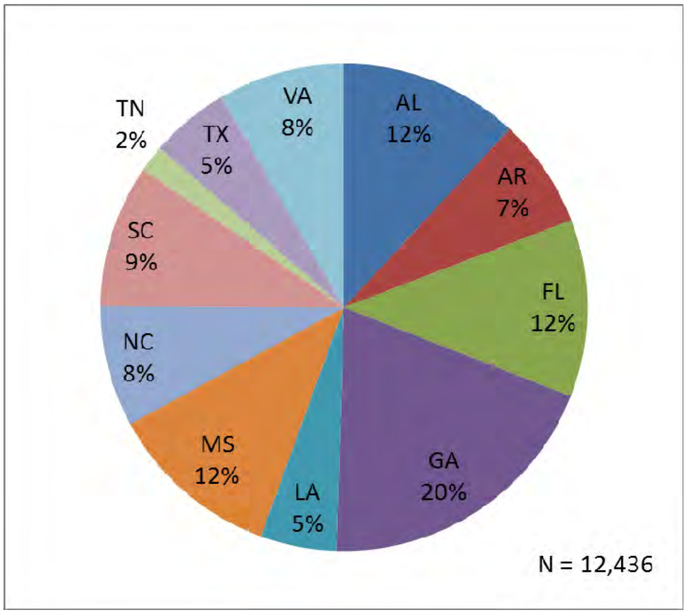

Figure 1. Percentage of total timber sale records with acreage reported from 2000 – 2011, by state.

Clearcutting as a percentage of all sales fluctuated within a narrow range while the median sale acreage increased in 2005, but has not varied widely since (Table 2). Median total tons harvested remained relatively stable throughout the period. Abnormally low volumes in 2004 are likely a result of very low reporting of harvest volumes in all four quarters of that year.

The proportion of clearcutting and partial cutting as a percentage of total harvested acres has varied over the past nine years in the South, despite the relatively small fluctuations in the proportion of total sales (Figure 2). When observing total acres cut, partial harvests have been performed on more acres each quarter for almost the entire period. Partial harvests have been performed on 59.5% of the reported harvested acreage since 2000, compared to 40.5% for clearcutting. This balance has shifted more heavily towards partial harvests in recent years, averaging 70.1% partial harvesting and 29.9% clearcutting in 2011.

Table 2. Summary of timber sale data by year based on Timber-Mart South data for the Southern states.

Year	Number of Sales	Median Acreage	Median Total Tons	Median Tons/Acre	Clearcut (% of all sales)
2000	1096	75	2499	36.3	53
2001	969	78	4150	53.8	58
2002	1054	78	4683	62.1	56
2003	1031	81	5482	54.7	54
2004	1056	78	2900	38.1	57
2005	1480	99	3841	42.2	49
2006	880	92	4604	45.8	46
2007	1112	99	4221	42.9	46
2008	859	102	4500	40.0	43
2009	1089	99	5134	49.4	50
2010	866	95	5340	52.3	51
2011	851	100	4505	43.5	42
Total or Mean	12343	90	4007	47.4	51

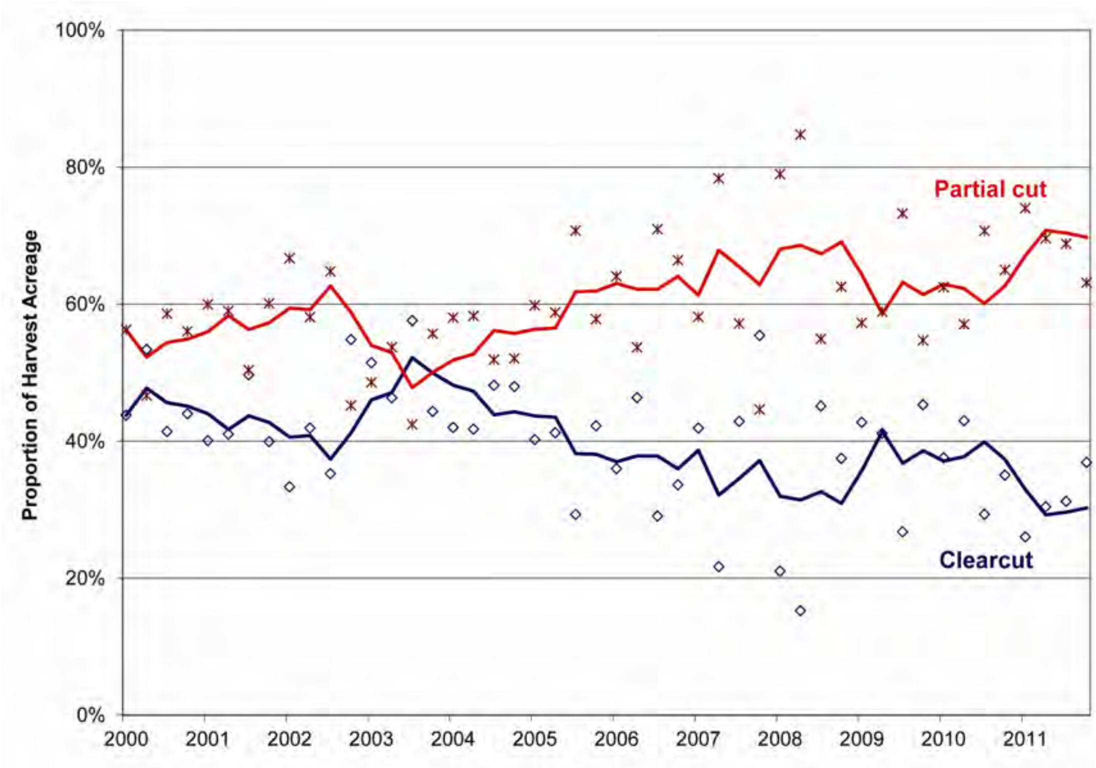

Figure 2. Relative proportion of total acres harvested in clearcut and partial cutting by quarter from January 2000 through December 2010. Four quarter moving averages are shown by lines.

The median acreage of tracts harvested during this time period fluctuated from quarter to quarter, but showed a slightly increasing trend over the entire timeframe (Figure 3). The four-quarter moving average for median clearcut size was around 85 acres at the end of 2011 and median partial harvest size around 120 acres. For a given quarter, median harvest size varied between 80 and 140 acres for partial harvests and between 50 and 100 acres for clearcuts.

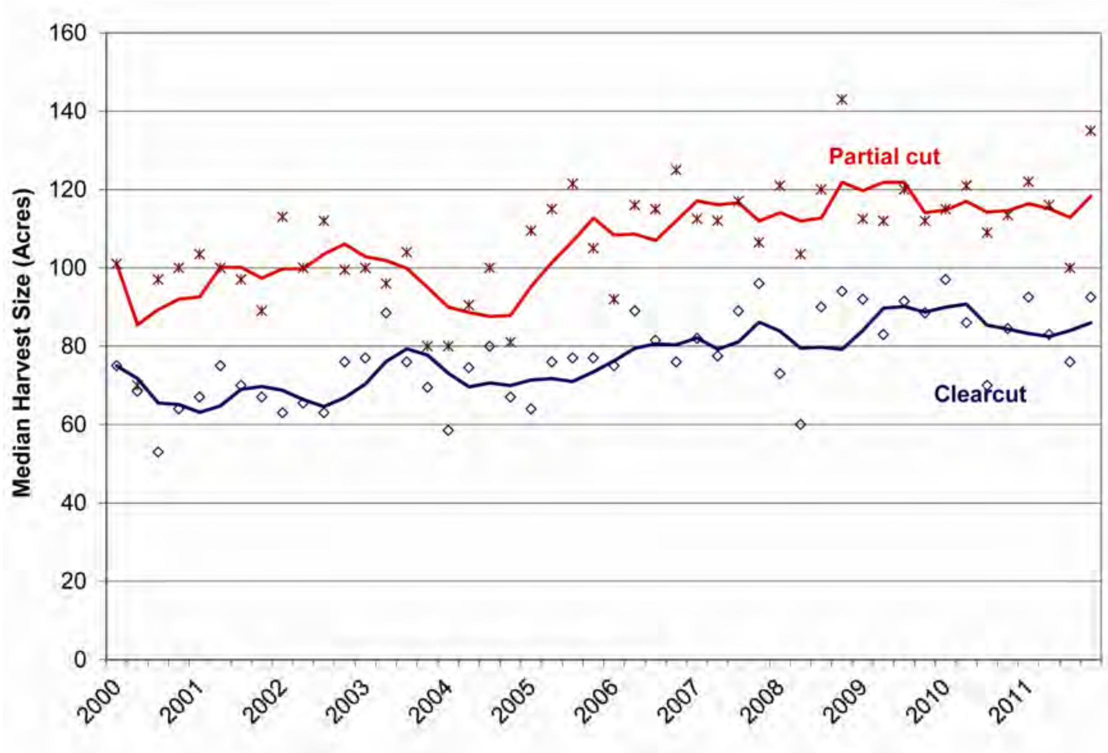

Figure 3. Median clearcut and partial cut acreage in the Southeastern US between 2000 and 2010. Four quarter moving averages are shown by lines.

Total volume harvested per tract fluctuated more than other measures over the period studied, but trends were not apparent over the entire timeframe (Figure 4). Through 2003 and 2004, a distinct peak is seen where total tract volume was higher for clearcuts. Median partial harvest volume ranged between 1300 tons and 4500 tons for a given quarter. Median clearcut harvest volume ranged between 2500 tons and 8000 tons. Both of these ranges are extremely wide considering they are median values for a quarter.

Despite the observed variation in total harvest volume, four-quarter moving averages of median per acre harvest volume remained comparatively stable (Figure 5). Partial harvest volumes per acre have stayed close to 30 tons since 2000, only once approaching 40 tons per acre and twice decreasing beneath 25 tons per acre. Excluding the first quarter of 2008, which is believed to be an anomalous value resulting from low reporting volumes, per acre clearcut volumes have fluctuated between roughly 50 and 80 tons, dipping below 50 tons on only one other occasion.

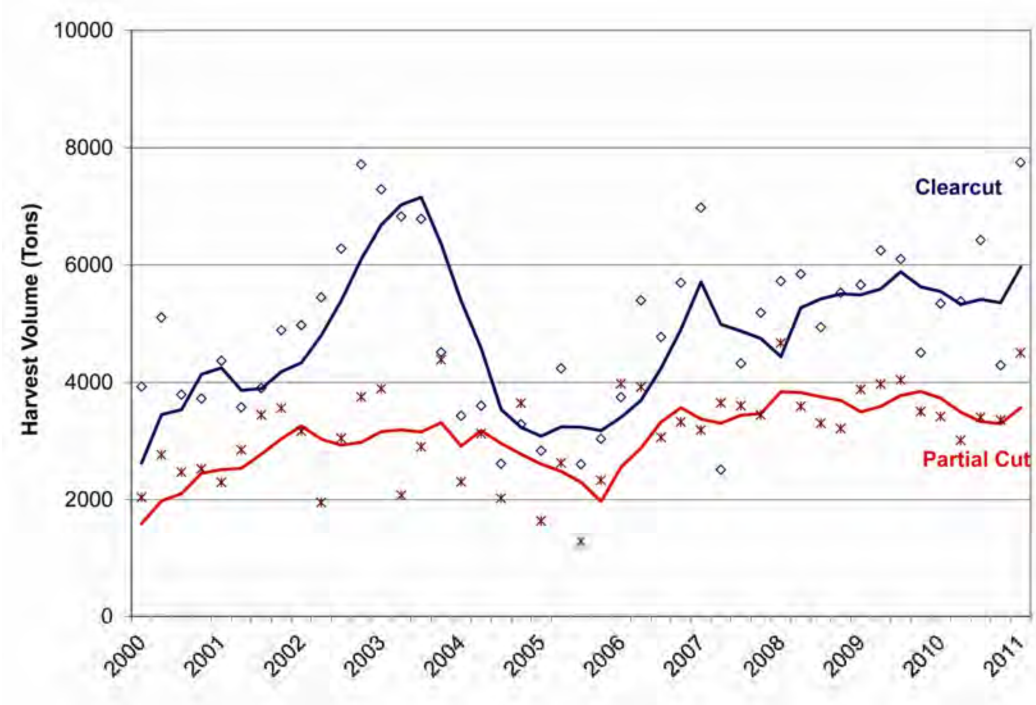

Figure 4. Median and four-quarter moving average total harvest volume per tract in tons for clearcuts and partial harvests from fourth quarter 2000 through fourth quarter 2010.

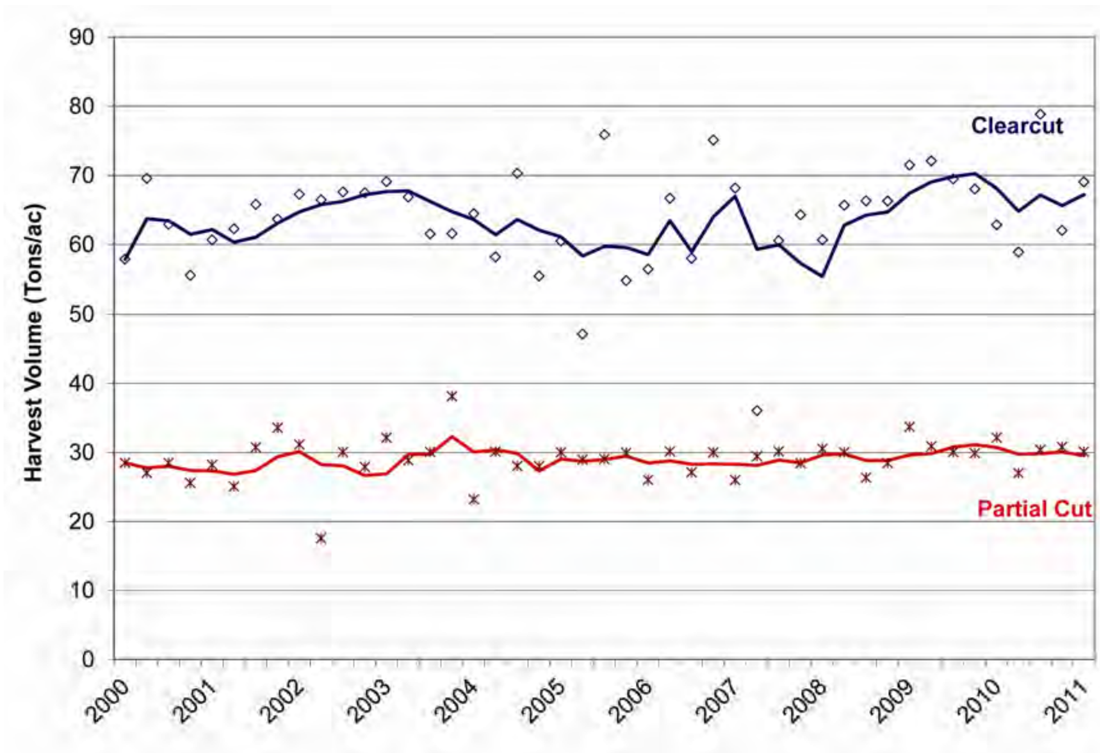

Figure 5. Median and four-quarter moving average tons harvested per acre for clearcuts and partial harvests from fourth quarter 2000 through fourth quarter 2010.

We used the observed ranges in harvested tract data using the Auburn Harvesting Analyzer to determine the sensitivity of the cut and load cost per ton to each variable of interest. When harvested acreages, quadratic mean diameters, or tons per acre were at low values, per ton logging costs increased rapidly (Figure 6). As the values of these variables each increased, per ton costs declined. Beyond some point, production reached a practical maximum in the given set of stand conditions, and costs decreased at a gradual rate as variable costs and tract fixed costs (e.g. road construction costs) per ton decreased incrementally.

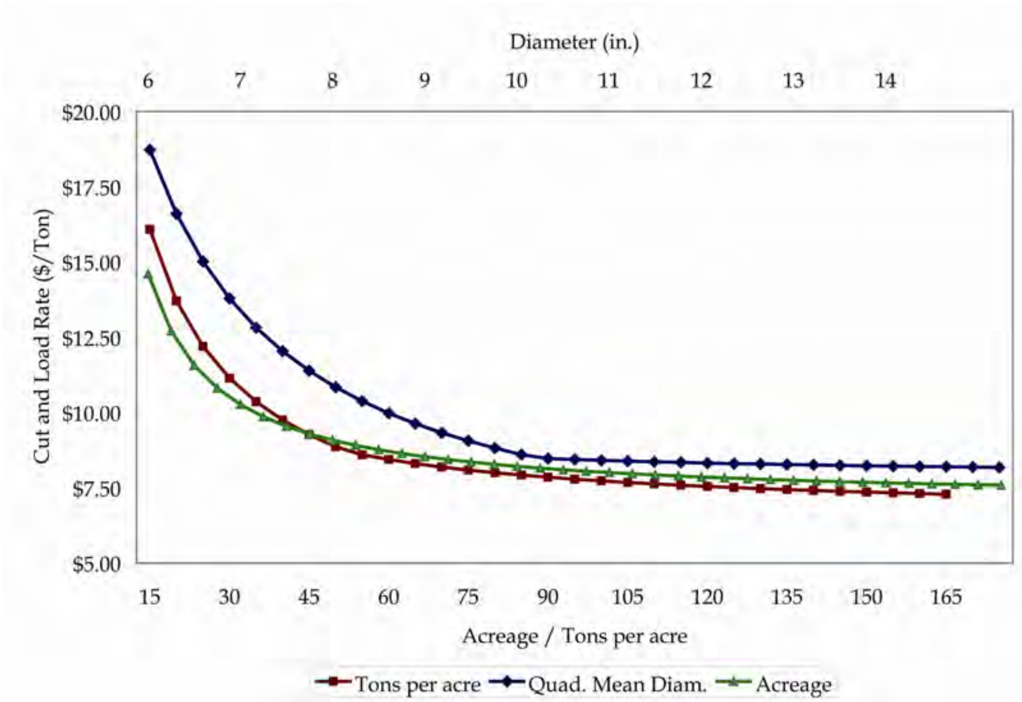

Figure 6. Modeled impact of changes in tons per acre harvested, quadratic mean diameter, and acreage on per ton cut and load rate.

When the average tract characteristics from the sales data were used in the cost model, few trends were apparent in the data with regards to cost impacts over the period studied (Figure 7). The higher rate for partial cuts was a result of a smaller average tree size and fewer tons harvested per acre. The implication appeared to be that shifts in the characteristics of harvested tracts have not yet had a large impact on average harvesting costs across the Southeast. While quarterly fluctuations have been high at times, the long-term average has not shifted appreciably. Other researchers have found substantial cost increases for harvesting contractors over the same timeframe (e.g. Stuart *et al.* 2008). These data suggest that harvesting cost increases would be driven by shifts in component costs (e.g. labor, fuel, etc.), as reported by Stuart, *et al.* (2008), more so than changes in tract characteristics.

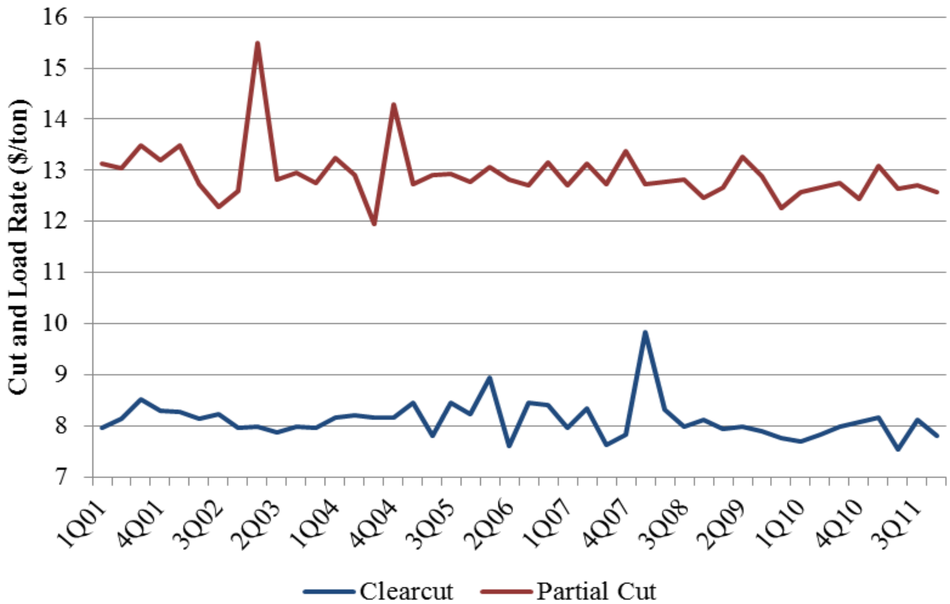

Figure 7. Quarterly changes in modeled cut and load rates based on average harvest tract characteristics from the 4th quarter 2000 through 4th quarter 2008.

Acknowledgements

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PRICE DETERMINANTS OF INVESTMENT GRADE TIMBERLAND: A HEDONIC APPROACH

Jacob Gorman, Larry Teeter, Yaoqi Zhang

ABSTRACT

Since the 1970s, researchers have investigated the determinants of timberland price using hedonic models. The majority of these studies have focused on smaller parcels of timberland ranging from about ten acres to as many as a few hundred acres. This paper extends the methodology to analyze the determinants of timberland price for investment grade timberland (tracts in excess of 5,000 acres which are assumed to derive their value from their capacity to produce timber). A hedonic model is described which analyzes property specific traits, demographics of the local area, and also macro and financial variables which may significantly affect the price of timberland. The study uses actual sale data on over 400 transactions in the Southeastern United States which occurred between 1997 and 2010. As expected, the primary determinants of value are the properties' timber producing characteristics such as the amount of merchantable timber, the average pine growth rate of the surrounding counties, and stumpage prices. In addition, variables such as the county population density suggest that HBU potential is priced into large tracts of timberland. Other significant variables to be discussed include the exchange rate, cpi, housing starts, and some location variables as well.

SOUTHERN FOREST FUTURES PROJECT: FINDINGS AND NEXT STEPS

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ABSTRACT

The Southern Forest Futures Project (SFFP) is designed to provide a science-based "futuring" analysis for the forests of the 13 southeastern United States. Organized by a set of scenarios and using a combination of computer models and science synthesis, the Futures Project examines a variety of possible futures and how they could shape forests and their many ecosystem services and values. The ultimate goal is to translate this vast array of science and modeling results into useable information for management and policy analysis regarding the South's forests by government, the natural resource community, and other key stakeholders.

This presentation will focus on the design and use of scenarios to address uncertainty about future conditions affecting forests in the South. It also draws out the implications of the ten key findings from the Futures Project which address urbanization, invasives, climate, fire, and wildlife implications.

HOW TO EFFECTIVELY INTEGRATE FORESTS INTO CLIMATE CHANGE POLICIES

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ABSTRACT

Decision makers need research based decision analysis models that include carbon sequestration and carbon dioxide emissions to develop successful climate change policies. We demonstrate how the collective good of forest carbon sequestration can be valued by employing a recently developed model. The model utilized compromise programming to investigate optimal stand level management for *Pinus taeda* with the competing objectives of maximizing economic value, forest carbon sequestration, and product storage and substitution. The optimal solution decreased soil expectation value by $462/hectare and increased carbon dioxide emission savings by 15 tonnes of CO_2 equivalents /hectare ($30/tonne of CO_2 equivalent). We show how the government could connect forest carbon storage with the two largest carbon dioxide emission sectors through an integrated cap-and-trade and carbon tax policy. Under the policy, the federal government would agree to buy a certain percentage of the *Pinus taeda* forest carbon credits for approximately $30/tonne of CO_2 equivalents, if the credits were not first bought by the capped electricity generation entities. A carbon tax of approximately $0.02/gallon of fuel would cover the government's cost of buying 90 million tonnes of CO_2 equivalents in case the electricity generation sector did not purchase the credits. This type of climate change policy, if implemented on a large scale, would effectively and efficiently price carbon on different forested stands, decrease emissions by the transportation and the electricity generation sectors, and increase carbon sequestration through the forest sector.

COMPARING THE AMENITY VALUE OF PUBLIC AND PRIVATE GREEN SPACE: AN APPLICATION OF A TWO STAGE HEDONIC MODEL

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ABSTRACT

Public green spaces such as parks and open space provide a number of benefits to consumers. For example, parks and open space provide recreational opportunities, increase aesthetic value, and protect ecosystem services such as air quality, water quality, and wildlife habitat. However, due to factors such as urbanization and development, open space preservation is currently being threatened in many areas throughout the world. In order to accommodate projected population growth and to minimize negative impacts to public environmental amenities, a considerable amount of planning and knowledge of the economic value of these green spaces is needed. The objective of this research is to explore the variation in welfare effect associated with private and public green space amenities. This was accomplished by employing a two stage hedonic method to first obtain implicit prices for both public green spaces as well as private green space for different sub-markets. The variation in implication prices was then used to derive a demand curve and estimate consumer surplus for the entire market. Results from this research are preliminary in nature.

Developing a model for eco-labeling standards for the U.S. forest products markets

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North Carolina State University and University of Helsinki

ABSTRACT

The markets are full of labels presenting everything from safety features to energy saving properties of the products. Forest products show a variety of labels endorsed by different organizations. Most of these labels promote sustainable forest management practices.
The goal of this study is to develop recommendations for eco-labeling of forest products in the U.S. market.
I use meta-analysis to summarize consumers' willingness-to-pay for eco-labeled products in the U.S. and European markets. I also systematically review the literature to understand the criteria used to judge the success of eco-labels and the factors associated with success. These systematic literature reviews will inform guidelines for an ideal eco-label for wood products in the U.S. market.

Perceptions to Corporate Social Responsibility in the Wood Products Industry -- An empirical study in the U.S. and China

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Francisco X. Aguilar
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ABSTRACT

This study examined U.S. and Chinese consumers' perceptions toward corporate social responsibility (CSR) in the wood products industry. A survey-based study was conducted in the U.S. and China in 2011. Pooled data analyzed using exploratory factor analysis indicates perceptions of CSR in the wood products industry is composed of three latent constructs: economic, legal and ethical, and philanthropic domains. In terms of each domain, U.S. and Chinese consumers' expectations toward wood products industry's CSRs are different. Chinese consumers expect a less industrial commitment to economic responsibilities compared with responsibilities in the other two domains, while U.S. consumers expect a lower level of philanthropic responsibility. No difference was detected between these two countries regarding consumers' support to purchasing wood products from recognized socially responsible companies.

CULTIVATING CONNECTIONS IN 2012 – WEB STRATEGIES USED BY FOREST PRODUCTS BUSINESSES IN THE SOUTHERN U.S.

Iris B. Montague[1] *Jan Wiedenbeck*[2]

ABSTRACT

Twelve years ago, many wood products manufacturing companies were just beginning to gain awareness of the potential of e-commerce and e-business. Most scoffed at the idea that e-strategies would become commonplace in the wood industry during the next decade. The "digital divide" between developed and developing countries, urban and rural areas, types of industries, sizes of enterprises, and generations has eroded faster than any futurist could have predicted. Globalization of markets has accelerated the development of a Web presence by U.S. wood products manufacturers as they understand the potential for e-business to help them reach and service new customers. The degree of development of Web-based communication and commerce within the forest products industry in 2012 was assessed for four southern states: Georgia, Louisiana, Kentucky, and West Virginia. Web page components were evaluated using a checklist developed for this project. Differences in Web usage among industry sectors were analyzed as were differences within sectors for companies of different sizes. While larger businesses, as expected, are more vested in Web-based communications and commerce, many outstanding examples of small business Web communications were identified. This evaluation will be used as a benchmark for future assessments of new developments and expanded use of the Web by companies in the forest products industry.

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Introduction

During the past two decades, the advancement of technology greatly exceeded imagination. A world that once depended largely on printed material has become heavily digitalized. Technology advances have allowed companies and consumers to be more productive and efficient in everyday activities. Research that once required a trip to the library can now be conducted in the comforts of one's home or office; companies are no longer dependent solely on newspapers, magazines, billboards, or mass mailings to market products or distribute company information; and individuals can gather information about favorite products and keep in touch with friends, family, and colleagues all at the same time. The Internet allows all of this to happen, plus more.

Internet usage has grown exponentially since it was introduced for commercial use in the early 1990's (All About Market Research 2010). Within 5 years of its introduction, the number of users increased from 16 million to 248 million. Today, according to Internet World Stats (2012), there are over 2.2 billion Internet users world-wide; the United States has the second highest number of Internet users (China is first). According to a recent study, 80 percent of Americans 18 years or older use the Internet and they spend an average of 13 hours per week online at home.

The Internet also has had a great impact on companies globally. It is at once a world-wide broadcasting mechanism, a channel for information dissemination, and a medium for collaboration and interaction between individuals and their computers without regard for geographic location (Internet Society 2012). It revolutionized business development and management and leveled the playing field, allowing equal visibility and accessibility for small and large firms alike (Vlosky 2001). The days of relying solely on postal delivery, faxes, or physical visits disappeared with the advent of the Internet.

In recent years, Internet accessibility has brought about a revolutionary trend, social media. Merriam-Webster (2012) defines social media as "forms of electronic communication through which users create online communities to share information, ideas, personal messages, and other content." Social media include message boards, podcasts, blogs, micro blogs, lifestreams, bookmarks, networks, communities, wikis, and vlogs. Currently, there are hundreds of social media network sites available online that cover a wide range of interests (e.g., business, politics, dating, cooking, fashion) and cater to just about every demographic group (Montague 2011).

Social media have grown rapidly within the past few years – today nearly four in five active Internet users visit social networks and blogs (Nielsen 2011). Social networking has rapidly become a part of individuals' personal life. Facebook alone has over 500 million users and Twitter claims to have 175 million users and 95 million tweets a day (Regus Business 2011). Although Facebook and Twitter are newer forms of social media, social media networking has been available for quite some time. However, with these sites attracting so much of the world's attention, commercial use of social media is becoming a growing trend. The emergence of Facebook, Twitter, and other social media sites has greatly changed companies' communicating tools and strategies used with customers (Mangold and Faulds 2009).

Many companies, including Fortune 500 corporations, have embraced social media, have found it to be an effective way to communicate with the public, and have used it as a vehicle to gain new clients. In fact, research has shown that the incorporation of social media into marketing strategies has increased brand recognition, product purchases, revenues, and profits (Gommans et al. 2001, Patterson 2011, Regus Business 2011, Singh et al. 2008, Weber 2007). It also is estimated that within the next year, organizations will spend $4.6 billion to expand their participation in social media (Young 2008). Because the Internet and social media use seem to be important components in product marketing and business strategies, it is worthwhile to determine the impact the Internet and social media may have on the forest products industry.

Research on Internet utilization in the forest products industry is limited. To fully understand the Internet's impact on the industry, more research is needed. It is important to determine how many forest products companies are using the Internet and what social media strategies are currently being incorporated into company marketing plans. The objectives of this research were to: 1) benchmark current use of social media/Internet usage in the wood products industry to serve as a baseline for future comparisons; 2) evaluate how adoption of social media/Internet usage is related to company size, sector, and state ; and 3) evaluate "best in class" uses of social media as a reference for future dissemination efforts.

Methods

This study focused on forest products producers in two major hardwood producing states, Kentucky and West Virginia, and two major softwood producing states, Georgia and Louisiana. A list of primary and secondary hardwood and softwood manufacturers in these regions and their company information were compiled using listings from state directories and other resources (Georgia Forestry Commission 2012, Kentucky Division of Forestry and University of Kentucky Department of Forestry Extension 2012, Louisiana Forest Products Development Center 2012, West Virginia Division of Forestry 2012). The study population comprised all forest products producers identified in these information sources.

To meet the objectives of the study, research was conducted through online investigation. Forest products manufacturing operations in the four states were identified by accessing on-line state maintained databases. Each of these state directories is updated periodically so the information on company size, type of products produced, and links to company Web pages can be considered to be current (Georgia Forestry Commission 2012, Kentucky Division of Forestry and University of Kentucky Department of Forestry Extension 2012, Louisiana Forest Products Development Center 2012,West Virginia Division of Forestry 2012). Information on

2,509 companies (1394 from Georgia, 721 from Kentucky, 250 from Louisiana, and 144 from West Virginia) was accessed and evaluated using these links. In cases where the state directories did not indicate a Web page address, a Web search was conducted – many additional sites were discovered in this way. These searches and Web site evaluations were conducted from March to June, 2012.

Using this information, companies were separated into groups based on products produced. Companies that produced products mainly for consumer use such as flooring, cabinets, doors, millwork, and crafts were placed into the consumer category. Companies that produced products mainly for industrial use such as lumber, logs, poles, timbers, pallets, and engineered wood products were placed into the industrial category.

Companies were then grouped into size classes (small, medium, and large) and production classes (consumer and industrial). In most cases, the number of employees was used as the determinant for size, where companies with 1-19 employees were classified as small firms, companies with 20-99 employees were classified as medium-size firms, and companies with 100 or more employees were classified as large firms. In some cases, companies were already classified as small, medium, or large in directory listings. Whenever employee numbers were available, size classification was based on this information.

The Web page links listed in the directories were used to explore company Web sites and analyze the type of Internet strategies used by companies. Each company Web site was examined to determine if the company used any type of social media (e.g., Twitter, LinkedIn, RSS feed) and if company sites had e-commerce, photo galleries of products offered, language translation, product literature, software downloads, customer service, and other attributes.

To simplify the analysis and capture additional demographic attributes in our interpretation, the southern states of Georgia and Louisiana were lumped together as were the states of West Virginia and Kentucky into the *"Gulf States"* and *"Mid-South"* regions, respectively. The *Gulf States*, in addition to being regionally proximal to one another, tend to be dominated by southern yellow pine operations while the *Mid-South* states tend to be dominated by hardwood operations.

Descriptive and parametric statistical procedures were used to analyze data. To determine how effective company size (*small, medium, or large)*, product class (*industrial or consumer*), and region (*Gulf States or Mid-South)* were in predicting Web, social media, and e-commerce usage, multiple logistic regression analysis was used to examine the data. In evaluating these three models, the dependent variable (*Web, social media, or e-commerce)* was a binary (yes/no) variable. The Stepwise Selection procedure was invoked to identify significant components for inclusion in the final model. Odds Ratio estimates together with Wald 95% Confidence Limits provided point estimates for the likelihood of occurrence of Web pages, social media, and e-commerce for companies based on their demographic characteristics for those predictor variables found to be significant. The level of significance for these tests was established as .05.

Results

Demographics

For the purpose of this study, key demographic characteristics for each company were evaluated and recorded. This included information on the manufacturer's location, production, sales, number of employees, products produced, Internet use, and social media use. This information was then used to group companies into size classes (small, medium, and large) and product-type classes (consumer and industrial). For the state of Georgia, size indicators were only available for some of the companies. Product classification was available for all of the listed companies.

Of the 1,212 companies that provided size indicators, 67.5 percent were classified as small firms, 24.2 percent were classified as medium-size firms, and only 8.3 percent were classified as large firms. When grouped into product classes, a substantial majority (73.3 %) of the total companies were classified as consumer-product producers. However, the industrial-product and consumer-product percentages were much different, 51 vs. 49, respectively, for the group of 1,212 companies for which size data was available. For all companies included in this analysis, 865 (34.5%) companies were located in the *Mid-South* states and 1,644 (65.5%) companies were located in the more softwood-dominated *Gulf* Coast states. For those companies for which the size data was available, the percentages were reversed with 69 percent located in the *Mid-South* and 31 percent located in the *Gulf Coast* region. This result reflects the more consistent reporting of company size data in the Kentucky and West Virginia data sets than in the Louisiana and Georgia data sets.

Of the 2,509 companies included in this study, 589 (23.5%) had Web pages (Fig. 1). Seventy percent of the companies with Web pages were classified as consumer-product producers and 30 percent were classified as industrial-product producers. While 30 percent of the companies from the *Mid-South* had Web sites, only 19 percent of the *Gulf Coast* producers had sites.

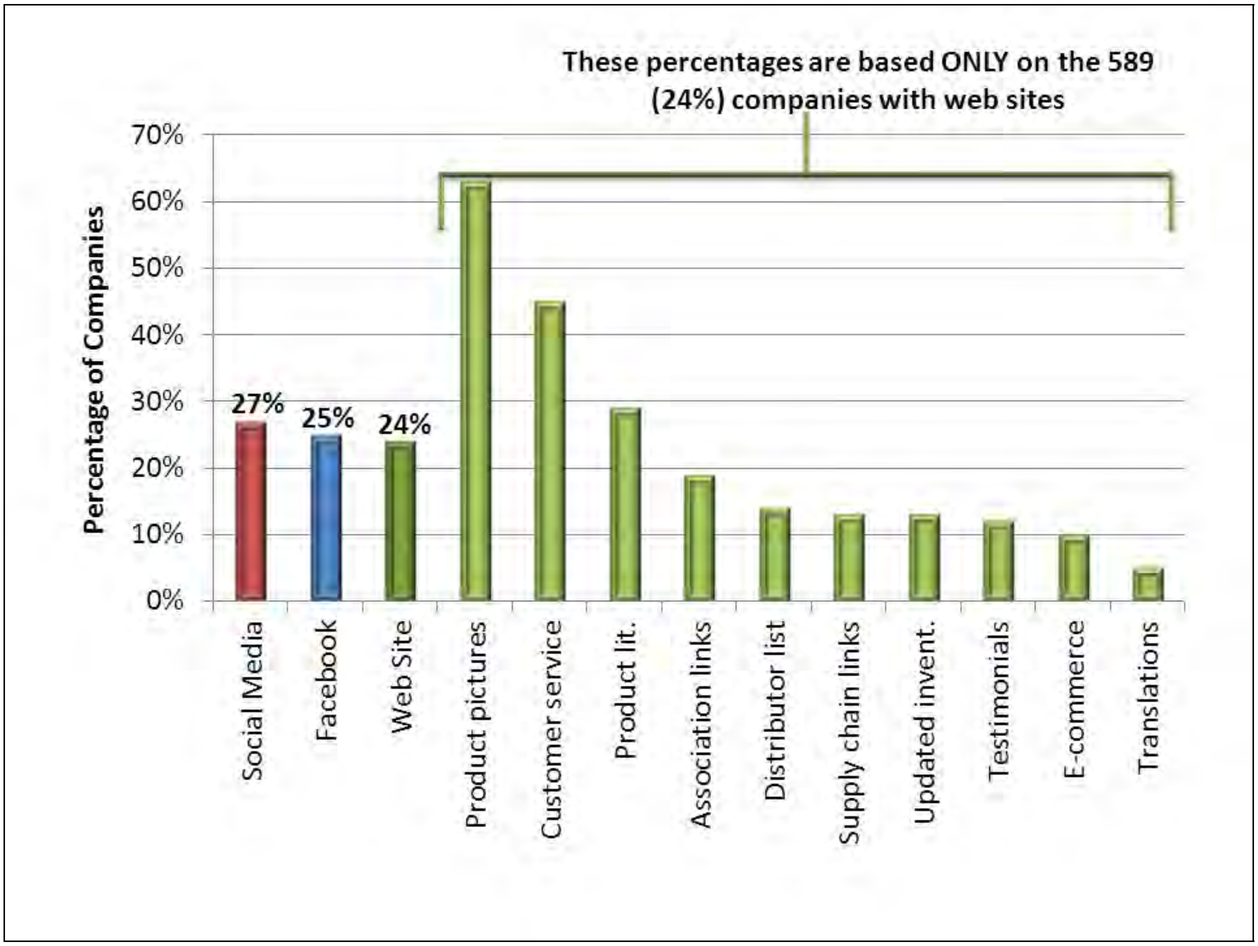

Figure 1. Frequency of use of different social media elements by forest products companies in West Virginia, Kentucky, Louisiana, and Georgia. The 10 light green bars on the right show the percentage of Web sites that included each of these components.

On a state by state basis, West Virginia had the largest percentage (40.3 %) of companies with Internet presence, followed by Louisiana (30. 4%), Kentucky (28.7%), and Georgia (18.1%).

Web Strategies

To determine Web strategies used by forest products producers, it was necessary to personally view available Web sites of each company. If a company had an available Web site, the site was viewed to determine if social media were incorporated into the business strategy, if the company used e-commerce, if a photo gallery of products offered was available, if product literature was provided, if language translation was provided, and if a link for customer service/feedback was provided (Fig. 1). Because Americans spend more time on Facebook than they do on any other U.S. Website (Nielsen 2011), Facebook searches also were conducted for each company listed.

It was interesting to discover that although some companies did not have an active Web site, they had a presence on a social media site. While there were only 589 companies with a Web site, there were 677 companies that used some type of social media. Facebook, Twitter, LinkedIn, You-tube, RSS feeds, and Flickr were some of the social media sites used. An overwhelming 94.1 percent of the companies that used social media used Facebook (25.4% of all companies.) Only 11.5 percent of social media users used Twitter (3.1% of all companies.)

In terms of e-commerce, were very few (2.4%) companies sold their products online. Of the 60 companies that participated in e-commerce, just over half (53.3%) were industrial producers. However, the number of e-commerce sites for industrial producers represented only a very small percentage (4.8 %) of all industrial producers. Twenty-eight consumer producers offered e-commerce, which represented 1.5 percent of the consumer-product producers.

Of the companies that had a presence on the Web, nearly two-thirds (63.3%; Fig. 1) had a dedicated photo album/gallery to showcase products offered, 2.9 percent offered software downloads, and 4.5 percent offered language translation. Languages offered for translation included Spanish, Chinese, Japanese, and Italian. While customer service is an important component of business strategies, only 45.5 percent of companies with Web sites offered customers the option of leaving feedback, requesting information, and/or requesting service or help. Some of the companies that did not provide this customer service option did provide e-mail addresses or contact information.

Predictors of Web Use and Social Media Strategies

Multiple logistic regression results based on the sample of 1,212 companies for which we had company size information, indicated that both *Size* and *Product Type* (industrial vs. consumer) are significant predictors of the existence of a Web site ($p<.0001$) for this sample of companies but *Region* was not. The Odds Ratio for the significant factors in this model indicated that for a given *Product Type* classification, large companies are 18.7 times and 5.2 times more likely to have a Web site than small- and medium-size companies, respectively. For a given company *Size* classification, consumer-product producing companies are 2.8 times more likely to have a Web site than are industrial-product producing companies. These results are evident upon close inspection of the percentages of companies with Web pages, by *Size* and *Product Type*, shown in Table 1.

Prediction, using multiple logistic regression, of the likelihood a company has a social media presence (e.g., Facebook) using the same three predictor variables returned a highly significant model that contained only one main effect, *Region* ($p<.0001$). The predicted odds that a forest products company in one of the Gulf Coast states would be involved in social media were 75 percent higher than the odds for a company from the South Central region (odds ratio = 1.75; Table 1).

The best multiple logistic regression model based on the stepwise procedure for company participation in e-commerce contained only the main effect predictor variable *Size*. The predicted odds for large companies to be involved in e-commerce were 3.4 times greater than for small companies and 2.0 times greater than for medium-size companies. Table 1 displays this trend. The statistical significance of the e-commerce model was not as strong as those for Web pages and social media ($p<.01$ as compared to $p<.0001$ for the other two models).

Table 1. Forest products company participation in Web sites, social media, and Facebook by region, company size, and product classification as a percentage of companies for which size data were available.

Region	Company size	Product classification	Web site	Social media	E-commerce	n=
			-- in percent --			
Gulf Coast	Small	Industrial	18	30	2	60
		Consumer	20	40	1	144
	Small total		**20**	**37**	**1**	204
	Medium	Industrial	37	38	7	76
		Consumer	53	65	9	34
	Medium Total		**42**	**46**	**7**	110
	Large	Industrial	76	34	8	53
		Consumer	100	67	0	3
	Large total		**77**	**36**	**7**	56
Gulf Coast Total			**35**	**39**	**4**	370
Mid-South	Small	Industrial	11	30	5	307
		Consumer	30	21	2	307
	Small total		**21**	**26**	**3**	614
	Medium	Industrial	38	25	3	100
		Consumer	76	30	6	83
	Medium total		**55**	**27**	**4**	183
	Large	Industrial	68	32	14	22
		Consumer	78	52	9	23
	Large total		**73**	**42**	**11**	45
Mid-South Total			**31**	**27**	**4**	842
Grand Total			**32**	**31%**	**4%**	**1212**

Discussion

Although the results show that only 23 percent of the companies examined in these four states have a Web site, the percentage of companies that use some type of social media in their business strategies is slightly higher (27%). One reason companies may choose social media sites over having company Web pages is cost efficiency. While there are a few places available online to create free Web-pages, the lack of experience in Web-site development, the amount of data storage needed, and the time and resources needed to develop and maintain Web sites can be cost prohibitive for smaller companies. In most cases, a company can register on a social media site for free and provide customers with some of the same information that would have been provided on a Web-page. In addition, social media sites allow companies to interact more readily with their consumer base.

Social media, then, should be a cost effective way for small companies to market products and reach consumers. The statistical results for social media involvement, unlike those for Web site presence, did not indicate that size is a factor affecting the likelihood that companies are using social media in their marketing mix. This finding seems to support the idea that smaller companies have considerable capability to be involved in social media. In contrast, larger companies were much more likely than smaller companies to have implemented Web sites. One of the advantages of being a larger firm is resource availability. Large firms may be better able to allocate the capital and man hours needed to develop and maintain a Web site. Recent studies have shown that some individuals are still apprehensive about Internet and social media use in terms of security and privacy (Montague 2011).

The statistical result indicating that companies manufacturing consumer products (e.g., furniture, flooring, cabinets, novelties) are more likely to have a Web page than companies manufacturing industrial products (lumber, pallets, board products) follows reason. Most industrial products are classified as commodity products – products with minimal differentiation based on manufacture and they may often be sold into a market that is of limited, discrete, and known size. The sale of hardwood crossties to railroad maintenance contractors where all players in the marketplace know one another, is an example of this. For these reasons, the benefits of marketing many types of industrial products through a Web site are expected to be smaller than those reaped by consumer product producers which often have more differentiated products and a much larger and broader potential market.

It is no surprise that an overwhelming majority of the companies that use social media use Facebook. Facebook has over 500 million users world-wide, more than 2.5 million Websites linked to its network, and reaches 70 percent of active U.S. Internet users (Nielsen 2011 and Regus Business2011). In a recent report, researchers found that 68 percent of Facebook users in the United States had shown support for a product, service, or company by becoming "fans" or "friends" of a page or group and 75 percent had "liked" a product, service, company or group on Facebook (Experian 2011). These statistics alone show how powerful a tool Facebook can be in gaining market access, brand recognition, and customer loyalty.

Conclusions

Company size is the dominant factor affecting whether U.S. forest products companies have developed Web sites and are using e-commerce to market their products in 2012; larger companies are more likely to have embraced these tactics. Excellent Web sites and Facebook pages developed by small companies can be found. Some of these sites and pages are particularly unique and personal, effectively engaging the attention of the perspective customer. It appears that companies producing consumer products are recognizing the breath and diversity of markets they can reach with implementation of a Web page.

It is important to note that during the online research phase of the study, several Web and Facebook sites were found that seemed to be abandoned (not updated) or that were very basic and provided little information. Research will be conducted to classify the quality of Web and Facebook sites and to determine how effective it is for U.S. forest products companies to have an Internet presence or incorporate social media into their marketing strategies.

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FAMILY FOREST OWNERS AND FEDERAL TAXES

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ABSTRACT

A series of ten focus groups was conducted with family forest owners to investigate their familiarity and experience with federal, state, and local taxes. Two focus groups each were held at locations in Alabama, New Hampshire, South Carolina, Washington, and Wisconsin selected to represent a broad range of state and local tax policies. This paper presents the results for the federal income and estate taxes.

The forest owners seemed to be aware of only a few of the federal income tax provisions that apply to them. The only provision brought up in half or more of the sessions was capital gain tax treatment of timber harvest income. Uncertainty and misconceptions were common: in seven of the ten groups, owners were unclear about how income from a timber harvest is taxed, believed it is taxed as ordinary income, or believed it is tax-free. The owners were somewhat more aware of the federal estate tax provisions that apply to them. Three provisions, gifting, the annual exclusion for gifts, and the effective exemption amount for estates, were brought up in half or more of the sessions. Also

frequently mentioned were sophisticated estate-planning tools, including trusts and forms of organization such as the limited liability company or family limited partnership. In six of the groups, however, owners had used risky strategies, including joint tenancy with right of survivorship or simply adding a child's name to an account or deed. Several themes emerged in group discussions in every region: the problem of children not being interested in the family forest, the disastrous results of inadequate planning or unwillingness to pay for expert advice, that not all experts are knowledgeable about federal taxes as they apply to forest holdings, and the effects of tax uncertainty.

Causes and Consequences of County Ordinances Regulating Forestry in Florida

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ABSTRACT

Across the US South, an increasing number of local ordinances regulate forest management and timber harvest on private lands, many with potential unintended negative consequences for forest landscapes and local economies. We examine ordinances in Florida's sixty-two counties, which vary widely in terms of both intensity of local regulation and importance of the forestry sector. We first model the drivers of local regulations that restrict and regulations that favor forest management, testing factors suggested by theories of the political market, median voter, interest group, and diffusion. This allows us to identify a sub-set of Florida counties matched on these observable characteristics to use in estimating regression models of forest outcomes as a function of ordinances and covariates

Past, Current and Future Economic Conditions of the Forest Sector in the U.S. Northern Region

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ABSTRACT

This presentation highlights the current economic situation, historical trends and possible future paths for the wood products industry in the US Northern Region. Current status and historical trends are based on US Forest Service FIA data, RPA publications, and other national statistics. Economic data include trends of forest areas and forest products with emphasis on fuelwood and mill and harvest residues. Conservation policies and effects will be discussed briefly. Results of our published and working papers on conservation effects of cost-share and easement programs and models for biomass energy consumption by different sectors in the northern region will be used for the discussion. Outlook into future scenarios for the industry will be discussed in the second part of the presentation. RPA predictions for wood products such as round wood, lumber, biomass, pulp wood, and other products will used as one source of the forecasts. Forecasts of woody biomass for energy consumption in the Northern Region are based on recent econometric studies. An outlook into forest conservation will also be discussed based on different sources of information. And synthetic analysis or overall analysis will be given with a view of social ecology. Involvement of the social and ecological relations among economic activities, forest recovery, inventory change, environmental protection, ownership, population increment, urbanization, and natural process are presented to discuss past trends and future scenarios under certain circumstances. Policy changes affecting the forest sector will be discussed too.

COST ANALYSIS OF MONITORING AND ASSESSING THE WETLANDS RESERVE PROGRAM EASEMENTS: FOUR-TIERED NEAP BIOASSESSMENT FRAMEWORK

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ABSTRACT

The Wetlands Reserve Program (WRP) is a voluntary conservation easement program operated by the USDA Natural Resources Conservation Service (NRCS) to restore and protect a variety of wetlands ecosystem services on private land. Currently, more than 10,000 easements that cover over 2 million acres in the United States have been enrolled in the WRP. In the eastern and southeastern United States, reforestation is a primary restoration practice, but NRCS has not yet implemented cost-effective strategies to monitor and assess biological condition on WRP easements. As part of the National Easement Assessment Project (NEAP), a four-tier bioassessment framework has been developed to guide NRCS in developing a new National Inventory, Monitoring, and Management Program. The Tier 1 approach suggests NRCS use current on-site qualitative monitoring checklists to track restoration progress and document violations, but not to assess biological condition. The Tier 2 strategy includes deriving a non-calibrated, semi-quantitative assessment of biological condition utilizing on-site assessment checklists and new resources outlined in Tier 1. Indicators would be identified by summarizing objectives outlined in state ranking criteria for each type of wetlands (e.g., forested, herbaceous, etc.). The Tier 3 strategy consists of a multi-scale biological assessment. Discrete categories of biological condition (e.g., high, medium, and low) would be assessed based on thresholds identified from published literature or expert opinion. In Tier 4, NRCS could use remote-monitoring techniques, rapid assessments, and intense vegetation and faunal monitoring simultaneously to provide best estimates of biological condition. The costs and workload of each approach were estimated based on the review of the monitoring programs of other federal and state agencies as well as non-profit organizations, and the pilot study conducted by the NEAP. Cost-effective strategies are identified and recommended for NRCS to successfully monitor and assess WRP easements.

USING PRIVATE LANDS TO MITIGATE PUBLIC ENDANGERED SPECIES ACT MANDATES FOR RED-COCKADED WOODPECKER IN NORTH CAROLINA

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ABSTRACT

Central to the recovery plan for the red-cockaded woodpecker (RCW) in North Carolina are military bases. A key strategy proposed for meeting the on base requirements of the Endangered Species Act (ESA) is the development of economic incentives to encourage cooperative conservation of RCW habitat between federal military and nonindustrial private agricultural and forest landowners (NIPAFs). Longleaf pine management regimes were analyzed for three primary goals that included (1) timber maximization, (2) multiple products, and (3) ecological services focused on developing RCW habitat. Capital budgeting models for land management options consistent with RCW habitat requirements were analyzed and compared with traditional pine management options and agricultural alternatives. The difference between these management options provides a baseline opportunity cost. Using a 4% real discount rate, longleaf pine managed for ecosystem services did not financially compete with conventional loblolly pine and only yielded a positive NPV with the addition of moderate pine straw revenues. The opportunity costs of longleaf pine managed for ecosystem services ranged from $485 to $698 per acre with no pine straw income to $56 to $255 per acre with moderate income from pine straw compared to returns NIPAFs could receive from loblolly pine. These results were

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highly sensitive to changes in both stumpage price and cost share rate, as shown in sensitivity analyses. The opportunity cost associated with transitioning average agriculture sites to longleaf ranged from $1,612 to $4,655 per acre dependent on the crop, indicating that any future incentives for habitat creating programs should focus on lands that favor forestry. These loblolly and crop opportunity cost estimates could be used as a basis to support conservation payments to provide an economic incentive for NIPAFs to manage for RCW habitat.

Keywords: red-cockaded woodpecker, longleaf pine, economics, opportunity cost, ecosystem services

Introduction

The red-cockaded woodpecker (RCW) (*Picoides borealis*) was declared endangered in 1973, upon enactment of the Endangered Species Act (ESA), due to a decline in population and natural range. Recent surveys estimated that slightly more than 14,000 individual birds survive in nearly 6,000 active clusters (USFWS 2003). The birds inhabit southern pine savannahs and rely on open forage conditions provided by a well-managed understory. Though RCW nesting cavities have been observed in various pine species, the preferred tree species is the longleaf pine (*Pinus palustris).* Foraging habitat may be available in younger stands, but nesting habitat is provided only in older trees (Wood and Kleinhofs 1995).

Central to the RCW recovery plan in North Carolina are military bases. Due to ESA's strict distinction between the responsibilities of private versus federal lands, a key strategy proposed for meeting the ESA requirements is the development of economic incentives to encourage cooperative conservation of RCW habitat between federal military and nonindustrial private agricultural and forest landowners (NIPAFs). The goal of this research was to generate realistic economic analysis of land management options consistent with habitat requirements for the endangered RCW. Comparing this analysis to economic valuations of loblolly pine and average agricultural returns provides a baseline estimate of the opportunity cost for NIPAFs to manage land for RCW that could then be used as a basis to support conservation payments to provide an economic incentive to manage for RCW habitat.

Methods

The capital budgeting process provides investors with the means for comparing various investment options over differing timeframes. To achieve the research goals, various scenarios were analyzed, concentrating on representative land management options available to NIPAFs in the Piedmont and Coastal Plain regions of North Carolina. Capital budgeting was used to assess the present value of each scenario and comparisons were then made to better understand the land management options and associated values that NIPAFs face. In each case, longleaf pine managed for RCW habitat was compared to a rural alternative use: longleaf pine for maximum revenue, shorter rotation loblolly pine regimes, and row crops. A standard capital budgeting approach was used as summarized by Klemperer (2003) and Wagner (2012), emphasizing net present value (NPV) and soil expectation value (SEV).

Longleaf Pine Scenarios

Four key components drove the longleaf pine analyses: management scenario, pine straw revenue, timber revenue, and management practice costs. Longleaf management scenarios common in the literature and those observed by North Carolina Forest Service (NCFS) experts were reviewed and synthesized into typical options, intended to represent finite points along the continuum of possible regimes from those designed primarily for RCW habitat benefits to timber revenue maximization (Ron Myers and Fred Cubbage, personal communication). Each varied rotation length, prescribed burning, and thinning to achieve desired goals as described in Table 1. This analysis emphasizes the maximum timber and RCW regimes for comparisons.

In addition to conventional timber revenue, each scenario was assessed both including and excluding additional revenue from the interim harvest of pine straw. Straw raking began at age 16 with harvest occurring every third year until final timber harvest or age 55, when pine straw productivity is expected to decrease significantly. Conservative and moderate value cases were developed: $75 per acre per harvest and $125 per acre per harvest respectively[2].

Table 1. Longleaf Pine Management Scenarios

Management	**Maximum Timber**	**Multiple Products**	**Ecosystem Services/RCW**
Rotation Length	40 years	60 years	80 years of active mgmt, no final harvest
Prescribed burning			
With pine straw	12 and 29 years	12 and 41 years	Every 5th year from 45 to 80 years
Without pine straw	None	None	Every 5th year from 12 to 37 years
Thinning Schedule	28 years to 80ft^{2}per acre basal area	28 and 40 years to 80ft^2 basal area	40 and 60 years to 60 and 80ft^2 basal area, respectively

[2] Representing low to mid-range estimates from literature and local pine straw sales. For example, 2011 sales at Bladen Lake State Park ranged from $150 to $300 per acre (Ron Myers, personal communication, November 28, 2011).

To determine timber yields for each of the proposed scenarios, annual growth in timber volume per acre was estimated using three longleaf pine growth and yield models: NATYIELD (1986), Farrar (1985), and Lohrey and Bailey (1977). In the preceding analysis, emphasis is given to NATYIELD results which are consistent with Lohrey and Bailey (1977) and geographically representative. Across scenarios the first thinning (at age 28) was assumed to contain 25% pulpwood and 75% chip-and-saw, and the second thinning and final harvest, 20% chip-and-saw, 50% sawtimber, and 30% large sawtimber. Stumpage prices by product class, were collected and averaged from 4th Quarter 2011 Forest2Market and Timber Mart-South reports. Prices were as follows: pulpwood for $7.93 per ton, chip-and-saw for $14.88 per ton, sawtimber for $25.41 per ton, and large sawtimber for $56.32 per ton (Forest2Market 2011, Timber Mart-South 2011).

Rural Alternative Scenarios

Comparisons were also made to two additional rural alternatives: shorter rotation alternative pine species and row crops. A simplistic representation of typical performance for each of these was developed. Loblolly pine managed as either conventional 25-year rotation or in perpetuity represents alternative pine species while the agricultural scenario was represented by typical corn and soybean budgets for average quality crop lands in North Carolina

Under the conventional scenario, the loblolly pine thinning and harvest volumes and management regime were based on prior research by Siry et al. (2001) and Cubbage et al. (2012), which used the TAUYIELD growth and yield computer program. The planting rate was 600 trees per acre with a site index (SI) of approximately 80 feet at age 50. Thinning volume was 475 ft^3 per acre at age 17, comprised of 75% pulpwood and 25% chip-and-saw. The final harvest volumes was 2,225 ft^3 per acre at age 25, comprised of 23% chip-and-saw wood, 67% small sawtimber, and 10% large sawtimber. Prices for each product class mirrored those used for the analysis of longleaf pine (Forest2Market 2011, Timber Mart-South 2011). Establishment costs ($242 per acre) for loblolly pine were lower than those of longleaf pine reflecting a difference in the price of seedlings.

Results

Value of Longleaf Pine Managed for RCW Habitat

Costs for site preparation, tree planting, and maintenance activities were collected for the appropriate regions from NCFS' prevailing practice rates provided by their Forest Development Program (NCFS 2011; Table 2). Active management occurred over an 80-year horizon creating habitat through prescribed burning, thinning, and pine straw harvest. The present value, at 4%, of the costs of these activities was $615 per acre without pine straw harvest and $697 per acre with pine straw harvest. The difference in these costs is due to variations in prescribed burning frequency and timing in order to maximize pine straw harvest in the latter scenario.

Table 2. Longleaf Pine Management Costs

Activity	**Cost per acre**
Site Preparation (mechanical chop)	$81
Planting (longleaf in containers)	$135
Herbicide Application (chemical ground machine)	$90
Prescribed Burn	$45

Direct estimates of revenue were calculated from timber thinning and pine straw harvest and exclude any potential revenue from the sale of conservation credits. Table 3 provides timber revenue estimated for the RCW habitat management scenarios using the capital budgeting approach. Pine straw revenue for the entire rotation was estimated as two potential present values: the conservative case of $236 per acre and the moderate case of $393 per acre. Note that the present values of timber revenue are greater without pine straw, because less timber is harvested to maintain the pine straw production system.

Table 3. Present Value, 4%, of Longleaf Timber Revenue per Acre by SI for Ecosystem Services/RCW Models

		SI at age 50	
	60	**70**	**80**
Managed only for timber, no pine straw	$221	$316	$426
Managed for pine straw and timber	$171	$260	$361

Value of Longleaf Pine for Maximum Timber Returns

A majority of private lands planted to longleaf pine in North Carolina is managed for timber revenue rather than RCW habitat. The maximum timber longleaf scenario represented financial returns on these properties. NPVs for each SI and pine straw intensity are provided in Table 4. NPVs increased with greater pine straw intensity or frequency and for higher quality sites.

Table 4. Net Present Value, 4%, Maximum Timber Longleaf Management from NATYIELD Model

Pine Straw Intensity	SI at age 50 60	70	80
None	($111)	($2)	113
Conservative	$83	$192	$306
Moderate	$240	$349	$463

Value of Loblolly Pine Land Use

Table 5 provides the results from the conventional loblolly analysis. An annual tax and management cost of $8 per acre is also included. Summing the present values below results in a conventional loblolly NPV of $126 per acre and an SEV of $201 per acre.

Table 5. Conventional Loblolly Pine Analysis Results, 4%

Year	Activity	Cost	Revenue	Value	Present Value
0	Establishment	$242	$0	($242)	($242)
17	Commercial thinning	$0	$103	$103	$53
25	Final harvest	$0	$1,305	$1,305	$490

In order to assess opportunities for providing RCW habitat using an alternative pine species, a long rotation loblolly case was also examined. This case used the same underlying values as the conventional case; however, the final harvest was replaced with a natural stand management regime with continual commercial thinning into perpetuity starting at age 25. The present value of thinning was $164 per acre. Management costs were increased to $208 due to a longer investment horizon. These adjustments produced an NPV of -$37 per acre, which was equivalent to the SEV due to the infinite rotation length.

Value of Agricultural Land Use

The agricultural scenarios assumed average North Carolina Coastal Plain crop returns for corn and soybean farms each year into perpetuity: $67.57 and $159.92 per acre, respectively (NCSU 2012). These assumptions were probably optimistic and provide the most conservative comparisons to the longleaf pine results and an upper bound of the opportunity cost to convert to longleaf pine. The analysis assumed that farmers would get average yields, maintain the current high crop prices, and encounter no weather or climate issues. Rotation of crops was also not considered. The SEVs for corn and soybeans were $1,757 and $4,158 respectively.

Analyses that might better reflect a lower bound of returns from agriculture and account for differences due to poor weather and poor soil quality would produce much lower returns. For example, in a trial near Goldsboro, NC, Cubbage et al.

(2012) found that on marginal agriculture lands with annual droughts, crops lost money in every year from 2007 to 2010—a total loss of $664 per acre in four years. When compared with annual risks and potential losses from agricultural crops, forestry investments can produce suitable investment returns.

Discussion

Change from Longleaf Pine for Maximum Timber Revenue

Many privately owned forested lands are already comprised of longleaf pine, but emphasize the maximization of timber revenue rather than provision for RCW habitat. Table 6 compares the SEVs between two longleaf pine cases of (1) maximum timber production versus (2) management for long rotations to develop RCW habitat. These were calculated under each pine straw intensity and SI. The difference in the values is the opportunity cost of managing for RCW habitat. For reference, the opportunity cost was then converted to an annual payment that would yield an equivalent value if it were paid to private landowners on a one time 10-year contract.

Higher opportunity costs and payments in each scenario that excludes pine straw may seem counterintuitive, but reflect the complicated interaction of two aspects of the analysis. First, pine straw intensity increases in both the maximum timber and RCW habitat scenarios; however, the impact on revenue is greater for the timber case due to a shorter rotation. Additionally, the difference in costs between the two scenarios decreases dramatically when pine straw harvesting is introduced due to dissimilarities in management practices.

Table 6. Estimated Difference Between Existing Longleaf Pine for Maximum Timber Revenue and Conversion to RCW Habitat Computed as Opportunity Cost and Payments

Site Index	Pine Straw	Longleaf for RCW Habitat SEV	Present Value Opportunity Cost	10-year contract annual payment
60	None	($497)	$608	$72
	Conservative	($218)	$301	$36
	Moderate	($54)	$294	$35
70	None	($399)	$510	$60
	Conservative	($125)	$208	$25
	Moderate	$39	$201	$24
80	None	($284)	$395	$47
	Conservative	($19)	$102	$12
	Moderate	$145	$95	$11

Change from Loblolly Pine Land Use

There were few situations where longleaf pine was capable of directly competing with loblolly pine. Many of the longleaf pine analyses returned negative SEVs, compared to the conventional loblolly pine SEV of $201 per acre, except on the higher site classes with moderate pine straw income. Table 7 uses the same logic employed above to calculate the opportunity cost and annual payments that would be needed to provide economic incentive to convert conventional loblolly pine systems to longleaf pine management for RCW habitat.

When compared to loblolly managed for habitat with an SEV of -$37 per acre, longleaf pine provides better returns in several cases that include pine straw revenue. Given current stumpage prices, longleaf pine's ability to provide pine straw and thinning revenue from higher value products while providing for RCW habitat make it financially competitive with loblolly pine.

Table 7. Estimated Difference Between Loblolly Pine for Maximum Timber Revenue and Conversion to Longleaf RCW Habitat Computed as Opportunity Cost and Payments

Site Index	Pine Straw	Longleaf for RCW Habitat SEV	Present Value Opportunity Cost	10-year contract annual payment
60	None	($497)	$698	$83
	Conservative	($218)	$419	$50
	Moderate	($54)	$255	$30
70	None	($399)	$600	$71
	Conservative	($125)	$326	$39
	Moderate	$39	$162	$19
80	None	($284)	$485	$58
	Conservative	($19)	$220	$26
	Moderate	$145	$56	$7

The same method was used to estimate the opportunity cost and required payment for converting conventionally managed loblolly pine stands to long rotation, habitat-generating, loblolly pine. Based on the conventional ($201) and the long rotation (-$37) SEVs, the opportunity cost is $238 that is equivalent to an annual payment of $28 per acre on a 10-year contract. This is comparable to the longleaf pine costs on high quality sites with moderate or conservative pine straw revenue. It should be noted that the long rotation loblolly scenario was simplistic and does not account for potentially costly understory control treatments such as prescribed burning or herbicide applications.

Change from Agricultural Land Use

Unsurprisingly, comparisons with row crops were less favorable. In part, this was due to the simplified agricultural calculations that did not account for deviations in weather and climate that have a great impact on annual yield. The comparison was also unfair as it compared high quality agricultural sites with lower quality forestry sites. Marginal agricultural lands may be more attractive for future conversion for RCW habitat. Further, agriculture is a far more intensive land use incurring higher environmental costs and demanding more time and labor input from landowners. A full analysis of agriculture and forestry would give consideration to how time currently spent on agricultural activities could be redirected to generate income elsewhere.

Considering all of these factors, it was still useful to calculate the opportunity costs and payments required to convert agricultural sites to longleaf pine to generate RCW habitat. These costs are likely the highest possible estimate and would be far lower in practice. Table 8 provides calculations that mirror those shown above for loblolly and longleaf pine. The SEVs for corn and soybeans were $1,757 and $4,158 respectively. Annual payments made on a 10-year contract ranged from $191 to $267 for corn and $476 to $552 for soybeans, dramatically higher than the loblolly pine range of $7 to $83.

Table 8. Estimated Difference Between Existing Agricultural Land Use and Conversion to Longleaf RCW Habitat Computed as Opportunity Cost and Payments

Site Index	Pine Straw	Longleaf for RCW Habitat SEV	10-year contract annual payment: Soybeans	10-year contract annual payment: Corn
60	None	($497)	$552	$267
	Conservative	($218)	$519	$234
	Moderate	($54)	$499	$215
70	None	($399)	$540	$256
	Conservative	($125)	$508	$223
	Moderate	$39	$488	$204
80	None	($284)	$527	$242
	Conservative	($19)	$495	$211
	Moderate	$145	$476	$191

Sensitivity Analyses of Stumpage Price and Cost Share Payments

It is important to note that the previous comparisons assume post-recession low stumpages prices and do not include cost share programs that are beneficial to longleaf pine and RCW management. To better understand the implications of these assumptions, two sensitivity analyses were conducted for the case which compares conventionally managed loblolly pine to longleaf pine managed for the provision of RCW habitat.

Sensitivity to Changes in Stumpage Prices

Stumpage prices in each pine analysis were from the fourth quarter of 2011, reflecting historically low timber prices in the southern U.S. These prices highlight the impact of a changing timber market and the uncertainty regarding the future recovery of the market. Use of these prices contributed greatly to longleaf pine's ability to compete with loblolly pine.

This sensitivity analysis assumed stumpage prices of 1.5 times current levels which increased the conventional loblolly SEV to $635 per acre. Table 9 presents updated SEVs, opportunity costs, and payments. Though the value of each longleaf pine investment improved with the increase in timber price, this did not offset the pronounced increase in loblolly pine's SEV. In each case, the difference between the scenarios grew.

Table 9. Estimated Difference Between Loblolly Pine for Maximum Timber Revenue and Conversion to Longleaf RCW Habitat as Opportunity Cost and Payments, High Price Case

Site Index	Pine Straw Intensity	Longleaf for RCW Habitat SEV	Present Value Opportunity Cost	10-year contract, annual payment
60	None	($382)	$1,017	$121
	Conservative	($129)	$764	$91
	Moderate	$36	$599	$71
70	None	($233)	$868	$103
	Conservative	$11	$624	$74
	Moderate	$176	$459	$54
80	None	($61)	$696	$83
	Conservative	$170	$465	$55
	Moderate	$334	$301	$36

Sensitivity to Inclusion of Cost Share Payment

North Carolina provides state and federal cost share programs that offer financial assistance to NIPAFs for planting longleaf pine. These programs can have a tremendous impact on the financial returns for longleaf pine, especially when compared to loblolly pine, which may qualify for a lesser cost share rate. An example of such a program is the U.S. Department of Agriculture's (USDA) Natural Resource Conservation Service's (NRCS) Environmental Quality Incentive's Program (EQIP) that will cost share up to 100% of establishment and maintenance activities for longleaf pine (USDA NRCS 2012a, 2012b). Assuming a minimum payment from EQIP, the opportunity cost between longleaf and loblolly pine was greatly reduced and in many cases disappeared. Table 10 presents opportunity cost and payments when a cost share of $306 per acre, to cover establishment costs, is included.

Table 10. Estimated Difference Between Loblolly Pine for Maximum Timber Revenue and Conversion to Longleaf RCW Habitat as Opportunity Cost and Payments, Cost Share Case

Site Index	Pine Straw Intensity	Longleaf for RCW Habitat SEV	Present Value Opportunity Cost	10-year contract, annual payment
60	None	($178)	$379	$45
	Conservative	$102	$99	$12
	Moderate	$266	NA[3]	NA
70	None	($79)	$280	$33
	Conservative	$195	$6	$1
	Moderate	$359	NA	NA
80	None	$36	$165	$20
	Conservative	$301	NA	NA
	Moderate	$465	NA	NA

Conclusions

The value of property managed for long term RCW habitat will vary significantly by individual sites and management practices applied, but ranged from -$497 to $145 per acre over the lifetime of the investment assuming a 4% discount rate. The above costs and benefits help to support the premise that financial returns for longleaf pine managed for long term RCW habitat are seldom positive, and that additional financial incentives are required to induce landowners to change their primary management goals.

These results assume that landowners are economically rational investors; use capital budgeting analyses explicitly or implicitly in making decisions; concur that the 4% discount rate represents their alternative rate of return; and would convert from traditional farm and forestry management uses if they were compensated with an equivalent annual payment to offset revenue differences. These are of course strong assumptions, but the results are at least indicative of the amount of funds it would take for economically rational landowners to change their land uses. Landowners who were not profit maximizers or who had different discount rates might take different amount of payments to change land use. Furthermore, some evidence suggests that conversion from one land use to another requires a higher than calculated NPV or SEV, because of the long term nature of such a decision, and the relatively higher cost to switch back to agriculture in particular.

[3] In several cases the longleaf pine SEV now exceeds loblolly pine's SEV ($201) and opportunity cost is not applicable.

Stumpage price, an area which is particularly unpredictable in the current economic climate, was shown to have a profound impact on to opportunity costs in each case which ranged from $301 to $1,017 per acre for the comparison between longleaf for RCW habitat and conventional loblolly pine management. Upcoming market fluctuations, and the underlying uncertainty of future returns for various forest products, will have a profound impact on landowner attitudes towards various pine species. Similarly, cost share programs can greatly reduce the opportunity costs for switching between pine species, and may favor management of longleaf pine over loblolly pine.

Considerable evidence from many farm programs does indicate that landowners will change land use if conservation payment incentives are adequate and comparable to income from alternative uses. Our analyses indicate what those levels might be, and provide estimates of the costs and financial incentives that would be needed for increased RCW habitat management in longleaf pine stands in North Carolina.

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SPILLOVER EFFECT OF PUBLIC INVESTMENT IN HABITAT CONSERVATION ON SUPPLY OF PRIVATE ACREAGE FOR HUNTING IN GEORGIA

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ABSTRACT

Hunting opportunities in public lands are limited resources with a relatively constant supply that hunters have been competing for. Further, existing public lands are under increasing pressure to meet public demand for other types of outdoor recreation such as bird watching, hiking, camping thereby further limiting their potential to serve as primary hunting grounds. Individual family and commercial forest lands are possible other sources of hunting grounds and have been serving as primary sites for recreational hunting in Georgia. Given the fact that a large majority of wildlife habitat in the nation is within private lands, garnering private landowner's cooperation and willingness to allow hunting on their land is crucial for ensuring the future of recreational and economic benefits of hunting. There are many ways government agencies could help landowners develop the recreational potential of their private lands. For example, providing conservation payment to landowners for habitat conservation and environmental enhancement could help improve the quality of hunting grounds and potentially increase the supply of private hunting acres. Despite the fact that payment for such programs improves the game habitat in private lands, effectiveness of public expenditure in such programs to increase the availability and use of private lands for hunting has not been well understood. Specifically, what is not clear is whether or not communities receiving such public funding for habitat conservation are actually opening their land to the public. In an aggregated supply model, this study evaluated the impact of habitat conservation and improvement programs on supply of lease hunting acres in Georgia. Results indicate that in addition to habitat type, access, proximity to major population centers, spillover effects of wildlife conservation programs such as wildlife management areas (WMA), and a variety of government payments programs that encourage landowners to engage in habitat improvement and enhancement increased the supply of lease hunting acres in Georgia. Findings provide support for policies aiming to continue or increase public investment in habitat conservation in both private and public lands

Changing Political Regimes and Tropical Deforestation: A Panel Data Analysis

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ABSTRACT

Rapid expansion of agricultural has been identified as the main cause for tropical deforestation. Although causes may vary, it is widely believed that government policies and weak property rights contribute to deforestation by encouraging landowners and landless to accelerate land clearing. Using panel data analysis similar to previous studies, we add the dimension of political regime changes, democratic and non-democratic, and investigate how the rate of agricultural land expansion in tropical countries depends on the nature and persistence of each regime. We find evidence showing that both new autocratic and democratic regimes have accelerated the expansion of agricultural land, thus yielding support to some of the findings in the earlier literature. Interesting differences emerge between regions, with the impact being most pronounced in Latin America. One explanation for our empirical findings is that regime changes increase tenure and ownership insecurity, which in turn is driven by the tendency of new regimes to implement land reforms as a form of social and economic policy or voter payback

Keywords: autocracy, democracy, land reform, tenure risk, tropical deforestation

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Introduction

It is widely agreed that the main driver of tropical forest loss has been the rapid expansion of agricultural land. Contributing factors include road building, illegal logging, industrial harvesting through concessions, and fuelwood collection by local communities (Pfaff et al. 2010). Population pressures and economic development have also been commonly suggested as important overall causes. In many instances, however, the actions and policies of the governments, in addition to institutional characteristics of the tropical countries, add to the extent and pace of deforestation (Palo and Lehto 2012). A considerable number of tropical forest countries have furthermore gone through some degree of political upheaval, such as revolutions and military coups, during the past half a century. Insecure property rights and subsidies for agriculture favor clearing land over keeping native forests, and land reforms frequently include provisions that grant ownership to migrants who clear forest for more productive uses.[2] Political instability, perceived through quick turnover of regimes, and accompanying ownership uncertainty undoubtedly reduce the profitability of long term investments such as forestry, favoring instead some form of extensive agriculture (Bohn and Deacon 2000).

The purpose of this paper is to highlight the impact of the political economy on tropical deforestation from a perspective that extends past work (e.g., Bohn and Deacon 2000; Barbier 2001; Buitenzorgy and Mol 2011). Using panel data and robust estimation methods, we examine how changes in political regime type affect the rates of tropical deforestation through agricultural land expansion. Most recently, Buitenzorgy and Mol (2011) examined the causal relationship between democratization and deforestation in a purely cross-sectional setting using regime data compiled by Polity IV Project.[3] We too make use of the Polity IV project to encode a set of regime transition indicator variables in a panel data context. This allows us to derive more reliable coefficient estimates and distinguish between new and established regimes, and in fact the same empirical strategy was recently applied by Rodrik and Wacziarg (2005) to identify the impact of democratization on economic growth.[4] Buitenzorgy and Mol (2011) combined data for the developed and developing world, but we instead concentrate on explaining the expansion of agricultural land in tropical

[2] The expectations of a future land reform can also motivate land owners to convert land into agriculture simply to strengthen their claim or to obtain easier access to formal title. Government policies further encourage migrant farmers to clear rainforests for cropland regardless of the fact whether the land actually is suitable for long term agriculture (Barbier, 2011).

[3] Bohn and Deacon (2000) also employ a similar type of an approach to identify the political factors influencing the investment environment. Their data on political attributes, however, come from a different source and the results with respect to deforestation are based on a limited cross-section study.

[4] Buitenzorgy and Mol (2011) use Polity IV Project's polity index measure ranging from -10 to 10 as their independent variable.

forest countries, and we go beyond cross sectional data by using a panel spanning 70 tropical countries from 1961 to 2008.[5] We also incorporate the same set of control variables as in Barbier (2001) to examine how political regimes are important to the broad set of literature using this land use data. Our contribution is therefore to investigate whether political regime changes, be them democratic or autocratic ones, are both significant predictors of higher rates of agricultural land expansion in tropical countries.[6] The expansion of agriculture in turn drives tropical deforestation.[7]

Our results give support to the findings in Barbier (2001) where political instability was shown to be a significant and positive predictor of agricultural land expansion. Our approach, however, enables us to identify the effects of both autocratic and democratic regime changes. This feature also allows us to contribute to the recent literature on the effect of democratization on environmental outcomes (e.g., Midlarsky 1998; Buitenzorgy and Mol 2011). We find that new democratic regimes accelerate the expansion of agricultural land. We do not, however, find a negative relationship between established democracies and agricultural land expansion as would be implied by the results in Buitenzorgy and Mol (2011). In addition, contrary to their results, we find that increasing level of income is statistically significant factor in reducing tropical deforestation, even after controlling for regime variables and country specific effects. Furthermore, we show that both new and established autocracies have a tendency to accelerate tropical deforestation. We interpret our collective findings mainly through the hypothesis of decreasing ownership security. The same underlying cause of deforestation has been discussed

[5] Barbier (2001) and Barbier and Burgess (2001) recommend this approach mainly because of problems relating to reliability of forest cover data.

[6] Acemoglu and Robinson (2001) build a theoretical model that explains the observation that both autocratic and democratic regimes have redistributed productive assets such as land in the past. Similarly, Grossman (1994) models land reforms as an optimal response on behalf of the landowning class that faces a "threat of extralegal appropriation of land rents". On the other hand, redistribution of wealth is also in the interest of democratic regimes since they need to consolidate support among the poor and also cater to the ambitions of the majority (Midlarsky 1998).

[7] In Brazil, Alston et al. (2000) find that land reform programs have been responsible for 30 percent of deforestation, or approximately 15 million hectares, between 1964 and 1997. The goal of the land reforms in countries like Brazil, Bolivia, and Colombia has been to realign the highly skewed distribution of wealth (Deininger and Binswanger 1999). In many cases, land reform policies are designed so as to penalize owners who keep their land "underdeveloped". In Cameroon the expectations of the 1974 land reform, where the government was planning to confiscate parts of the community forests for commercial exploitation, led villagers to rapidly expand croplands in order to establish ownership claim (Karsenty 2010)

extensively in the past literature (e.g. Deacon 1994; Mendelsohn 1994; Deacon 1995; Deacon 1999; Bohn and Deacon 2000; Amacher et al. 2009).[8]

The structure of this paper is as follows. In the second section, we outline our empirical strategy and the econometric model. The third section describes the data and the fourth presents the results and a discussion. The fifth section concludes.

Econometric Model

Barbier (2001) and Barbier and Burgess (2001) survey the past empirical research on the causes of tropical deforestation. Their papers conclude that the best empirical approach in modeling country level deforestation is to use a "synthesis" model that concentrates on explaining the factors driving agricultural land expansion. This approach is justified mainly on two grounds: first, expansion of agriculture is the main driver of tropical deforestation, and secondly, data on forest cover is very limited. The synthesis model should include both structural variables, such as population growth and agricultural productivity, and institutional factors as explanatory variables. The role of institutional factors has been acknowledged in multiple previous empirical studies, most recently in Ferreira and Vincent (2010). Deacon (1994) presents descriptive evidence and simple hypothesis tests to show the impact of institutional and political factors on tropical deforestation. He uses cross-sectional data with change in forest cover from 1980-1985 as the dependent variable. Barbier (2001) and Barbier and Burgess (2001) also incorporate institutional determinants in the empirical analysis by using constant indicator variables to capture differences in institutional quality, such as the perceived level of corruption and rule of law.

Barbier and Burgess (1997, 2001) and Barbier (2001, 2004) start their empirical work from the following theoretical assumption:

$$F_{it} - F_{it-1} = -(A_{it} - A_{it-1}) \tag{10}$$

where Fit and Ait refer to forest and agricultural land cover in country i at time t, respectively. Deforestation in tropical countries is therefore assumed fully explained

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[8] Bohn and Deacon (2000) provide evidence that political instability decreases investment share of total output, thus implying a reduction in forest capital as well. Mendelsohn (1994) demonstrates that even a small increase in the probability of confiscation leads squatters to favor more "destructive" forms of agriculture. Deacon (1994) identifies cronyism and the inability of the government to enforce property rights as the two main factors feeding political uncertainty, which in turn deteriorates the profitability of long term investments.

by agricultural land expansion. Barbier (2001) proposes an empirical relationship of the following form:

$$(A_{it} - A_{it-1}) = A(Y_{it}, Y_{it}^2, \boldsymbol{s}_{it}, \boldsymbol{z}_{it};\ \boldsymbol{q}_{it}) \tag{11}$$

where $i = 1, \ldots, N$ and $t = 1, \ldots, T$. Variable *Y* denotes national income as measured by GDP. Inclusion of the squared income variable allows us to test for the Environmental Kuznets Curve hypothesis. Vector $\boldsymbol{s}$ includes structural variables (e.g., agricultural yield), vector $\boldsymbol{z}$ contains other important exogenous variables (e.g., population growth), and vector $\boldsymbol{q}$ contains institutional factors (e.g. prevalence of corruption). Inclusion of institutional variables in a panel data setting however imposes some restrictions to the set of estimation methods since many of these qualities are time invariant.[9] Our empirical strategy is to augment the empirical model in (11) to include various dummy variables that identify different phases of a transitioning new political regime. These variables are assumed to capture the effect of increasing uncertainty on land rents as new regimes have more active stance toward redistribution of land and, in many cases, they favor agricultural land use to forests due to social stability considerations. The indicator variables enter through the vector $\boldsymbol{q}$.

To parameterize the relationship in (11), we follow Barbier (2001) and assume the following linear functional form:

$$\%\Delta A_{it} = \beta_0 + \beta_1 Y_{it} + \beta_2 Y_{it}^2 + \boldsymbol{s}_{it}^{'}\boldsymbol{\beta_3} + \boldsymbol{z}_{it}^{'}\boldsymbol{\beta_4} + \boldsymbol{q}_{it}^{'}\boldsymbol{\beta_5} + \eta_{it} \tag{12}$$

Here the dependent variable now takes the form of a percentage change from the previous year's agricultural area.[10] This transformation is necessary because land areas between countries are highly variable. Changes in independent variables, such as new political regime, therefore cause either an increase or a decrease in the percentage rate of agricultural expansion. The term η_{it} is the stochastic component of our model. It captures unobservable time-specific and country-specific effects as well as

[9] Standard method of estimating Fixed Effects model does not allow for estimation of time invariant variables.

[10] The dependent variable is bounded between -100% and some positive upper limit, *K%*. These bounds mean in effect that, within one year, a country can at most annihilate all existing agricultural land within its borders, or it can at most convert all available land to agriculture. Both of these cases are highly implausible.

other purely random fluctuations coming from outside the model. The assumptions made about the stochastic term also determine the best estimation strategy which we will describe next.

The stochastic term in our econometric model of equation (12) takes the following general form:

$$\eta_{it} = \alpha_i + \omega_t + \varepsilon_{it} \tag{13}$$

Following the standard approach in panel data analysis, we allow for both unobservable individual effects, α_i, and unobservable time-wise effects, ω_t. The individual effects may exhibit correlation with the independent variables in equation (12), i.e. a fixed effects model (FE), or alternatively, they can be viewed as random draws from an i.i.d. distribution with zero mean and common variance, i.e., a random effects model (RE). A test will be performed for which of these assumptions better fits our data. We also perform tests to determine whether it is necessary to include individual or time effects in our model in the first place.[11]

The last term in equation (13), ε_{it}, represents pure stochastic disturbances. It is a mean-zero random variable that potentially exhibits within panel serial correlation and heteroskedasticity. Any statistical inference based on an i.i.d. error assumption can be seriously misleading, especially when serial correlation is present (Cameron and Trivedi 2005).[12] To diagnose whether our data exhibits any of these features, we apply a test for within panel serial correlation proposed by Wooldridge (2002) and a modified Wald-test for group-wise heteroskedasticity (e.g., Greene 2011). In order to attain consistent standard error estimates, we then use a cluster robust covariance-variance estimator that allows for arbitrary within serial correlation and heteroskedasticity (Arellano 1987).[13] As a robustness check, we also specify a model with first-order autoregressive error process (AR-1). Since our dataset consists of annual observations, this approach provides a reasonable description for potential

[11] The advantage of panel data methods is that we are able to control for unobserved individual effects that may bias coefficient estimates in cross-sectional studies if they correlated with independent variables.

[12] Inclusion of individual and time specific effects may not be adequate to correct for biases arising from serial correlation, especially if the correlation is of a decreasing form, e.g. autoregressive.

[13] Consistency of the cluster robust estimator relies on asymptotic theory where the number of cross-sectional units is assumed to become large. This feature may bring limitations for its applicability in cross-country studies. Based on simulation results, however, Kézdi (2004) provides evidence that the cluster robust estimator performs surprisingly well even in small samples consisting of 50 cross-sectional units.

persistence in temporal shocks. AR-1 specification has also been widely used in other related empirical work (e.g., Barbier 2001; Rodrik and Wacziarg 2005).[14] We next describe our dataset in more detail.

Data

We utilize the same data as in two previous but separate works: Rodrik and Wacziarg (2005) and Barbier (2001). The former paper estimates the impact of political regime change in developing countries on their economic growth, whereas the latter estimates a model of agricultural land expansion in tropical countries. We have chosen the same exogenous and structural variables as used in Barbier (2001) due to data availability (see Table 1.A). For example, the model specification in Barbier (2004) does not allow for as extensive data coverage across the countries as does the specification used in Barbier (2001). The data comes from the World Bank's World Development Indicator Database, WDI. Here tropical countries are defined as the countries that have the majority of their land mass located between the tropics (Barbier and Burgess 1997; Barbier 2001, 2004). Our final sample is an unbalanced panel dataset including 70 tropical countries and spanning years from 1961-2007. The sample descriptive statistics are presented in Table 1.B.

One of the most obvious shortcomings with this specification is the lack of price and wage data. Variables for cereal yield and agricultural export share, however, serve as good proxies to the value of agricultural products in different countries. Notice also that in our error specification the time-wise component captures time-specific global shocks to agricultural product prices, whereas the country-specific effects capture other idiosyncratic differences. In order to control for institutional differences, we also created a corruption dummy variable which takes value 1 if the country is listed as "highly" corrupt using in the World Bank's WGI database, which scores countries between -2.5 and 2.5 in this regard. Along this scale, smaller numbers mean a higher level of corruption. Any cutoff point for high corruption is of course somewhat arbitrary. We decided to designate countries in the bottom quintile of our sample as highly corrupted.[15] This approach should capture the effect of corrupt institutions on land use decisions in a clear way.

Next we describe the set of political regime variables that are new to our empirical approach. Using Rodrik and Wacziarg (2005) we have recreated their set of indicators that serve to identify a change in each country's political regime. They use information reported by the Polity IV Project[16] (2002) to encode political regime

[14] We also estimate our model using Newey-West corrected standard errors (Newey and West 1987) in subsamples where the number of cross-sectional units is small. Generally, in settings where the number of cross-sectional units is large enough, cluster robust standard errors outperform Newey-West correction (Petersen 2009).

[15] The bottom quintile in our sample is below -0.97. Most of these countries are located in Africa (see table 1.B).

[16] www.systemicpeace.org/polity/polity4.htm.

transitions, whereas we use a newer version (2009) of the same source. Dummy variables "new democratic regime" and "new autocratic regime" take on values 1 starting from the year of a major regime change depending, of course, on the direction of the change. Note that the definition of a major regime change is given by the Polity IV Project (Marshall and Jaggers 2010).[17] These dummy variables continue having value 1 for the subsequent five years unless the regime is disrupted during that period. If the new regime survives the first five years, then the dummy variables "established democratic regime" and "new autocratic regime" take on values 1 thereafter until they are possibly again disrupted by a new major regime change. The sum of the new regime and established regime variables are labeled as "democratic regime change" and "autocratic regime change". Finally, we augment their original set of dummy variables to also include two indicator variables that capture the preceding two years prior to a democratic and autocratic regime change, recognizing that there may be some preemptive policy shifts before a new regime formally takes over.[18] Further, and more importantly, anticipation of a regime change might potentially increase the rate of agricultural expansion if landowners expect that the new rulers intend to redistribute wealth through land reform.

This complete set of indicators enables us to investigate the impact of different phases of a new political regime in more detail. For example, the average life-span of a military regime is five years (Brooker 2009). These types of regimes are usually concentrated on getting a few specific objectives completed before stepping down. It is interesting therefore to see whether the first years of a new regime have distinct impact on the expansion rate of agriculture as the level of uncertainty on land rents might be at its highest. Notice that the baseline case here is "no regime changes of any kind" during the sample period. Thus the dummy variables capture the effect of a regime change compared to status quo, whether that is a democratic or autocratic regime. Also, it is important to note that transitions from one regime to another are not clear cut or instantaneous in many cases (see Appendix) which somewhat complicates the identification of the year of a regime change.[19]

Results and Discussion

[17] See Appendix A for some country examples.

[18] We assume here that the preceding two years are enough to capture the expectations of a regime change and any uncertainty caused by a prospective land reform.

[19] For example, a revolution could sweep in during one year or it could require a prolonged civil war before any clear outcome is perceivable. In many cases, the outcome is actually muddled where the new regime lies somewhere in between the two regime types. In encoding the indicator variables, we have followed the definitions provided by Polity IV in a consistent manner in order reduce ambiguities.

Table 2.A reports the main results from five different sets of model specifications using a sample with all countries.[20] In addition to a country specific unobserved effect, we have also included a fixed time effect to control for cross-sectional correlation. To account for within cluster serial correlation and heteroskedasticity, we have used cluster robust standard errors. As the number of clusters is well above 50, we can confidently base our inference on the reported standard errors. Based on a cluster robust Wald test (Wooldridge 2002), we also conclude that the fixed effects model is more appropriate for our sample data.

The signs of the significant variables are expected. Coefficients for GDP per capita are negative while GDP growth rate has a positive effect on the dependent variable. Increases in cereal yield lead to decreases in the rate of expansion of agricultural land. The political regime change variables are positive and mainly highly significant. Both new democracies and new autocracies increase the pace of deforestation. Moreover, the first five years of both new democratic regimes and new autocratic regimes accelerate the expansion of agriculture. The preceding two years prior to a switch to an autocracy accelerates the expansion as well. Established autocracies also increase the rate of expansion, whereas the coefficient for established democracy is positive but not statistically significant. In the last column of table 2.A, we also report results from the model including our corruption variable. Its coefficient is negative and highly significant, meaning that high levels of corruption are related to smaller rates of agricultural land expansion, other things equal. This result should be taken with caution, however, as we have had to use random effects specification due to the time-invariant nature of the corruption variable. Since fixed effects were deemed more appropriate in the other models, random effects may lead to biased coefficient estimates.

To check for the robustness of our earlier findings, we also estimate the same set of models as above but now assuming a priori an AR-1 error process. Table 2.B reports the results from these model specifications. We continue to use the fixed effects model as this was shown to be more appropriate based on a robust test result. Notice that the estimation of a model with AR-1 error reduces our sample size somewhat as we must difference out the first observation for each country. Overall the results support our earlier findings with minor changes in the standard error estimates. Now cropland share as a percentage of total land area has also a positive and significant effect on the rate of expansion. The political regime change variables continue to be positive and significant albeit the magnitudes of the coefficient estimates have changed somewhat in most cases. The estimated autocorrelation coefficient averages 0.21 across the specifications. The same concern for the reliability of our corruption variable estimate continues to hold as was discussed above.

[20] Kuusela and Amacher (2011) provide additional estimation results using different subsamples.

Overall, our empirical results support the hypothesis that political instability in the form of regime changes causes the rate of tropical deforestation to increase. One explanation for this is that new regimes, regardless of their type, favor socio-economic benefits flowing from agriculture, or conversely, the quick rents that can be captured from myopic forest extraction. Uncertainty stemming from land reform policies enacted by these new regimes further encourages land users to prefer some form agricultural production over sustainable forestry.[21] Our results also show that established democracies do not necessarily decrease the rate of agricultural expansion, but increasing income levels do. This result lends support to the view that improving economic conditions also help to reduce, or at least moderate, environmental degradation. Interestingly, established new autocracies continue to have a higher rate of deforestation. This may highlight the need of autocratic leaders to appease the majorities by enabling them access, directly or indirectly, to productive assets such as land. Alternatively, the well connected few are able to capture more and more of the country's forest assets and extract short-run rents through timber concessions which in turn provide access for the ensuing encroachment of extensive forms of agriculture.[22]

Conclusions

Bohn and Deacon (2000) conclude their paper with an optimistic note. They deem that the recent "trend toward democracy and reduced political instability worldwide" provides a good prospect for the future of global forests. Based on the above empirical findings, our conclusions are not as optimistic. Once we include new politically constructed data on regime implementation and persistence and success, we find that democratization should not be viewed automatically as a panacea that leads to reduced pressures on the exploitation of tropical forest resources. New democratic regimes might simply favor the socio-economic and political stability implications of wider access to agricultural land over the other land use alternatives (Midlarsky 1998). On the other hand, our empirical results show that increasing level of income reduces pressures to clear land for agriculture and therefore decreases the rate of deforestation.

Our results provide empirical support for the hypothesis that new regimes, whether autocratic or democratic, favor the political dividends in the form of wider access to agriculture over longer term investments in forestry. Barbier (2011) further notes that the demand for new agricultural land in Latin America, Africa and Asia is unlikely to be reduced. He projects that, within the next forty years, over one-fifth of the expansion in crop production will rely on the creation of new cultivated land area

[21] Kuusela and Amacher (2011) build a formal model of land use decision that explicitly incorporates the risk of land expropriation.

[22] For example, Saastamoinen (1996) attributes the historical deforestation in the Philippines to a skewed power structure that favors the wealthy minority and their interests.

rather than on more intensive use of existing agricultural area, and that two thirds of the expansion area will come at the expense of primary forests. Brooker (2009) on the other hand predicts that the 21st century will witness its share of regime changes, both democratic and non-democratic. The future of the remaining world tropical forests will most likely remain uncertain according to our results, and it will crucially depend on the relative economic values of alternative land uses, but also, without a doubt, on the political pressures to guarantee wider access to cultivated land among the populace.

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Table 1.A. Variable Definitions

Dependent Variable:	• *Percentage change in agricultural area from last year's value. Agricultural land is defined as the land area that is arable, under permanent crops, and under permanent pastures (WDI, FAO).*
Structural (***s***):	• *Cereal yield (kg per hectare)* • *Cropland share of total land area (%)* • *Agricultural export share of total merchandise exports (%)* • *Arable land per capita (Hectares per person)*
Other Exogenous (***z***):	• *GDP per capita (Constant 2000 US$)* • *Population growth (% annual change)* • *GDP growth (% annual change)*
Institutional (***q***):	• *New Democratic Regime (first five years, or if interrupted during that period, then the years prior to the interruption)* • *New Autocratic Regime (first five years, or if interrupted during that period, then the years prior to the interruption)* • *Established Democracy (subsequent years or until a new interruption)* • *Established Autocracy (subsequent years or until a new regime interruption)* • *Preceding two years prior to a democratic regime change* • *Preceding two years prior to a autocratic regime change* • *Corruption dummy variable (takes on value 1 if country is deemed as "highly" corrupted)*

Table 1.B. DESCRIPTIVE STATISTICS: Sample Means and Standard Deviations

Variables	All Countries (N=1996)	Africa (N=887)	Latin America (N=769)	Asia (N=340)
Annual change in agricultural land (%)	.610 (1.86)	.462 (1.23)	.591 (2.30)	1.04 (2.06)
GDP per capita (Constant 2000 US$)	1460 (1560)	643 (994)	2600 (1620)	1040 (896)
GDP growth (% annual change)	3.91 (4.70)	3.66 (5.12)	3.65 (4.41)	5.14 (3.90)
Population growth (% annual change)	2.31 (.878)	2.66 (.846)	2.05 (.857)	2.00 (.647)
Cereal yield (kg per hectare)	1680 (971)	1140 (861)	1980 (786)	2410 (836)
Cropland share of land (% of land area)	3.80 (4.86)	2.24 (4.16)	3.77 (4.16)	7.92 (5.58)
Agricultural export share (% of merchandise exports)	10.4 (15.7)	15.4 (20.2)	4.60 (6.58)	10.4 (11.6)
Arable land per capita (Hectares per person)	.296 (.305)	.420 (.402)	.220 (.135)	.146 (.093)
New democratic regime (first five years dummy variable)	.104 (.305)	.104 (.305)	.104 (.301)	.103 (.304)
Established democracy (subsequent years dummy variable)	.180 (.385)	.103 (.304)	.289 (.453)	.138 (.346)
New autocratic regime (first five years dummy variable)	.061 (.239)	.081 (.273)	.046 (.209)	.041 (.199)
Established autocracy (subsequent years dummy variable)	.100 (.300)	.162 (.369)	.056 (.230)	.035 (.185)
Preceding years to democracy (prior two years)	.041 (.199)	.037 (.189)	.043 (.203)	.047 (.212)
Preceding years to autocracy (prior two years)	.027 (.162)	.027 (.162)	.022 (.147)	.038 (.192)
Corruption dummy[23]	.130 (.337)	.281 (.450)	.008 (.088)	.015 (.121)

[23] The corruption dummy takes on value 1 if the average of the Control of Corruption indicator (WGI) between the years 2000 and 2005 was below -0.97, that is, if the country fell into the lowest quintile.

Table 2.A. ALL COUNTRIES (n=70, N=1996): Two-way fixed effects model with cluster robust standard errors[24]

GDP per capita/1000	-0.754**	-0.647*	-0.652*	-0.675**	0.010
(constant 2000 US$)	(0.333)	(0.333)	(0.331)	(0.328)	(0.135)
GDP per capita squared/10^6	0.040	0.031	0.031	0.033	-0.028
	(0.029)	(0.028)	(0.028)	(0.028)	(0.024)
GDP growth	0.017*	0.018*	0.018*	0.019*	0.024***
(% annual change)	(0.010)	(0.010)	(0.010)	(0.010)	(0.009)
Population growth	0.130	0.140	0.136	0.136	0.105
(% annual change)	(0.115)	(0.115)	(0.114)	(0.114)	(0.066)
Cereal yield/1000	-0.325*	-0.317*	-0.312*	-0.312	-0.101
(kg per hectare)	(0.189)	(0.188)	(0.187)	(0.188)	(0.076)
Cropland share of land	0.074	0.062	0.063	0.067	0.029*
(% of land area)	(0.073)	(0.073)	(0.073)	(0.074)	(0.016)
Agricultural Export Share/100	0.425	0.413	0.420	0.419	0.604*
(% of merchandise exports)	(0.645)	(0.689)	(0.694)	(0.710)	(0.319)
Arable land per capita	-0.256	-0.305	-0.259	-0.251	-0.379**
(Hectares per person)	(0.441)	(0.346)	(0.368)	(0.359)	(0.158)
New democracy		0.487***			
(sum of new and established)		(0.171)			
New autocracy		0.522***			
(sum of new and established)		(0.165)			
New democratic regime			0.594***	0.569**	0.489***
(first five years)			(0.205)	(0.218)	(0.169)
Established democracy			0.369	0.368	0.257*
(subsequent years)			(0.228)	(0.239)	(0.153)
New autocratic regime			0.510***	0.584***	0.468***
(first five years)			(0.156)	(0.170)	(0.132)
Established autocracy			0.550***	0.615***	0.376***
(subsequent years)			(0.205)	(0.208)	(0.122)
Preceding years to democracy				-0.004	-0.030
(prior two years)				(0.188)	(0.142)
Preceding years to autocracy				0.678*	0.620*
(prior two years)				(0.343)	(0.358)
Corruption dummy variable					-0.457***
					(0.130)

[24] Standard errors are in parentheses and the significance levels are *=10%, **=5%, ***=1%. F-test and Wald test statistics measure model fits in the case of fixed effects model and random effects model, respectively. Breusch-Pagan LM-test tests for the presence of individual effects. Test for fixed effects is a modified Wald test (Wooldridge 2002). Estimation was done using Stata 11.

F-test/Wald test statistic[25]	2.33***	3.66***	3.32***	3.17***	175.68***
Breusch-Pagan LM-test statistic	90.05***	86.50***	84.49***	83.25***	80.04***
Test statistics for fixed effects	18.53***	23.83***	39.54***	45.18***	-
Preferred model	FE[26]	FE	FE	FE	RE

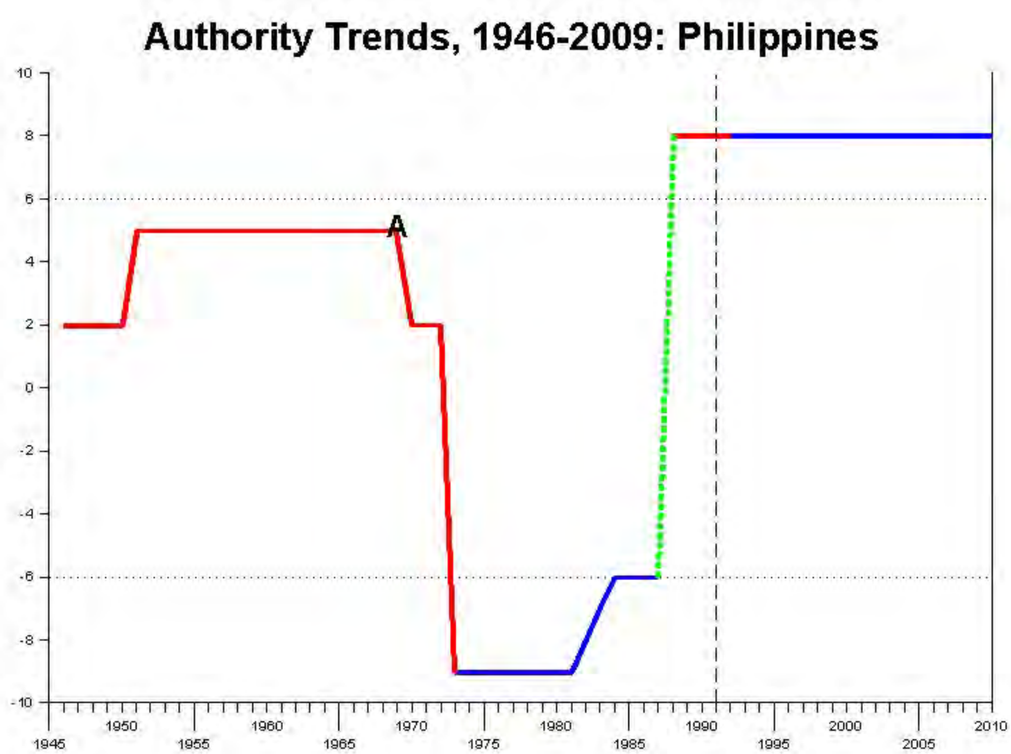
[25] In panel data settings, R-squared types of model fit measures do not have a similar interpretation as in cross-sectional studies.
[26] FE stands for fixed effects and RE for random effects.

Table 2.B. ALL COUNTRIES (n=70, N=1926): One-way fixed effects model with first-order autocorrelation error structure

GDP per capita/1000	-0.767***	-0.725***	-0.722***	-0.734***	0.107
(constant 2000 US$)	(0.273)	(0.272)	(0.272)	(0.272)	(0.112)
GDP per capita squared/10^6	0.041	0.036	0.036	0.037	-0.041**
	(0.027)	(0.027)	(0.027)	(0.027)	(0.017)
GDP growth	0.020**	0.020**	0.021**	0.021**	0.022**
(% annual change)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
Population growth	0.141	0.154*	0.142	0.135	0.120*
(% annual change)	(0.093)	(0.093)	(0.094)	(0.094)	(0.072)
Cereal yield/1000	-0.355***	-0.393***	-0.375***	-0.369***	-0.108
(kg per hectare)	(0.120)	(0.121)	(0.122)	(0.122)	(0.074)
Cropland share of land	0.136**	0.113**	0.117**	0.123**	0.029**
(% of land area)	(0.053)	(0.054)	(0.054)	(0.054)	(0.014)
Agricultural Export Share/100	0.475	0.442	0.470	0.475	0.641
(% of merchandise exports)	(0.602)	(0.599)	(0.600)	(0.599)	(0.390)
Arable land per capita	-0.309	-0.153	-0.168	-0.216	-0.236
(Hectares per person)	(0.428)	(0.433)	(0.434)	(0.437)	(0.229)
New democracy		0.413**			
(sum of new and established)		(0.168)			
New autocracy		0.405**			
(sum of new and established)		(0.190)			
New democratic regime			0.517***	0.505**	0.399**
(first five years)			(0.193)	(0.201)	(0.167)
Established democracy			0.303	0.315	0.141
(subsequent years)			(0.196)	(0.202)	(0.148)
New autocratic regime			0.340	0.444*	0.388*
(first five years)			(0.235)	(0.240)	(0.208)
Established autocracy			0.475**	0.539**	0.330*
(subsequent years)			(0.221)	(0.223)	(0.184)
Preceding years to democracy				0.023	-0.041
(prior two years)				(0.237)	(0.221)
Preceding years to autocracy				0.606**	0.580**
(prior two years)				(0.282)	(0.265)
Corruption dummy variable					-0.425**
					(0.202)
F-test/Wald test statistic	6.41***	5.94***	5.07***	4.69***	59.60***
Breusch-Pagan LM-test statistic	90.05***	86.50***	84.49***	83.25***	80.04***
Test statistics for fixed effects	18.53***	23.83***	39.54***	45.18***	-
Preferred model	FE	FE	FE	FE	RE

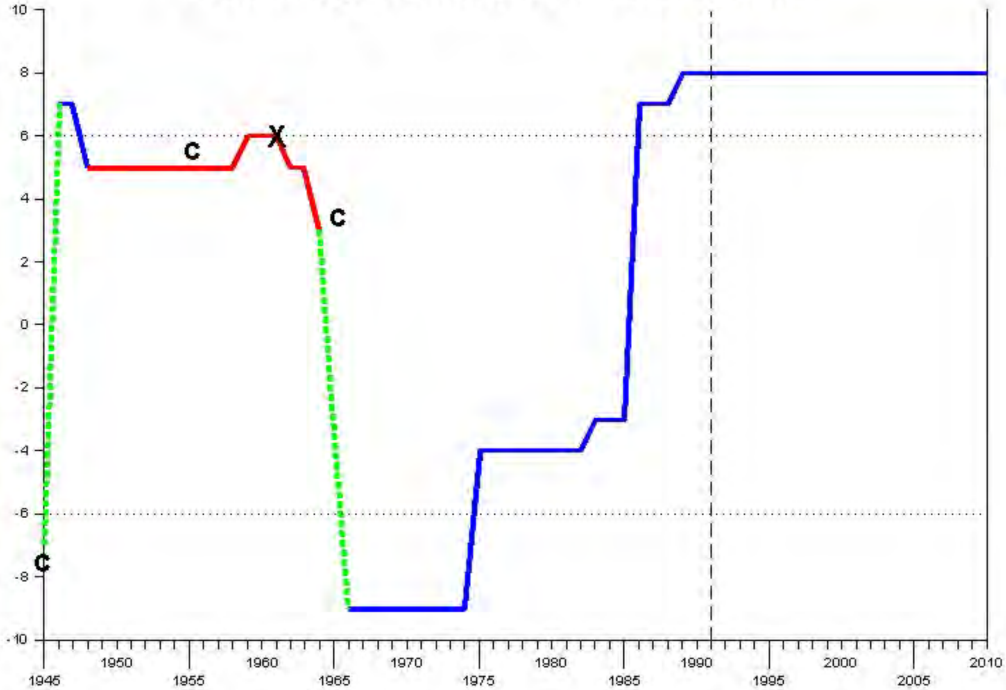
APPENDIX A: Polity IV Project

This section provides two country examples and a description of how each political regime type is scored based on Polity IV Project's definitions. Each country is given a polity score between -10 and 10. Values below –6 mean "full autocracy" and values above 6 mean "full democracy". In these graphs, blue solid line indicates general regime polity scores. Red solid line indicates a period of factionalism, whereas green dashed line indicates a period of regime transition. More detailed description of transition periods and encoding can be found from the Users' Manual for Polity IV Project: Political Regime Characteristics and Transitions, 1800-2009.[27] We have followed a convention of identifying a regime change as clear transition towards a new regime type. The letter symbols denote the following events: *Autocratic Backsliding Event (**X**), Executive Auto-coup (**A**), Revolutionary Change Event (**R**), State Failure Event (**S**), and Coup d'Etat Event (**C**).*



[27] http://www.systemicpeace.org/polity/polity4.htm

Authority Trends, 1946-2009: Brazil



Using Expert and User Knowledge to Analyze the Relative Importance of Issues Confronting Community Forests in the Mid Hills Region of Nepal

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ABSTRACT

The Analytic Hierarchy Process (AHP) was used to analyze the issues confronting community forestry in the mid hills region of Nepal. The data were collected through focus groups composed of community forestry experts and local community users. The results indicate that both local community users and community forestry experts think the positive aspects of community forestry are more important than its negative aspects. In addition, results from a comparison of three major forest types (Pinus roxburghii, Alnus nepalensis, and Schima-Castanopsis) indicate that Alnus nepalensis is the most beneficial forest type for conservation followed by Schima-Castanopsis and Pinus roxburghii respectively. With respect to local benefits, Schima-Castanopsis was found to be the most beneficial forest type with Pinus roxburghii second and Alnus nepalensis the least beneficial. Finally, the results suggest that the Analytical Hierarchy Process can be a useful tool in a variety of decision making situations where tradeoffs are difficult to quantify.

FOREST POLICY AND MANAGEMENT IN URUGUAY

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ABSTRACT

Since the 1960s, the government of Uruguay has been encouraging forestry as an alternative use for marginal agricultural lands in an effort to promote economic development, diversification, and environmental services. The Forestry Law of 1988 introduced subsidies and tax exonerations for the development of forest plantations and wood manufacturing industries. Consequently, the new forest sector has been growing rapidly, attracting foreign investment. Currently, forest plantations cover 850,000 ha; they are composed from eucalypts and pines. Typical rotations are 15 to 16 years for eucalypts grown for sawtimber, and 7 to 9 years for eucalyptus grown for pulpwood. The objective of this paper is to illustrate the current situation of the Uruguayan forest sector as well as to evaluate the impact of Uruguay forest sector development policy on the country's economy by conducting a cost- benefit analysis. The results indicate a positive net impact when compared with existing livestock production. The NPV associated with the forest sector development was US$ 615.4 million, and the IRR was 32.4%.

Keywords: forest policy, forest management, Uruguay, cost-benefit analysis

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Introduction

During the past few decades, there has been a trend to expand forest investments worldwide. This global expansion has been characterized by forest companies investing abroad, and building processing facilities, and with investors buying land and planting. In this context, South America has emerged as an attractive region for forest investments. The development of the forest sector in Latin America has been a result of forest policies that started in the 1960s, and were broadly adopted in the 1980s (Morales Olmos and Siry, 2009). The region offers opportunities for fast growing plantations, with short rotations. The majority area is covered with eucalyptus and pine. The genetics has been developing the last years achieving great improvements in productivity (Cubbage et al, 2007). Due to the fast growing forests, and competitive costs, the continent attracted many foreign investors both corporate and investment funds (Mendell et al, 2005; Morales Olmos and Siry, 2009). Currently, some of the advantages are not present, such are subsidies, tax breaks, but the sector is still growing.

The Uruguayan Forest Sector

Uruguay is a small country in South America located between Argentina and Brazil. The Gross Domestic Product (GDP) growth was 5.7% in 2011, and the GDP per capita around 15,000 US $. The inflation rate has been stable for the past years, and was 8% in 2011 (BCU). The unemployment rate has been decreasing in the past years, reaching its lowest rate in 2011 with 6% (INE). It is a small market, with a population of 3.2 million.

The government promoted forest investments in the late 80s, in order to increase total forest area by attracting forest investments. Uruguay passed its Forestry Law in 1988, and the sector has been developing since then (Morales Olmos and Siry, 2009). The success of the policy can be seen with the increase of the forest area after the Law was passed (Figure 1). The area increased rapidly and has been growing at a slower pace in recent years.

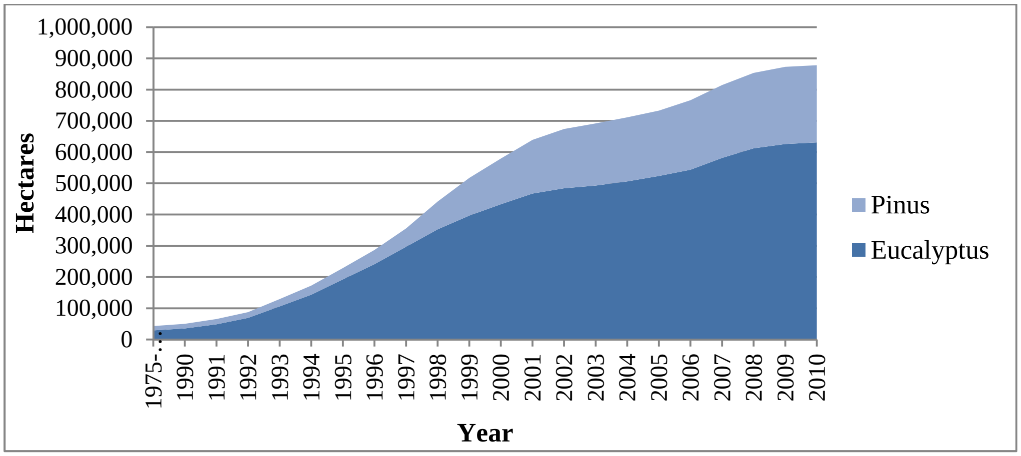
The total forest area is around 1.6 million ha as of 2010[2]. Plantations cover 850,000 ha and native forests cover 750,000 ha (Forest Division Uruguay). Plantations are mostly eucalyptus, but also pine is present. The main eucalyptus types are *Eucalyptus Globulus and Eucalyptus Grandis*, and the main pine types are *Loblolly Pine* and *Slash Pine*. Most of the land is under private ownership and the government does not manage land for commercial purposes. The departments more planted are Rivera, Tacuarembó, Río Negro, Paysandú and Lavalleja.

Eucalyptus plantations are managed for pulpwood and for sawtimber. Pine plantations are managed for sawtimber. Typical rotations are 15-16 years for eucalyptus grown for sawtimber, with at least one intermediate thinning, and 7-9 years

[2] According to some publications, there are more than 900,000 ha planted, but the official data show 850,000 ha.

old for eucalyptus grown for pulp. Growth rates depend on site quality, species, and management regime. For *Eucalyptus Grandis* grown for sawtimber or solid wood the average mean annual increment (MAI) ranges from 27-35 cubic meters/ha/ year (cbm/ha/yr.); if it is grown for pulp, the average MAI ranges from 22-40 cbm/ha/yr. For pine grown for solid wood, the average MAI ranges from 18-27 cbm/ha/yr.

Figure 1. Forest area planted in Uruguay, cumulative



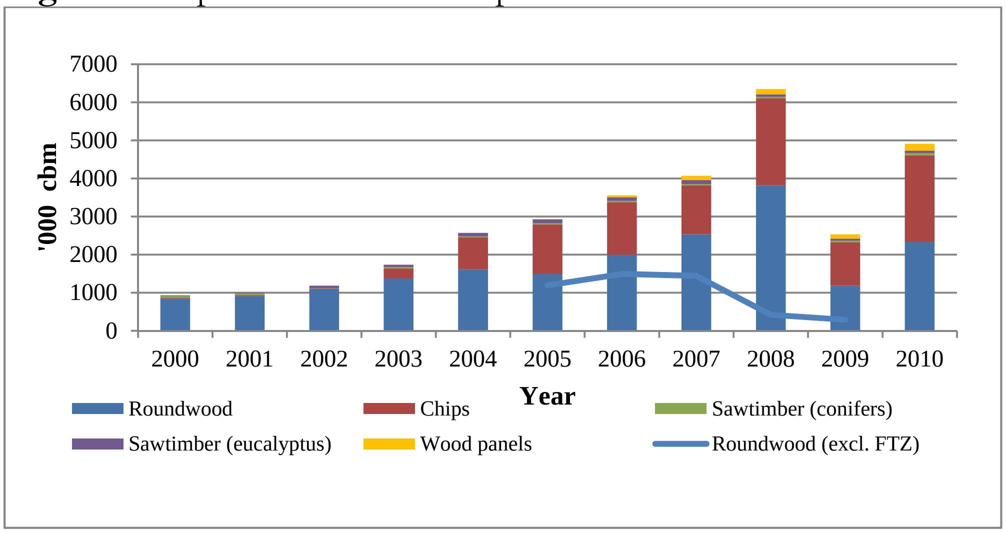
Source: Forest Division Uruguay.

Harvest reached 11.8 million cbm in 2010 and 93% of that was eucalyptus which is consistent with the area available in the country. It has been increasing since 2000, when the total harvest reached 2.9 million cbm. The total harvest as of 2010 is divided into 20% of the harvest for firewood and 80% for industrial roundwood. From the industrial roundwood harvested, 51% was dedicated to pulp production, 30% to chips, 16% to sawtimber and plywood. Around 4% of the industrial roundwood harvested was exported as logs. The largest industry is a pulp mill which produces cellulose fiber and its capacity is producing 1.1 million tons per year (ton/yr.) and the mill consumption is 3.6 million cbm/year (UPM).

Forest exports, including paper, represented 7% of the total exports in 2010 (these data do not include the exports from or to the Free Trade Zones). The main markets for Uruguay's forest products, excluding paper, where Europe: Portugal, Spain and Norway (Uruguay XXI). Portugal Spain and Japan has been the markets for Uruguayan chips. Paper and containerboard paper exports reached 89 million US $ in 2010. The largest amount was shipped to Argentina, which in 2009 and 2010 shared 46% and 55% of the total exports in US$. The rest goes also to the region: Brazil, Chile and Paraguay accounted for 34% of the total exports of this item in 2010. The exports of this item have been stable in the last 10 years in volume. Industrial roundwood exports reached 2.3 million cbm in 2010, sawnwood 125,000 cbm, chips 2.2 million cbm, and panels 178 cbm (Figure 2).

Uruguay has a small local market, then it is expected that the majority of the forest production will be exported. The eucalyptus industrial roundwood is expected to be harvested for pulpwood. This pulpwood will continue being processed in the country, and exported as wood pulp. On the other hand, the conifers industrial roundwood would be allocated for sawlogs and veneer logs as there is not market for conifers pulpwood.

Figure 2. Exports of main forest products in volume



Source: Forest Division Uruguay, 2011. Roundwood (excluding Free trade zone) from Uruguay XXI.

Regulation

In Latin America, the use of incentive mechanisms promoting forest investments started in the 1970s and was broadly adopted in the 1980s. Chile, Argentina, Brazil and Uruguay introduced subsidies, tax breaks and tax exonerations to promote the development of forest plantations and wood manufacturing industries, with different results.

In 1968 the Uruguayan government made its first attempt to develop a forest sector by passing a Forestry Law but it was not successful (Forestry Law 13723, 1968). In 1987 it made a second attempt and it succeeded, approving the Forestry Law 15939 (Forestry Law 15939, 1988). This Law had the approval of the entire parliament. The objective was to increase planted the area planted with commercial forests and to protect the native forest. The other objectives were to promote industrial development in non-industrialized regions, and to increase and diversify exports.

The Forestry Law included instruments such were regionalization of the country, tax exonerations, subsidies and credit. The Law defined forest priority soils and commercial plantations were not allowed to be allocated in other soils. The total available was around 3.8 million ha. Tax exonerations included land taxes and goods and inputs used for forestry activities. Subsidies were given for up to 30% of the cost of plantation, and later to 50%.

The sector has been developing for the past years and the regulation has encompassed that development with new decrees and resolutions. The main changes have been related with tax exonerations, subsidies and forest priority soils. Some of the tax exonerations are not currently in force, subsidies are not in force, and the classification of forest priority soils had small changes. The total area that is allowed to be planted with commercial plantation as of today is around 4.1 million ha, from which 20% is already planted.

Ownership

The picture of the major players in the sector has changed in recent years. As of 2007, five firms were the leaders: Botnia, Colonvade, Fymnsa, Cofusa-Urufor, and Urupanel, and two firms were planning to invest in pulp manufacturing: Ence and Stora Enso.

Currently, Botnias' pulp mill has converted into UPM pulp mill and started operating by the end of 2007. The production capacity is 1.1 million tons of cellulose per year, with a consumption of 3.6 million of cbm per year. The production is FSC certified (UPM). The raw material comes from its forest partner FOSA, and from third parties.

Ence, the Spaniard company who was planning to construct a pulp mill, sold most of its plantations to a new investor: Montes del Plata. Montes del Plata is a partnership between the Finnish company Stora Enso and the Chilean company Arauco. This group is beginning to construct a pulp mill, which will be operational by 2013 and will produce 1.3 million tons of cellulose when it operates at full capacity.

The companies that own plywood mill have also changed in these years. Weyerhaeuser, the North American company, and Global Forest Partners, ended the joint venture called Colonvade. Both stayed in the country, with Weyerhaeuser investing in the East of the country, and keeping half of the assets in the North plus the plywood mill in Tacuarembó. Urupanel, the Chilean company that owned the other plywood mill in the country, was sold and it is currently operating. The two local firms that operate sawmills, Fymnsa and Cofusa-Urufor, have expanded their production capacity.

In addition to these companies, which are vertically integrated, there are several pension funds that have invested in the country. Local funds include: Caja de Profesionales Universitarios, Caja Bancaria, and Caja Notarial who have had their investments for many years. Recently, Caja de Profesionales made an agreement with FOSA to manage some of its lands. Foreign funds include: FAS, Rio Biabo, GFP, GMO, and RMK. FAS manage the funds from Harvard University at the US and it is managed by a partnership of Chilean and Uruguayan organizations. Rio Biabo, a Chilean organization, manages the plantations of an investment fund from the US.

Cost-benefit analysis

In order to evaluate the impact of the new forest sector on the Uruguayan economy, it was conducted a cost-benefit analysis (CBA) for the period 1989-2005. The evaluation process included: first, to identify the costs, benefits, and investments associated with the policy, second, to quantify them, and third, to evaluate the impact of the policy on the economy. Until then, two studies had attempted to measure the economic impact of the sector in the economy but using different methodologies than the one proposed, and both estimated the impact as positive (Vázquez Platero, 1996; Ramos and Cabrera, 2001). A study done for a private company estimated the impact of building a new pulp mill in the Uruguayan economy. It used an input-output model and evaluated it as positive (Metsa-Botnia, 2004).

Using the CBA from the point of view of the economy implied that: taxes and subsidies were not included in the as they are transfers between agents in the economy as well as some costs and benefits; the discount rate used was a social rate; prices are corrected from market distortions (Nas, 1996). We used a "with" and "without" analysis. The "With" situation is defined as the situation of the country with the Forestry Law 15939, and the "Without" situation is defined as the situation of the country without the Law. Under the latter situation it was assumed that the lands used for forestry would have been used for livestock.

Costs, investments and benefits were estimated using primary and secondary sources. To obtain primary information, it was conducted a survey in Uruguay in July 2006 with the most important companies by that time as well as with public organizations. To obtain secondary information there were used Uruguayan publications and personal communication with the Forest Division (DF), the Agricultural Planning and Policy Office (OPYPA), the Agricultural Statistics Division (DIEA), the Forest Producers Society (SPF), the National Institute of Statistics (INE), the Central Bank of Uruguay (BCU), the Association of Industries of Uruguay (CIU), the Agricultural and Livestock Plan Office (IPA), and the National Colonization Institute (INC).

It was estimated a positive impact of the forest sector on the Uruguayan economy in the period 1989-2005 compared with an alternative production. The Net Present Value (NPV) equaled 630.2 million US $ with a 6% discount rate. The internal rate of return (IRR) for the forest sector was 36.4%. Sensitivity analyses showed that results were very sensitive to changes in wood prices, and to yields.

Conclusions

The forest policy in Uruguay had a positive impact on the Uruguayan economy. The government developed tools to use marginal lands, to increase industrialization, and to attract foreign investments that were controversial but supported by the legislature. Subsidies were proved to be particularly contentious but were seeing by the investors more as a signal of a policy than getting money to finance their investments. Although some changes during these years, the forest policy has been consistent through different governments.

The sector has the sector's development has entered the second stage: the development of wood product manufacturing industries. Since 2007, we have seen changes in the ownership in the forest sector, with new investors coming to the country, as well as new partnerships started. Some studies have attempted to predict how the development of forest industry could proceed based on the timber supply available (Durán, 2004). However, the 2009 financial crisis changed the world markets, impacting forest industry worldwide. This results in new scenarios for Uruguay that need to be examined.

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A Look at Long Run Price Relationships between Woody Biomass and Other Sources of Energy

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ABSTRACT

Volatile nature of non-renewable energy prices, especially oil prices, has contributed to the recent interest in wood-based energy in the United States. A study of price relationships between wood and other energy sources is therefore important to investigate wood-based energy pricing and associated market dynamics. The specific objective of this study is to investigate whether there are long run relationships between prices of woody biomass, coal, natural gas, and gasoline. Furthermore, we also derive short-run estimates of price transmission elasticities of woody biomass in relation to prices of other energy sources. Seven states from different regions were selected for this study. Co-integration and Vector Error Correction Model were used to study time series data. Results suggest that there is co-integration between different energy prices in the long run. Wood energy price is strongly influenced by LPG price, and moderately influenced by gasoline price. Biomass prices show positive effect with changes in natural gas prices and a negative relationship with changes in coal prices.

Internal, External and Location Factors Influencing Cofiring of Biomass with Coal in the U.S. Northern Region

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ABSTRACT

The use of biomass as a source of energy has been identified as a viable option to diminish reliance on fossil fuels. We parameterized the effect of selected internal (e.g. coal -fire presence), external (e.g. price and renewable energy mandates) and location (e.g. biomass availability, infrastructure) variables on the likelihood of using biomass in cofiring with coal by building a two-stage econometric model. The first stage controlled for factors driving the spatial location of coal energy plants and the second stage concentrated on factors influencing cofiring. The empirical model was applied in the Northeast quadrant of the U.S. where the unit of observation was an individual county. Results of our model stress the significant effect of existing flexible coal feeding systems that permit the incorporation of biomass, transportation infrastructure and biomass availability (woody biomass in particular in the form of residues from the wood products industry). State-level renewable energy portfolio standards showed to statistically non-significant effect on the adoption of cofiring biomass with coal. Further developments of biomass cofiring in the U.S. Northern region are most likely to take place in the Great Lakes Region.

A PRELIMINARY ASSESSMENT OF ISSUES RELATED TO MILL RESIDUE UTILIZATION IN MISSISSIPPI

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ABSTRACT

Mill residues obtained as a byproduct of wood processing industries represent an important feedstock for the wood-based bioenergy industry. Even though mill residues are a high quality feedstock, few published studies have addressed the issues related to their potential use in wood-based bioenergy industry. This study explored issues pertaining to mill residue utilization in Mississippi wood processing facilities by administering a mail survey instrument amongst millowners in the state. Results indicated that 92% of the total volumes of mill residues were obtained from the primary wood processing industry. Unused volumes of mill residues were higher in primary, larger, and year round operational facilities than in other mill types. Study results indicated the need for awareness regarding market opportunities, such as bioenergy, among less formally educated millowners in the state. Since considerable volumes are not internally used in mills, these mill residues can be used to generate wood based bioenergy in Mississippi.

Key words: millowner, bioenergy, regression analysis, survey, residues

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Introduction

Wood-based bioenergy has received increasing policy attention in the United States, given its numerous benefits pertaining to energy security, environment, and economy (Gruchy et al. 2012, Joshi and Mehmood 2011, Guo et al. 2007). Perlack et al. (2005) in their billion ton vision report indicated that 50% of the existing biomass energy consumption in the United States, highest among all sources, is contributed by mill residues and a large part of this volume is currently utilized to generate energy in the nation (Guo et al. 2007). Despite their widespread use, recent studies suggest that significant volumes of mill residues are still available for sale in the United States (GC and Potter-Witter 2011, Indiana Department of Natural Resources 2011). Likewise, some mill residues, in absence of a profitable market, are either disposed of or given away at no cost (Grebner et al. 2009). Given the existence of unused stocks and the relative high quality of mill residues compared to other sources (Foster et al. 2005), generating energy from mill woody residues might be relatively cost-effective form of woody biomass feedstock. Even though mill residues are a high quality feedstock, few published studies in the past (GC and Potter-Witter 2011, Carter 2010) have addressed the issues related to their potential use in wood-based bioenergy industry. Therefore, this paper is expected to fill the existing gap in knowledge pertaining to the issues related to utilization of mill residues as a bioenergy feedstock in Mississippi.

Method

The information related to residues in Mississippi forest product industries was obtained by administering a mail survey instrument. Mississippi Development Authority's online searchable SIC Code 24/25 and 26/27 database was used to obtain the mailing addresses of targeted respondents. After the pilot survey, a total of 582 surveys were mailed to key persons involved in wood processing businesses such as millowners, managers, and/or their representatives in the first week of August, 2011. The survey was administered following recommendations by Dillman (2000). The survey instrument contained three sections: 1) the type of wood processing facilities, and total volumes mill residues produced 2) information regarding methods of mill residue utilization, transportation distance and millowners' opinion on future market of mill residues, and 3) the demographic information of survey respondent.

Descriptive statistical analyses were performed to quantify the availability and use pattern of mill residues in Mississippi. Likewise, an econometric analysis was conducted to understand mill residue utilization behavior of millowners in Mississippi. Ordinary least square (OLS) regression analysis was conducted by establishing a functional relationship of available woody residues with mill characteristics, market opportunities and socio-demographic attributes in Mississippi. The multiple linear regression is functionally expressed as:

Available residue = f (type of facility, technical capacity, size, duration of operation, season of operation, organization structure, market, education, sale)

The preliminary results based on descriptive and inferential statistical analysis are reported in following sections.

Results

The total survey response was 99 returns with an adjusted response rate of 21.6%. Results based on descriptive statistics indicated that the majority of the respondents (54%) had a primary wood processing facility. In terms of volume, 92% of the total mill residue generated in Mississippi was contributed by primary wood processing facilities. Largest volumes of mill residues (69%) were internally used for energy generation. Likewise, a considerable volume (30%) was sold. Only 1% of mill residue, in absence of profitable market, was either disposed of or given away. The results based on regression analysis indicated that millowners having primary wood processing facilities, with higher number of employees, and year-round operations, were significantly more likely to have unused woody residues. Millowners interested in working with others to find better ways to utilize residues and facilities located nearby a mill residue market had a higher possibility of having unused mill residues. Finally, facility owners with postgraduate level of education were less likely to have mill residues. Regression analysis based results of significant variables are reported in Table 1.

Discussion and Conclusion

Significant OLS regression variables (level of processing facility, employee numbers, season(s) of operation, available market, millowner interest in utilization, and millowner education level) help to characterize Mississippi mills that are likely to produce unused mill residues. The sign of the variables are logical and guided by economic rationale. Since 92% of mill residues were produced in primary wood processing facilities, these facilities are of main importance. Mills with higher output production are also likely to have a larger number of employees who are generating more residues. Likewise, total volumes of mill residues generated in a seasonal forest product industry would be less than those that operate year-round. Millowners having residue markets near their firm would have a competitive market environment for their products, providing flexibility in utilizing mill residues to the best of their economic interests. It is also logical that millowners who have available unused mill residues will be more interested in working to find better ways to utilize the residues. And, millowners who may have acquired advanced managerial skills during postgraduate degree education could be better able to recognize and exploit the opportunities in mill residue utilization, thus explaining the negative correlation between graduate education and available mill residues.

Study results generally indicate that refined biomass obtained during wood processing can be utilized to develop wood-based bioenergy in Mississippi. As primary wood processing facilities and availability of unused mill residue were positively related, it can be argued that bioenergy can conceivably be generated at a competitive price, if the industry is located near a primary forest product mill.

Likewise, some information related to wood-based bioenergy and other mill residue markets might help less formally educated millowners to efficiently utilize mill residues. In summary, results indicate that forest product industries can become important contributors in supplying wood-based bioenergy feedstock in the region.

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Table 1. The attributes showing significant functional relationship with unused woody biomass in wood processing facilities, based on multiple linear regression, in Mississippi.

Variables	Coefficient	t-value
Primary processing facilities	0.98*	1.69
Larger firm in term of employee number	0.84**	2.12
Season of firm operation	2.39*	1.76
Available market	1.22**	2.03
Millowner interest to work	1.33 **	2.09
Millowner education (post graduate degree)	-1.26**	-2.05
Intercept	-0.81	
N	61	
R^2	0.31	
*significant at 10%, ** significant at 5%		

RESPONSE SURFACE OPTIMIZATION IN FOREST MANAGEMENT

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ABSTRACT

A method was proposed to simulate forest stand growth, timber prices, and interest rates, by distribution-free bootstrapping, and then optimize management controls for economic and ecological objectives by response surface analysis. The method was applied to Douglas-fir/western hemlock stands to predict the effects on economic and ecological objectives of management alternatives defined by the cutting cycle, C, the residual stand basal area, B, the diameter of the largest tree, D, and the ratio, q, of the number of trees in adjacent diameter classes. The effects were described with response surfaces, which were used to determine the best combinations of B, q, and C for each management criterion. Adjusting B, q, and C could control for 97 to 99 percent of the variability in the expected value of species diversity, size diversity, percentage of peeler logs, and basal area, and for 80 to 90 percent of the variability in land expectation value and annual production. Economic and ecological criteria were generally most sensitive to the q ratio, the residual basal area, and the cutting cycle. Annual production was negatively correlated with tree size diversity and wood quality. There was no apparent conflict between stand diversity and wood quality.

TREE GROWTH, CROP YIELDS, INTERACTIONS, AND ESTIMATED RETURNS AFTER FIVE YEARS FOR AN AGROFORESTRY TRIAL NEAR GOLDSBORO, NORTH CAROLINA

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ABSTRACT

A 17 acre (6.9 ha) agroforestry research and extension alley cropping trial was established with a randomized block design with five replications at the NC Department of Agriculture/NC State University Center for Environmental Farming Systems in Goldsboro, North Carolina in January 2007, Loblolly pine (*Pinus taeda)*, longleaf pine (*Pinus palustris)*, and cherrybark oak (*Quercus pagoda*) were planted in staggered rows. An annual rotation of soybeans (*Glycine max*) and corn (*Zea mays*) were planted in the 40 ft or 80 ft alleys between the tree rows for the first five years. Tree survival and growth were measured at the end of the fourth year; crop yields were measured annually; estimated timber returns were calculated using growth and yield equations; and tree and crop interactions were assessed based on field data each of the five years; and on soil-crop interactions in the fifth year.

The trees grew well, at an average of about 90% survival for the trees after four years. The weather had droughts each of the first four years, and one average rainfall period

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in the fifth year, leading to large crop financial losses in the first four years and average returns in the fifth year. The trees did not appear to reduce crop growth in the first four years, but began to adversely affect the soybean growth some in fifth year on the best replication with the tallest trees. Soybean growth appeared to be affected only slightly by moisture competition, but shade from trees reduced their growth significantly. In addition, deer moved into the planted tree shelter in the most productive replication and browsed heavily on several rows of beans next to the tree rows, reducing crop yield more than the shade did on other sites. The results support the merits of agroforestry systems in the upper South, at least on poor agriculture sites, to diversify farm and tree products for income, reduce farm income losses due to drought or climate change, and lessen financial risks.

Key Words: agroforestry, trees, crops, economics, North Carolina

Introduction

In 2007, we established an agroforestry trial near Goldsboro, North Carolina in the Upper Coastal Plain on a farm managed jointly by the North Carolina Department of Agriculture and North Carolina State University. The purpose of the trial was to provide a demonstration and research site to test the production and economics of a tree and crop agroforestry system, which eventually will be converted to a silvopasture system. The trial was established on a 17 acre site on the Cherry Farm near Goldsboro, North Carolina, which also includes an extensive research component named the Center for Environmental Farming Systems (CEFS: http://www.cefs.ncsu.edu/). The site is in the Upper Coastal Plain, and lies in alluvial river bottom of the Neuse River, a major tributary from the Piedmont of North Carolina to the Atlantic Ocean. The site has widely varying conditions on mostly poor soils, ranging from sandy loam at the driest end to more clay and some organic matter at the wetter end near the river and an adjacent swamp.

The objectives of this project were to: (1) provide a demonstration of the potential for agroforestry systems in North Carolina for landowners, farmers, natural resource professionals, and researchers; (2) establish a long-term research project that could be used to monitor the implementation of an alley cropping and eventually silvopasture system at the site; (3) measure the effects of trees on crop production and eventually livestock production; and (4) provide a research site for graduate students and professors interested in agroforestry.

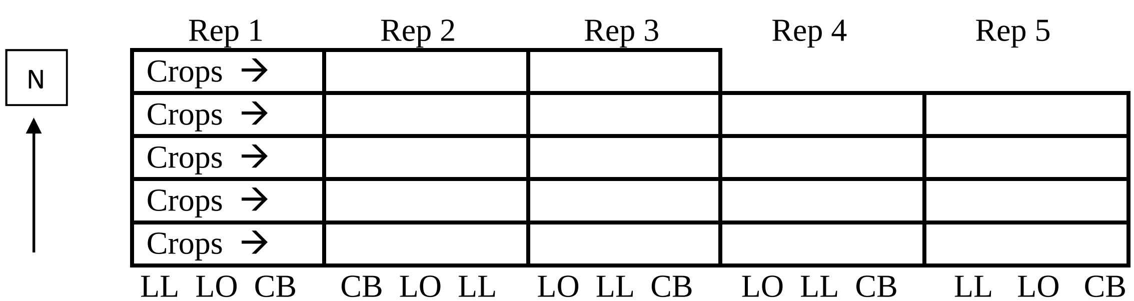
Methods

Per those objectives, we monitored and measured tree and crop growth on the site since 2007 when the trees were planted, as well as performed a related study on tree effects on soil moisture and soybean growth in the fifth growing season. We reported on the early results from this trial for the four years of 2007, 2008, 2009, and 2010 in a recent article (Cubbage et al. 2012). To avoid duplication, this proceedings article recaps the tabular results and provides an update on the growth and economic results for 2011, which was in fact a different outcome in terms of crop yields and tree/crop interactions than in the preceding years. We briefly summarize the highlights for the first four years drawing on the Cubbage et al. (2012) article, and proceed to summarize the interesting new results on crop growth and tree interactions from the last year.

We established the site as a randomized block design with five replications. Replication 1 was on the west end of the field, which had the driest, sandiest soil. The east end, Rep 5, was on the wetter, lower elevation near the river and had more clay content in the soil. Loblolly pine (*Pinus taeda)*, longleaf pine (*Pinus palustris)*, and cherrybark oak (*Quercus pagoda*) were planted in staggered rows, with each species planted for 140 ft (43 m) per Replication (Figure 1). We also planted two square blocks of each tree species at a 10 ft by 10 ft spacing at the wet end of the field as check plots to assess if the trees in rows grew differently than the trees in these check plots, which approximated conventional forest plantations.

A rotation of soybeans (*Glycine max*) and corn (*Zea mays*) was planted in the 40 ft or 80 ft crop land alleys between the tree rows, in the five alternating years since establishment. Note that the tree rows ran roughly east and west, which allowed the most possible sunlight on the crop alleys as the summer sun moved across the horizon.

Figure 1. Representation of Alley Cropping Project Layout, Center for Environmental Farming Systems, Goldsboro, North Carolina



Crop rows varied randomly between 40 ft (12.2 m) and 80 ft (24.4 m)
Three tree rows (6 ft by 6 ft; 1.83 m x 1.83 m) in each row; each species in each replication (420 ft / 128 m)
Trees established in blocks across the replications (Rep) as noted at the bottom of the diagram were:
LO-Loblolly pine; LL-Longleaf pine; CB-Cherrybark oak

Tree survival and growth were measured at the end of the fourth year; crop yields were measured annually; estimated timber returns were calculated using growth and yield equations; and tree and crop interactions were assessed based on field data each of the five years; and on soil and crop interactions in the fifth year.

Growth and yield projections were made for traditional timber production using growth and yield package by Smith and Hafley (1980). We then used capital budgeting criteria (Wagner 2012) to calculate returns for the different tree species at a 4% discount rate. These financial calculations were made without any government incentive or subsidy payments. Owners can receive some cost-share payments for tree planting of all species if funds are available, and hardwoods and longleaf pine are apt to have higher percentage of the costs covered, and receive payments under more programs, since they are considered more environmentally important.

In 2011, a study was initiated to investigate tree competition effects on soybean growth and development by considering below ground and above ground interactions caused by shade and roots. Soybeans were intercropped with the loblolly pines in the 80 ft crop alley widths. In these crop alleys, there were areas where tree roots were pruned and root barriers installed to eliminate the effect of competition on the soybeans, and other areas where tree roots were left intact. Areas within blocks were also separated by zones that received maximal (> 6 hours) and minimal (< 3 hours) amounts of shade each day. In each block, the sixteen rows of soybeans proximal to the strips of pines and environmental conditions near them were examined for soil moisture and temperature, soybean chlorophyll content, fractional interception of light, and soybean height. Measurements were taken once a month over the growing season (July, August, and September), after which soybean plants were harvested for determination of biomass. Statistical analyses were used to evaluate the impacts and relationships among above and below ground competition effects from the trees and on the development of the soybeans.

Results

Timber Growth and Returns

As of 2011, tree survival rates were 93% for cherrybark oak, 88% for longleaf pine, and 97% for loblolly pine. Average tree diameter at ground level was 1.0 in (2.5 cm) for cherrybark oak, 2.1 in (5.3 cm) for longleaf, and 3.2 in (8.1 cm) for loblolly. Heights averaged 4.6 ft (1.4 m) for cherrybark oak, 5.2 ft (1.6 m) for longleaf pine, and 10.4 ft (3.2 m) for loblolly pine (Table 1).

Table 1. Survival, Tree Trunk Diameter at Base, and Height of Trees in Goldsboro Alley Cropping Trial at 4 Years Old, by Replication and Control Plots, 2011

Characteristic[1]	Loblolly Pine	Longleaf Pine	Cherrybark Oak
Survival, All Replications (%)	97%	88%	93%
Trunk Diameter (in)			
All Replications	3.2	2.1	1.0
Replications 1-4	2.9	2.0	1.0
Replication 5[1,2]	4.6	2.3	1.4
Check Plots	4.3	2.0	1.7
Height (ft)			
All Replications	10.4	5.2	4.6
Replications 1-4	9.3	4.9	4.2
Replication 5[3]	15.7	6.3	6.6
Check Plots	14.3	4.7	8.0

[1]All diameters and heights between species were statistically different (α=0.01).
[2]For longleaf pine and cherrybark oak, the mean diameter in Rep 5 is statistically different from the mean of the check plots (α=0.01). For loblolly this difference was significant at α=0.10.
[3] The mean height in Rep 5 is statistically different from the mean of the check plots for all species (α=0.01).

We had some fear that the pervasive deer on the site would reduce tree survival and growth, but the trees prospered regardless of the high deer pressure. The oaks had more tips of seedlings clipped by deer, but even this mostly just created a temporary fork in the tree that it grew out of in a couple of years. Generally the deer preferred to eat soybeans or corn in the crop alleys, or strawberries in an adjacent field, compared to tree seedlings.

In addition, we were not sure if the longleaf pine containerized seedlings would emerge from the grass stage or falter, and if the cherrybark oak would grow well at all. We did spray the tree rows in March of 2007 and 2008 with Oust pre-emergent herbicide to control weeds, which seemed to be sufficient to foster good tree growth. We also hand weeded in the first year using a hoe to remove sicklepod (*Senna obtusifolia*) and morning glory (*Ipomoea purpurea*), which were choking the seedlings. The longleaf pine have mostly come out of the grass stage and look tall and healthy, especially on the sandier Reps 1-3 and possibly Rep 4. This suggests that herbicides could be used as an effective tool tool in place of prescribed burning to help establish longleaf pine, at least on similar crop land sites.

The oaks are smaller on reps 1-3, on these sandy, well drained soils. But they look healthy and tall in Rep 5, and to a lesser extent in Rep 4. These results are typical of many hardwood plantings where slight differences in microsite conditions can produce variations in tree height and growth for a particular species. Loblolly pine actually had more variation between the dry and wet sites due to the amount of clay content in Rep 5, although they were taller everywhere.

Results from the growth and yield projections and economic calculations are shown in Table 2. Loblolly pine had the largest projected internal rate of return, at 7.2%, followed by longleaf pine with pine straw harvests at 5.5%, longleaf without pine straw at 3.5%, and cherrybark oak at 1.9%. There might be more loss in crop and silvopasture production with loblolly, however, and the production of longleaf pine straw income or mast production from cherrybark oaks may offer other benefits.

Table 2. Tree Growth Rates and Yields and Capital Budgeting Results for Three Species for Timber Production Management Regime at a Discount Rate of 4%

Species	Rotation Age (yrs)	Harvest Years	Total Projected Volume Cut / Mean Annual Increment (ft^3/ac)	Net Present Value ($/ac)	Land Expectation Value ($/ac)	Annual Equivalent Value ($/ac)	Internal Rate of Return (%)
Cherrybark Oak	80	55&80	4,846 / 61	-360	-376	-15	1.9
Longleaf Pine – Timber Only	40	25&40	2,826 / 71	-49	-61	-2	3.7
Longleaf Pine – Timber and Pine Straw	40	25&40	2,826 / 71	274	346	11	5.5
Loblolly Pine	25	17&25	2,700 / 108	493	789	32	7.2

Agriculture Crop Growth and Returns

Crop yields on the sandy soils on the site were very poor during the first four years observed, which had a bean-corn-bean-corn rotation, but the beans at least had almost average yields in 2011 (Table 3). The first four years had a series of droughts and floods, resulting in average bean yields of only 12 bushels per acre in 2007 and 2009, and average corn yields of 50 bushels per acre in 2008 and 20 bushels per acre in 2010. These led to net financial losses totaling more than $664 per acre for those four years for the demonstration site, or an average of $166 per acre per year. We also calculated the returns for the best case measured of all the five Reps (#5), which had yields close to the state average each year. These best Rep 5 average farm budget returns—which occurred in both years for the soybeans and only in 2008 for the corn—had moderate profits, at an average of $80 per acre per year.

Table 3. Crop Yields, Average Costs, Prices, and Returns per Acre by Year and Best Scenario

Year	Crop	Average Yield (bushels/ac)	Average[1] Cost ($/ac)	Prices per Bushel	Total Sale Price ($/ac)	Net Returns ($/ac)
2007	Soybeans	12	228	10.10	121	-107
2008	Corn	51	299	3.50	179	-120
2009	Soybeans	12	228	9.59	115	-113
2010	Corn	20	411	4.35	87	-324
2011	Soybeans	31[3]	273	12.00	370	97
Best Beans, Rep 5, 2007&2009[2]	Soybeans	30	228	10.40	312	84
Best Corn, Rep 5, 2008[2]	Corn	112	411	4.35	487	76

[1]Source: NC State University Cooperative Extension, http://www.ag-econ.ncsu.edu/extension/Ag_budgets.html
[2]Best yields based on the year they occurred in Rep 5; net returns based on 2010 costs and prices
[3]Soybeans in 2011 based on 2012 crop budgets (only available ones); and yields in Reps 1-4 only.

The fifth year had better crop growth of soybeans, with an average yield of 28.5 bushels per acre for all five Reps; 30.8 bushels per acre for Reps 1 through 4; and 17.1 bushels per acre for Rep 5. Note the striking differences in the crop yields in 2011 versus previous years. Part of this difference is the result of adequate rainfall during the 2011 growing season, allowing soybeans to grow well—at almost the state average of 35 bushels per acre. The previous years, which had varying levels of drought—two actually set new records for the least rain ever recorded in 50 years (13.5 inches in 2007 and 12.7 inches in 2010)—during the growing season and all were below the 50 year average of 28.2 inches. In 2008 there were 23.9 inches of rain; 19.9 in 2009. Even 2011 only had 27.3 inches of rainfall, and 11.7 inches fell in August, mostly during a hurricane, but just in time to prevent a crop failure. Corn has been planted in 2012, and so far we have had 12 inches of rain in March, April, and through May 15, which should create good crop growth rates and yields and reasonable profits for corn for the first time this year.

As noted, these rainfall amounts on a mostly poor site with sandy soils led to poor crop performance, with only one of five years recorded having acceptable yields when compared to the state averages. If climate change is the cause of these low rainfall amounts, this will make agroforestry/silvopasture more attractive, since the trees prospered regardless of the precipitation variations so far, and climate change augurs to increase. It is possible that the dry years actually helped the trees by reducing the vigor of the weeds in the tree rows.

Another trend contributing to the increased crop yields in 2011 was the reversal of the tendency to see the best crop yields in Rep 5. This reversal can be attributed to two reasons. First, the trees in Rep 5 were much taller, with an average height of more than 20 ft for loblolly pine by 2011, and even up to 8 ft for the cherrybark oak, which grew well in the wet bottomland conditions close to the Neuse River. Second, hunting is prohibited on the Cherry Farm/CEFS due to logistical and administrative constraints. As a result, the overpopulation of resident deer herds is substantial. In particular, they liked to bed down and rest in the planted loblolly trees in Rep 5, and ate most of the first four rows of soybeans. The combination of the shade from the larger loblolly trees and the deer browse in Rep 5 resulted in lower soybean yields per acre in 2011, especially since there was adequate rainfall on all parts of the site, eliminating the previous crop production advantage for the wetter Rep 5.

Tree-Crop Competition

Little competition was seen between the crops and the trees in the first four years, because the trees were small and the droughts damaged the crops so much that tree interactions were the least of the problems. In fact, the more fertile Rep 5, which is where trees grew best, also had the best crop yields from 2007 to 2010. However, as noted above, this trend reversed with the soybeans in 2011 due to apparent tree shade, soil moisture, and herbivore impacts from deer. As noted, the deer on the farm were ubiquitous, but their presence and detrimental impacts occurred more in Rep 5. In additions to the impacts from deer, the tall trees of 20 feet or more in height in rep 5 were beginning to shade out a greater amount of the crop alleys by the fifth year, reducing yields.

The soybean yields in 2011 averaged 30.8 bushels per acre in Reps 1-4; 17.1 bushels per acre in rep 5. Similarly, they averaged 25.8 bushels per acre in the 40 ft crop alleys, and 31.9 bushels per acre in the 80 ft crop alleys. So the tree rows did seem to be decreasing crop yields, with the differences being significant at p=.001.

The field study in the fifth year examining the interaction of soil moisture and shade on the soybeans planted in 2011 found that the trees did not yet affect soil moisture regimes for the plants, but that shade did decrease plant growth. In addition, we had to eliminate Rep 5 from that study because the deer browse eliminated most of the edge rows of soybeans (Brown 2012).

Overall, it seems that for good soils and sites, direct competition between trees and agriculture crops had started to occur by year 5, in the best soils and tree species (loblolly) in Rep 5. However, this same competition was only moderate for the slightly slower growing longleaf pine and cherrybark oak species and drier soils in Reps 1 through 4. We expect that any direct competition and effects of these trees on crops will occur within 3 to 5 years, or by age 8.

Conclusions

This agroforestry trial on the NCDA Cherry Farm/Center for Environmental Farming has provided considerable empirical information about the merits of mixed trees and crops in the Upper Coastal plain of North Carolina. The results and analyses can serve as a model for discussion and extension to other regions and be applied directly to working farms that are considering agroforestry systems.

Recall that the tract is a poor agriculture site with variable sandy soils, without much water holding capacity. In addition, we had below average rainfall in all five years that we recorded crop and tree growth results, and two of the years had the least rainfall recorded during the growing season in the past 50 years. These biophysical characteristics affect the findings, which may differ for more fertile tracts and soils, and years with better rainfall quantity and distribution.

First, on this site, the trees grew well. They were planted by inexperienced labor, with success, and treated with a pre-emergent herbicide in the first two years, and had one hand weeding treatment in the first year. They did not have any other stand improvements. Longleaf pine did comparatively better on the drier sandy soils, but came out of the grass stage and looked pretty good on all but Rep 5 and in the wet check plots. Loblolly pine grew fast on all sites, but the best growth occurred in the wetter soils. Cherrybark oak survived reasonably well, and grew well in the wetter, better soils in Rep 4 and 5 and in the check plots by the Neuse River. The check plots grew somewhat differently than the rows of trees, but were at least close enough that they allowed us to comfortably use conventional growth and yield models for the tree row economic models.

Second, the crop yields were poor to awful given the poor site and lack of rainfall during the growing season. They were better in Rep 5 for the first four years, but the crops there were beginning to suffer from shade and deer browsing by 2011. The soybean-corn crop rotation lost an average of $664 per acre in the first four years, although the $97 profit per acre in 2011 would reduce this loss to $567 per acre in the first five years. Still, the poor quality agricultural site and the hot, dry weather suggest that forestry or silvopasture may be better goals for farm management, profits, and risk than pure crop rotations, particularly on lower quality sites. The statewide average corn and bean yields were profitable for all of these years, indicating that there are good crop lands in other regions of the state, and indeed there are some even on the Cherry Farm.

Third, the large trees and their beginning adverse effect on crop yield indicates that on a good site, with loblolly pine at least, one could start the shift from agroforestry with crop alleys to a silvopasture system now, in less time than for the other tree species. Loblolly pine will produce greater tree yields and better financial returns, at least for the tree species alone. But it will decrease crop returns sooner than longleaf or hardwoods will. If crop production is desired for a few more years before shifting to a silvopasture or pure timber system, then longleaf or hardwoods might be advantageous.

Fourth, the loblolly trees were large enough to allow grazing without damage from cattle by 2011, the fifth year. On this demonstration trial this shift to silvopasture would need to be delayed due to the smaller longleaf pine trees and more palatable cherrybark oak trees, which could be damaged or eaten by cattle. Thus we will probably wait three to five years, but certainly move toward a silvopasture system when the trees are large enough to survive with cattle. Continuing large crop financial losses are undesirable for practical reasons as well for this demonstration trial. The Cherry Farm is self supporting from farm revenues, and will seek to minimize revenue losses, even for a good research and demonstration cause.

The results of this demonstration trial do support the merits of agroforestry systems in the upper South, at least on poor agriculture sites, to diversify production, reduce farm income losses due to drought or climate change, and lessen financial risks. Following a period of five to eight years, these agroforestry systems may be good candidates to transition to a silvopasture system. The trees can provide income in the future, and cattle grazing is apt to be more desirable with better shade and less heat stress for the animals during hot months in the summer. Other configurations of trees, crops, and eventually livestock use can be adapted easily based on the results of this trial. We will continue to monitor and report on this agroforestry→silvopasture trial in the future, and welcome visits to the site to fulfill its demonstration role, as well as suggestions for further research and extension.

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ECONOMIC ASSESSMENT OF STAND-LEVEL TREATMENTS FOR SOUTHERN PINE BEETLE PREVENTION

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ABSTRACT

Treatments for the prevention of Southern Pine Beetle will not result in higher Expected Present Values for southern forest landowners.

The effect of silvicultural treatments on damages from southern pine beetle depends on treatments and the assumed probability of damages. This research will evaluate the stand level benefits and costs of prevention treatments used to reduce damages from Southern Pine Beetle. For the thirteen southern states, a set of treatments and a set of representative stands will be selected to characterize a prevention program. The representative stands will be used in the growth and yield model. The model will be used to grow the representative stands under various conditions, including treatments and probability of tree mortality from SPB. The products from the growth and yield will be used in an economic analysis. An expected present value framework will be used to evaluate the net present value where there are probabilities of damages. We will also evaluate the effect of changes in these probabilities on EPV.

TIMBERLAND IN A MIXED ASSET PORTFOLIO FROM THE INVESTOR PERSPECTIVE

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When comparing timberland performance to other investment options in a mixed asset portfolio, the results most often look quite different depending on the country of origin of the Investor. A Japanese or Australian Investor may view timberland in a mixed asset portfolio much differently than a Canadian or European Investor. This study exams the performance of comparative assets over time from various Investor perspectives and attempts to suggest drivers of relative performance.

ASSESSING THE ROLE OF U.S. TIMBERLAND ASSETS IN A MIXED PORTFOLIO UNDER THE MEAN-CONDITIONAL VALUE AT RISK FRAMEWORK

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ABSTRACT

This study examines the role of U.S. timberland assets in a mixed portfolio from the risk perspective. Using the mean-conditional value at risk (M-CVaR) optimization approach, the efficient frontier of the mixed portfolio is dramatically improved by adding timberland assets compared with the traditional mean-variance (M-V) optimization approach. Our study uses three risk metrics including standard deviation (SD), value at risk (VaR), and CVaR to measure and compare the portfolio risk. The results indicate that SD underestimates downside risk VaR and CVaR. Both static and dynamic risk decomposition of portfolios are used to identify the risk sources under four different scenarios. The empirical results reveal that large-cap stocks and small-cap stocks are generally risk intensifiers, whereas treasury bonds, treasury bills, and timberland assets are risk diversifiers in the mixed portfolio. The asset allocation strategies formulated by the M-CVaR approach indicate that timberland assets maintain a significant allocation in the mixed portfolio over static and dynamic optimizations.

Keywords: asset allocation, efficient frontier, mean-conditional value at risk (M-CVaR), risk decomposition, timberland assets

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Introduction

Timberland assets have attracted institutional investors in recent decades because of its distinct features, including high risk-adjusted returns (Cascio and Clutter, 2008), risk diversification potentials (Caulfield, 1998b), and inflation hedging abilities (Washburn and Binkley, 1993). To better understand the timberland assets, previous studies employed the modern portfolio theory to evaluate its performance and analyze its diversification effects. Mills and Hoover (1982) introduced the mean-variance (M-V) optimization approach to examine the relationship between returns and risks in forest investments and proved that forest investment could provide diversification benefits. Zinkhan et al. (1992) and Caulfield (1998a) demonstrated that adding timberland assets to a portfolio could improve the portfolio performance and provided asset allocation suggestions for institutional investors. Newell and Eves (2009) analyzed the risk-adjusted performance of U.S. timberland in real estate portoflios and concluded that the timberland assets strongly performed over 1987 – 2007.

Under the M-V framework, variance or standard deviation (SD) of asset returns is used to measure the portfolio risk under the assumption of multivariate normal distribution. When asset returns follow a normal distribution, SD can help us understand how much the asset returns vary around the mean value. However, investors are more concerned about the significant losses from the extreme events such as financial crisis, and therefore, more attention have been paid to downside risks in practice. Meanwhile, value at risk (VaR) has become a popular tool among portfolio managers to measure the downside risk since it is easy to calculate and interpret. VaR gives the maximum loss that will not be exceeded with a given probability over a period of time, whereas conditional VaR (CVaR) measures the loss greater than VaR.

It is well observed that the returns of financial assets such as stocks and bonds are not normally distributed. They generally exhibit non-normality properties such as skewness and kurtosis in the real world (Sheikh and Qiao, 2010). For instance, negatively skewed asset returns suggest that the left tail is longer than the right tail, implying that the probability of the occurrence of negative returns is higher than positive returns. Asset returns with fat tails imply that both of the extreme negative and positive returns occur more frequently than those normally distributed ones. It is obvious that the mean and variance alone fail to describe the true distribution. Therefore, the M-V approach may not fully reveal the relationship between returns and risks, and therefore, may not correctly construct the efficient frontier for a portfolio. To address the risk measure and non-normality issues, the Mean-CVaR (M-CVaR) optimization approach is introduced in this study. The M-CVaR approach minimizes downside risk measured by CVaR with a given level of target return and does not assume a multivariate normal distribution.

The overall purpose of this study is to examine the role of U.S. timberland assets in a mixed portfolio from the risk perspective. First, the efficient frontier is constructed by the M-CVaR optimization approach, which minimizes downside risk CVaR and accounts for the non-normality of asset returns. The empirical results indicate that the M-CVaR approach leads to a more efficient frontier than the M-V approach. Second, three risk metrics including SD, VaR, and CVaR are used to evaluate and compare portfolio risks. It is found that SD underestimates the portfolio risk compared with VaR and CVaR, which should reflect the true downside risk. Finally, the portfolio risk is decomposed to identify how the aggregate risk is contributed by individual assets under four different scenarios through backtesting. The results reveal that both large-cap and small-cap stocks are risk intensifier, whereas treasury bills, bonds, and timberland assets are risk diversifiers.

Methodology

Modern Portfolio Theory

Modern portfolio theory proposed by Markowitz (1952) establishes the foundation of portfolio optimization and asset allocation strategies. This theory constructs a set of optimal portfolios through weighted combinations of assets whose returns are viewed as random variables. The returns of these portfolios are measured by the sample means of the combined assets. Mathematically, a set of assets indexed by $i\,(i=1,2,\cdots,n)$ generate individual returns $r=(r_1,r_2,\cdots,r_n)^T$ at the end of the holding period. Their mean values are denoted by $\overline{r}=\varepsilon(r)=(\overline{r}_1,\overline{r}_2,\cdots\overline{r}_n)^T$ over the holding period. Investors construct their portfolios by adjusting the weight of individual asset $w=(w_1,w_2,\cdots,w_n)^{\mathrm{T}}$ constrained by $\sum_{i=1}^{n} w_i=1$ and $w_i>0$ (short-selling is not allowed). Therefore, the portfolio return can be calculated by $R(w,\overline{r})=w^T\overline{r}=\sum_{i=1}^{n} w_i\overline{r}_i$, where R is a random variable with a cumulative distribution function F_R. Assume the portfolio risk $\Re$ is a function of asset weights and returns, then the portfolio can be optimized by minimizing the risk subject to a given target return u as follows.

$$
\begin{aligned}
&Min\ \Re(w,r) \\
&s.t.\ w^T\overline{r}=u \text{ and } \sum_{i=1}^{n} w_i=1
\end{aligned}
\tag{1}
$$

Risk Measures

Risk measure I: standard deviation (SD). The standard deviation defined in equation (2) is commonly used to measure the portfolio risk, where Σ is the variance-covariance matrix of the n assets. This portfolio optimization is under the multivariate normal distribution assumption and is called the mean-variance (M-V) optimization approach. Solving the problem of $Min\,\sigma^2(w,r)$ with a given set of target returns can generate M-V efficient frontiers, where $\sigma^2(w,r)=w^T\Sigma w$ is the variance of the portfolio. This portfolio optimization problem can be solved by quadratic programming solvers.

$$SD(w,r) = \sqrt{w^T \sum w} \tag{2}$$

Risk measure II: value at risk (VaR). VaR has become the most widely used industry standard to measure risks. It calculates the downside risk into one number, allowing easy comparisons among individual assets and portfolios (Morgan, 1996). It is defined as the maximum loss that will not be exceeded within a period of time at a confidence level. Given a confidence level $\alpha \in (0,1)$, a portfolio's $(1-\alpha)\%$ VaR can be calculated by the following formula.

$$VaR_\alpha(w,r) = -F_R^{-1}(1-\alpha) \tag{3}$$

Where F_R^{-1} is the quantile function of the asset or portfolio returns. Although VaR has become a popular risk measure, it lacks of some desirable properties such as subadditivity (Artzner et al., 1999). For example, a portfolio's VaR may be greater than the sum of the individual VaR. Moreover, it is difficult to minimize a portfolio's VaR since it is a non-smooth and non-convex function with respect to asset weights.

Risk measure III: Conditional value at risk (CVaR). CVaR overcomes many of the drawbacks of VaR as a downside risk measure. For example, CVaR has the coherent properties, including subadditivity, homogeneity, monotonicity, and translation invariance (Krokhmal et al., 2002). CVaR is defined as the conditional expectation of losses exceeding VaR at a confidence level. A portfolio's CVaR can be defined in terms of its own VaR with a confidence level α.

$$CVaR_\alpha(w,r) = -E[R(w,r) \mid R(w,r) \le -VaR_\alpha(w,r)] = -\frac{1}{1-\alpha}\int_{-\infty}^{-VaR_\alpha(w,r)} zf(z)dz \tag{4}$$

Where $f(z)$ is the probability density function of portfolio return $R(w,r)$. Solving the problem of $Min\, CVaR_\alpha(w,r)$ with a given set of target returns can generate M-CVaR efficient frontiers (Rockafellar and Uryasev, 2000).

Risk Decomposition

Risk decomposition can help portfolio managers to identify the sources of risk in a portfolio, and therefore, provide important implications for risk management. The contribution by each asset in a portfolio is easily calculated by the Euler's theorem since all these three risk measures (SD, VaR, and CVaR) are homogenous of degree one. The risk contribution of the i^{th} asset to the portfolio's SD, VaR, and CVaR can be calculated by equations (5) – (7) and can be interpreted as the change of the portfolio risk with respect to the percentage change in weight w_i (Martin et al., 2001; Pearson, 2002; Boudt et al., 2008).

$$D_i SD(w,r) = w_i \frac{\partial SD(w,r)}{\partial w_i} \tag{5}$$

$$D_i VaR_\alpha(w,r) = w_i \frac{\partial VaR_\alpha(w,r)}{\partial w_i} \tag{6}$$

$$D_i CVaR_\alpha(w,r) = w_i \frac{\partial CVaR_\alpha(w,r)}{\partial w_i} \tag{7}$$

If the risk contribution is greater than the weight, the asset is a risk intensifier, and otherwise, the asset serves as a risk diversifier. If they are equal, the asset is a neutral. In addition, the individual risk contribution satisfies $\sum_{i=1}^{n} D_i SD(w,r) = \sum_{i=1}^{n} D_i VaR_\alpha(w,r) = \sum_{i=1}^{n} D_i CVaR_\alpha(w,r) = 1$.

Backtesting

Backtesting is a common method to evaluate the performance of a portfolio using historical data with given strategies. It can provide crucial implications for asset allocation and portfolio management. In this study, backtesting is employed to formulate the asset allocation strategies and analyze the asset risk contributions under the M-CVaR framework. Asset allocations with a given target return are formulated and compared across different scenarios. The corresponding risk contribution is calculated to evaluate the role of timberland assets.

Data and Scenarios

Four assets including large-cap stocks, small-cap stocks, treasury bonds, and treasury bills are considered in this study. Among them, returns on large-cap stocks are proxied by the S&P 500 Index collected from the Center for Research in Security Prices (CRSP). Returns on small-cap stocks are approximated by Russell 2000 Index collected from Russell Investments. Returns on treasury bonds are proxied by Barclays Capital U.S. Government/Credit Index collected from Barclays Capital. Returns on treasury bills are approximated by the 3-month treasury bills collected from CRSP. The NCREIF Timberland Index is used to proxy the returns for U.S. timberland investments. Quarterly data from 1987Q1 to 20011Q4 are used in this study.

Institutional investors primarily invest in traditional assets such as stocks and bonds in their portfolios. In practice, individual assets are constrained by allowable allocations. In order to better understand the role of timberland assets in a mixed portfolio, two scenarios are assumed. Scenario 1 places the minimum asset allocation on the large-cap stocks by 20%, small-cap stocks by 15%, treasury bonds by 10%, and treasury bills by 5%. Scenario 2 adds the restriction of a maximum 10% weight on timberland assets to Scenario 1.

Empirical Results

Descriptive Statistics

The descriptive statistics of the individual assets from 1987 to 2011 are reported in Panel A of Table 1. The results show that timberland assets have the highest quarterly return (3.2%) and treasury bills have the lowest standard deviation (0.6%). Returns on large-cap stocks, small-cap stocks, and treasury bills are negatively skewed, whereas returns on treasury bonds are slightly positively skewed and timberland assets are highly positively skewed. Returns on timberland assets have the highest excess kurtosis, indicating fat tails of their distribution. Additionally, results of the Jarque-Bera normality test reveal that the null hypothesis of normal distributions of large-cap stocks, small-cap stocks, and timberland assets are rejected at the 10% confidence level. The Shapiro-Wilk multivariate normality test is rejected at the 1% level.

Three risk measures are applied to individual assets first and the results are reported in Panel B of Table 1. The VaR and CVaR of large-cap stocks and small-cap stocks are much higher than the SD of them, indicating the SD underestimate individual downside risks. Regarding timberland assets, the VaR are lower than the SD but the CVaR is higher than the SD, suggesting that their skewness and kurtosis affect the evaluation of risks. Panel C of Table 1 presents the correlations between each pair of the assets in the mixed portfolio. Large-cap stocks are highly correlated with small-cap stocks but slightly correlated with treasury bills and timberland assets, and negatively correlated with treasury bonds. The low and negative correlations between these assets provide a potential for portfolio diversification.

Table 1 Descriptive Statistics, Risks, and Correlations (1987Q1 – 2011Q4)

	Large-cap Stocks	Small-cap Stocks	Treasury Bonds	Treasury Bills	Timberland Assets
Panel A: Descriptive Statistics					
Observations	100	100	100	100	100
Minimum	-0.232	-0.291	-0.032	0.000	-0.065
Mean	0.020	0.027	0.018	0.010	0.032
Maximum	0.209	0.297	0.080	0.024	0.223
Standard Deviation	0.083	0.111	0.024	0.006	0.042
Skewness	-0.609	-0.452	0.081	-0.124	1.797
Excess Kurtosis	0.789	0.565	-0.700	-0.882	4.810
JB Normality Test	0.009	0.074	0.389	0.202	0.000
SW Multivariate Normality Test					0.000
Panel B: Risks					
SD	0.083	0.111	0.024	0.006	0.042
VaR (95%)	0.129	0.167	0.022	0.000	0.036
CVaR (95%)	0.185	0.237	0.029	0.002	0.076
Panel C: Correlations					

Large-cap Stocks	1.000				
Small-cap Stocks	0.882	1.000			
Treasury Bonds	-0.145	-0.199	1.000		
Treasury Bills	0.066	-0.058	0.198	1.000	
Timberland Assets	0.017	-0.042	0.124	0.366	1.000

Efficient Frontiers

The comparison of the M-V and M-CVaR efficient frontiers is shown in Figure 1. The M-CVaR efficient frontier is dramatically improved with timberland assets compared with the M-V one. For example, with a target return of 2%, the SD and CVaR of the portfolios without timberlands are 2.8% and 3%, respectively. After adding timberland assets in the mixed portfolio, the SD of the portfolio with the same target return is 1.6%, whereas the CVaR of that portfolio is 0.8%. These results indicate that the M-CVaR approach can reduce more risk than the M-V approach. This is because the M-CVaR approach considers the non-normality of the asset returns.

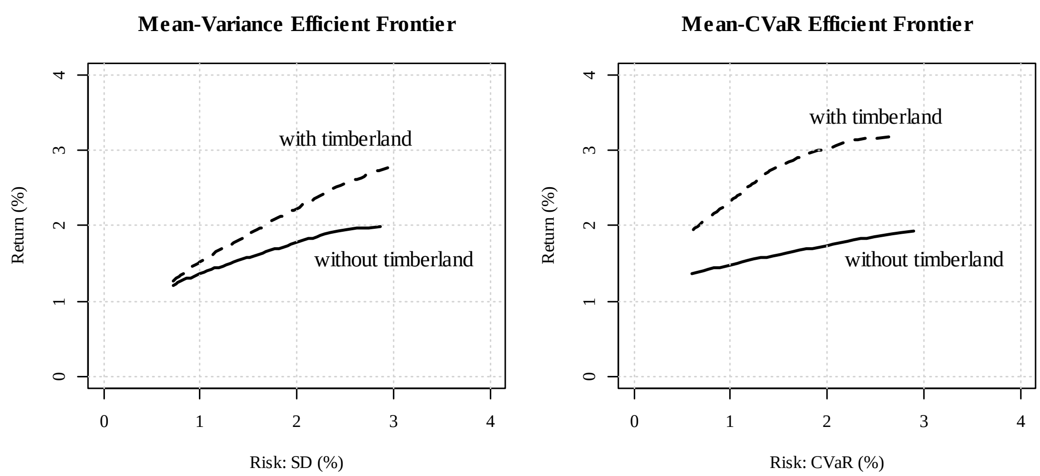

Figure 1 Comparison of the M-V and M-CVaR Efficient Frontiers with Timberland Assets

Static Asset Allocations

Figure 2 shows the static M-CVaR asset allocations under two different scenarios. In Scenario 1, the allocation on treasury bills is more than that on treasury bonds in lower target returns. The weight of timberland assets increases up to 48.5% as investors require higher level of target returns. In Scenario 2, the asset allocations are similar to Scenario 1 in low target returns. Timberland assets are substituted by treasury bonds and small-cap stocks for higher target returns. Overall, timberland assets have a significant allocation in the mixed portfolio.

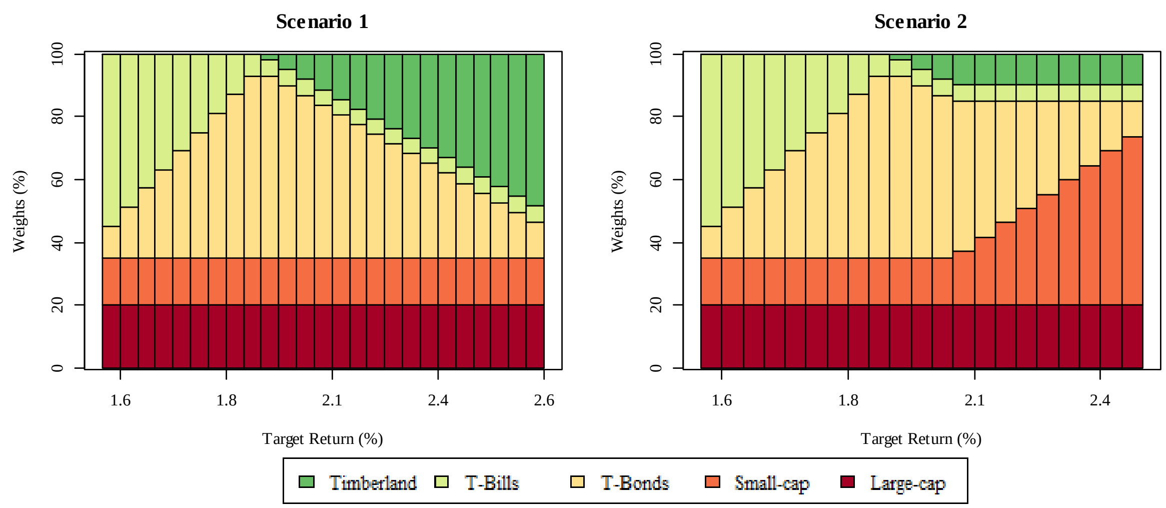

Figure 2 Static Asset Allocations in a Mixed Portfolio under Two Scenarios

Static Backtesting by Risk Decomposition

Based on the asset allocation strategies in Figure 2, the optimal portfolio with a target return of 2% is selected and the its corresponding risks measured by SD, VaR, and CVaR are reported in Table 2. Under both scenarios, the portfolio's SD is less than its VaR, which is less than its CVaR. This indicates that the portfolio's SD underestimates the portfolio downside risk. Next, the portfolio's SD, VaR, and CVaR are further decomposed by equations (5) – (7) to understand the risk contribution of individual assets. The risk contributions of large-cap stocks and small-cap stocks are much higher than their own weights, indicating that stocks are risk intensifiers. In contrast, the risk contribution of treasury bonds is much lower than its own weight, suggesting it is a strong risk diversifier. As for treasury bills and timberland assets, their decomposition percentages are low and less than their own weights. This implies that they are slight risk diversifiers in the mixed portfolio. Therefore, adding treasury bonds, treasury bills, and timberland assets into a mixed portfolio can significantly reduce the portfolio downside risk.

Table 2 Risk Decomposition of the M-CVaR Portfolios with a Target Return of 2%

	Scenario 1				Scenario 2			
	MU	D_iSD	D_iVaR	D_iCVaR	MU	D_iSD	D_iVaR	D_iCVaR
Portfolio	**2.0**	**3.3**	**3.5**	**4.8**	**2.0**	**3.3**	**3.5**	**4.8**
Large-cap Stocks	20.0	45.4	65.0	65.4	20.0	45.4	65.0	65.4
Small-cap Stocks	15.0	44.1	61.8	63.7	15.0	44.1	61.8	63.7
Treasury Bonds	55.1	9.8	-22.7	-26.0	55.1	9.8	-22.7	-26.0
Treasury Bills	5.0	0.1	-1.3	-1.0	5.0	0.1	-1.3	-1.0
Timberlands	4.9	0.6	-2.8	-2.1	4.9	0.6	-2.8	-2.1
Sum	100	100	100	100	100	100	100	100

Note: The bold numbers are MU, SD, VaR, and CVaR for the portfolio with a given target return. MU denotes the target return. SD denotes the standard deviation. All the numbers are interpreted in percentage.

Table 3 provides a comparison of risk decomposition between the low target return of 1.6% and the high target return of 2.4% under Scenario 2. At the low level of target returns, treasury bills as the lowest risk asset dominate in the mixed portfolio because it has low or negative risk contribution to the portfolio. Moreover, it is noted that the allocation to timberland assets is zero at low target returns. Although the allocations to large-cap stocks and small-cap stocks are at their minimum levels, their risk contributions to the portfolio are more than 50%. At high level of target returns, treasury bills are replaced by small-cap stocks and timberland assets. The risk contribution of small-cap stocks to the portfolio's SD, VaR, and CVaR are 78%, 82.8%, and 82.9%, respectively.

Table 3 Comparison of Risk Decomposition between the Low and High Target Returns

Scenario 2	Weight	D_iSD	D_iVaR	D_iCVaR	Weight	D_iSD	D_iVaR	D_iCVaR
Portfolio	**1.6**	**3.2**	**4.1**	**5.9**	**2.4**	**6.9**	**9.9**	**14.0**
Large-cap	20.0	50.2	61.8	60.7	20.0	22.4	24.8	24.7
Small-cap	15.0	49.2	59.2	58.5	49.2	78.0	82.8	82.9
T-Bonds	15.0	-0.5	-10.0	-11.4	15.8	-0.7	-4.8	-5.0
T-Bills	50.0	1.2	-11.0	-7.8	5.0	0.0	-0.5	-0.4
Timberlands	0.0	0.0	0.0	0.0	10.0	0.2	-2.3	-2.2
Sum	100	100	100	100	100	100	100	100

Dynamic Asset Allocations

The dynamic efficient frontiers are constructed over a 10-year rolling window from 1987 to 2011. As the rolling portfolio is annually rebalanced, there are 16 efficient frontiers constructed in total. Figure 3 illustrates the dynamic asset allocations for a 2% target return with a 10-year rolling window over 1996 – 2011. Scenario 1 shows that large-cap stocks and small-cap stocks are allocated by the constraint conditions of 20% and 15%. The weight on timberland assets is more than 30% in most of the times except the time period around 2001. Scenario 2 is similar to the scenario 1 except that timberland assets are allocated to the maximum level of 10%.

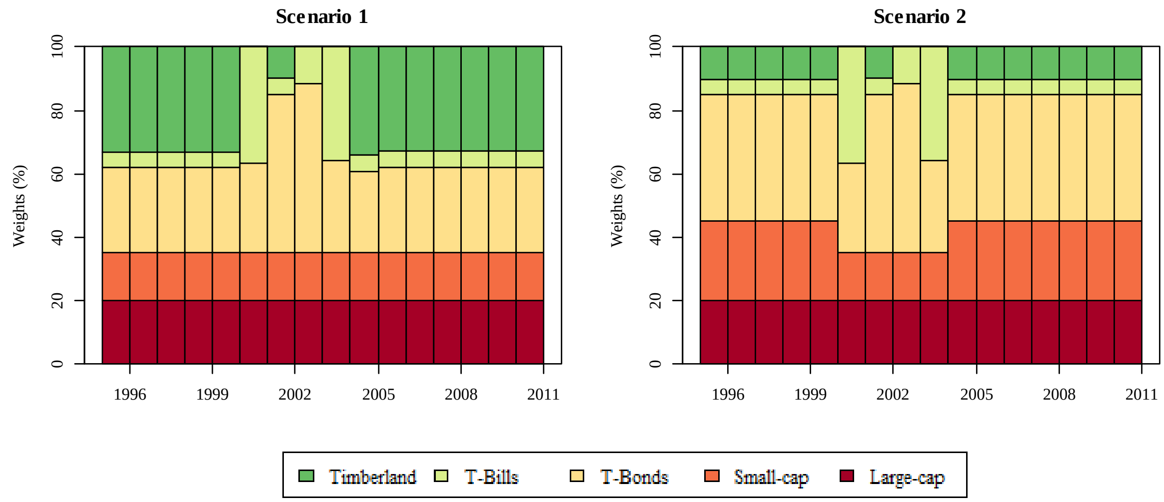

Figure 3 Dynamic 10-year Rolling Asset Allocations with a Target Return of 2%

Conclusions

Timberland assets have become a popular alternative investment for institutional investors in the United States since 1980s. This study employs the M-CVaR optimization approach to formulate asset allocation strategies and to examine the role of timberland assets in a mixed portfolio from the risk perspective. Both static and dynamic backtesting are used to assess the stability of asset allocations and the persistence of asset performance. Several conclusions are reached.

The choice of risk measures is an important decision for portfolio management. First, the commonly used standard deviation may not fully reflect the nature of risk. As investors are particularly concerned with the downside risk in reality, risk measures such as VaR and CVaR are more appropriate than SD. Second, asset allocations under a minimized downside risk framework provide optimal investment strategies for the downside risk averse investors. This is because the M-CVaR method fully reflects the tradeoff between downside risks and returns for investors. Furthermore, the risk decomposition helps us to identify risk sources and manager risks in a mixed portfolio. Overall, risk measures play an important role in portfolio construction and risk management.

Whether the M-V frontiers are efficient or not has been a debatable topic ever since asset returns exhibit non-normality such as skewness and kurtosis in reality. This study provides empirical evidence that the M-CVaR approach constructs more efficient frontiers than the M-V approach through adding timberland assets in a mixed portfolio. This is because the M-V approach underestimates the tail loss under the assumption of multivariate normal distribution. In contrast, the M-CVaR approach fairly captures the asymmetry and fat tail properties and selects asset returns with positive skewness and low kurtosis to reduce the portfolio risk. Thus, the M-CVaR method is more attractive since it not only incorporates the portfolio downside risk into optimization but also considers the non-normality of assets returns.

The asset allocations are conducted over both static and dynamic optimizations. If there is no restriction on timberland assets, both treasury bonds and timberland assets dominate in the portfolio because of their positive skewness. Moreover, timberland assets are preferred in the high level of target returns, indicating its ability to generate high returns. The 10-year rolling optimization offers consistent strategies with static allocations and reveals that the allocations were affected around 2001–2003. It was probably due to the weak performance of the NCREIF Timberland Index over that period of time (Mei and Clutter, 2010). Based on the backtesting, this study also provides some empirical evidence that stocks intensify a portfolio risk, whereas treasury bills, bonds, and timberland assets diversify a portfolio risk. Overall, timberland assets maintain a significant allocation in the mixed portfolio and behave as a persistent risk diversifier.

This study first introduces the M-CVaR approach to analyze the role of timberland assets in a mixed portfolio from the risk perspective. The methodology and findings provide practical implications for investors with different risk preferences and investment purposes. It should help institutional investors to better manage their portfolios and reduce the downside risk. Nevertheless, it should be noted that this ex post analysis does not necessarily guarantee future performance, especially in the current changing markets. Moreover, it may be not easy to frequently rebalance the portfolio from a practical perspective since timberland investment is a long term investment. However, investors can adjust their portfolios through the liquid financial assets such as stocks and bonds to rebalance their portfolios.

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Assessing and Comparing the Financial Performance of Timberland Investments in the United States

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ABSTRACT

Timberland investment is a good vehicle for portfolio diversification because of its relatively low correlations with other financial assets. To assess the financial performance of timberland investments in the United States, the capital asset pricing model (CAPM) and the arbitrage pricing theory (APT) are implemented using quarterly data 1987Q1-2010Q4. The CAPM analyses show that private-equity timberland investment outperforms the market but has lower systematic risk, whereas public-equity timberland investment performs similarly to the market. The APT analyses show that private-equity timberland investment has higher excess returns than public-equity timberland investment. Compared with the CAPM approach, a larger portion of the variations in timberland returns are explained by the APT approach because more causal factors are considered. In order to evaluate the performances of timberland assets over time, two sub-periods, 1987Q1-1999Q4 and 2000Q1-2010Q4 are studied separately. Both asset pricing models show that timberland assets have higher expected rates of return in the first sub-period than in the second sub-period. The difference may indicate improved efficiency of the US timberland market.

Keywords: Asset pricing, evaluation market efficiency, required rate of return

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Introduction

Timberland investment has attracted much attention because of its special financial performance. It is generally believed that timberland investment provides an opportunity for portfolio diversification because of its relatively low correlations with other financial assets and low level of financial risk (Redmond and Cubbage, 1988). Timberland investment is also commonly viewed as a good hedge against inflation (Washburn and Binkley, 1993). In the US, investments on timberland can be achieved by many means. For most of the institutional investors such as pension funds, university endowments, foundations and trusts, they invest through timberland investment management organizations (TIMOs). TIMOs find proper timberland investment properties for their investors and manage them to achieve adequate returns. Investment through TIMOs is regarded as private-equity timberland investment because the information is not open to public. On the other hand, buying stocks of publicly traded timber firms that manage timberland is treated as public-equity timberland investment. Private- and public-equity timberland investments have different financial performances due to different organizational structures (Mei and Clutter, 2010).

The history of the institutional ownership of timberland can be traced back to the mid-1970s, when the federal Employee Retirement Income Security Act (ERISA) as well as other similar legislations required pension plans, endowments and foundations to diversify their investments from traditional financial assets such as stocks and bonds. Direct ownership of timberland provided a diversification opportunity to institutional investors. At the same time, vertically integrated forest products companies with both large land holdings and processing facilities were undervalued by analysts on Wall Street. Some companies decided to reduce or restructure their ownership of timberland. Institutions and pension funds with large amounts of capital became buyers of the timberland (Binkley, et al., 1996). This substantial structure change in the timberland market had significant impacts on timberland investments.

Timberland assets have three return drivers: biological growth, timber price change, and land value appreciation (Caulfield, 1998). Among the three, biological growth dominates with a contribution of more than 50% to the total timberland investment returns. Moreover, timberland investment is a long-term investment. For a typical southern pine plantation, it takes 20-30 years for trees to mature. Given these unique features of timberland assets, in this research, two financial models, the capital asset pricing model (CAPM) and the arbitrage pricing theory (APT) are used to examine the financial performance of private- and public-equity timberland investments. Similar approaches have been used to analyze the relationship between risks and returns for agricultural assets (Arthur, et al., 1988) and to study the financial performance of forestry-related assets (Sun and Zhang, 2001). The data has been extended to 2010Q4 in order to study the effects of the recent turmoil in the world economy and the substantial structure changes in the timberland market. In addition, current and earlier performances of timberland investments are compared.

Methodologies

Capital Asset Pricing Model

Proposed by Sharpe (1964) and Lintner (1965), the CAPM is widely used in asset pricing because of its easiness to understand and implement. Built on Markowitz's portfolio theory (Markowitz, 1952), the CAPM assumes that the required rate of return of an asset is proportional to the covariance of its return with the market portfolio. The required rate of return is equal to the rate of return earned on a riskless asset plus a premium that depends on the asset's β_i and the expected risk premium on the market portfolio:

(1) $$E[R_i] = R_f + \beta_i (E[R_m] - R_f)$$

where $E[R_i]$ is the required return on asset i, R_f is the risk-free rate which is usually represented by the returns of short-term Treasury Bills, β_i is asset *i*'s systematic risk, and $E[R_m]$ is the expected return of the market portfolio. Jensen (1969) proved that the CAPM is consistent with the regression equation in excess return form:

(2) $$R_i - R_f = \alpha_i + \beta_i \left(R_m - R_f \right) + \mu_i$$

ex post realized returns R_i and R_m are used instead of ex ante expected returns $E[R_i]$ and $E[R_m]$. Intercept α_i is called Jenson's alpha. It signifies appreciation of an asset due to factors other than the overall market. A positive α suggests that an asset has a higher expected return than what the market would require for the asset in that risk class, and thus indicates a superior risk-adjusted return. The opposite is true if α is negative. Therefore, Jensen's alpha becomes a commonly used measure of abnormal performance. Parameter β_i measures the sensitivity of an asset's return with respect to the return of the market portfolio and therefore is an index of systematic or non-diversifiable risk (Babcock, 1972). If beta is greater than 1, the asset is more risky than the market. If beta is less than 1, the asset is less risky than the market.

Arbitrage Pricing Theory

The APT was developed by Ross (1976) and enhanced by others (Roll and Ross, 1980). It is based on the law of one price, which states that two otherwise identical assets should have the same price. It is gradually replacing the CAPM to price assets because of less restrictive assumptions it requires. Like the CAPM, the APT assumes that the asset return is linearly related to a set of industry- and market-wide factors. Asset returns are randomly generated by an *n*-factor model:

(3) $$E[R_i] = R_f + \beta_{i1}\lambda_1 + \beta_{i2}\lambda_2 + \ \dots \ + \beta_{in}\lambda_n,$$

where λ_n is the risk premium associated with factor *n*, and β_{in} is the sensitivity of asset *i* to factor *n*, which measures the relative sensitivity of an asset's return to a particular risk factor. In conjunction with the assumption of zero arbitrage profits, the sensitivity coefficient β_{in} is estimated from the market model:

(4) $$R_i = E[R_i] + \beta_{i1}\delta_1 + \beta_{i2}\delta_2 + \ldots + \beta_{in}\delta_n + e_i$$

where R_i is the actual rate of return on asset *i* in any given period, $E[R_i]$ is the expected return on asset *i*, δ_n is a common factor with a zero mean that influences the returns on all assets, and e_i is the error term.

The application of the APT can be achieved via the statistical factor model, with which common factors are derived from factor analysis. Factor analysis is a variable reduction technique that describes the variance relationships among many variables in terms of a few underlying, but unobservable, random quantities called factors. There are two common methods used for factor analysis to extract factors: principle component analysis (PCA) and maximum likelihood analysis (MLA). PCA is mathematically defined as an orthogonal linear transformation that transforms a large set of correlated variables into a smaller set of uncorrelated variables called principle components. The process is to project the greatest variance of the data on the first PC, the second greatest variance on the second PC, and so on. A principal component is a linear combination of weighted observed variables. Principal components are uncorrelated and orthogonal (Kim, 1978). PCA has comparatively fewer assumptions which make it standout among other methods. MLA is another method of deriving factors, which is based on the maximum likelihood function. It has the advantage of offering a chi-square test to find the optimal number of factors, which makes it popular. However, this method requires a strong assumption, assuming that data is normally jointly distributed. In reality, the returns of financial assets such as stocks and bonds are usually not normally distributed. They generally exhibit non-normality properties such as skewness and kurtosis (Sheikh and Qiao, 2010). In this study, factors are derived through PCA

PCA can be done by eigenvalue decomposition of a data covariance (or correlation) matrix. The initial factor pattern matrix is not unique. By some rotation methods, simpler factor structure and more meaningful and interpretable factors can be achieved. Orthogonal rotation is one of the most common ways and VARIMAX is a widely used orthogonal rotation. For VARIMAX, a simple structure means that each factor has a small number of large loadings and a large number of small or even zero loadings. This simplifies the interpretation because, after a VARIMAX rotation, each original variable tends to be associated with a small number of factors, and each factor represents only a small number of variables (Adbi, 2003)

Data

Quarterly returns from 1987Q1 to 2010Q4 are used to estimate the CAPM and the APT for private- and public-equity timberland investments. The returns of private-equity timberland investment are proxied by national- and regional-level of National Council of Real Estate Investment Fiduciaries (NCREIF) Timberland Index

(NTI). NTI, NTI-S, NTI-NE and NTI-PNW stands for the National, the South, the Northeast and the Pacific Northwest levels of NTI. PUBLIC stands for the returns of public-equity timberland investment which are proxied by a dynamic portfolio of the US public traded forestry firms that had or have been managing timberlands.

For the CAPM, the market returns are the value-weighted returns on all NYSE, AMEX, and NASDAQ stocks from the Center for Research in Security Prices (CRSP). The risk-free return is based on the one-month Treasury-Bill from Ibbotson Associates. They are available on Kenneth R. French website (French, 2012).

Fourteen price indices or investment portfolios are selected to derive factors for the APT. The first three assets are WOOD, PAPER and CHAIR which represent lumber and wood products, paper and allied products, and furniture and fixtures, respectively. Returns of the assets are obtained from Kenneth R. French website (French, 2012). The fourth to sixth returns are John Hancock Timber Indices which are provided by Hancock Timber Resource Group. They contain the US domestic timberland returns (JHTI-US), non-US timberland returns (NONUS) and global timberland returns (GLOBAL). Since they are timberland returns in different regions, they may have similar factors to influence the return generation process. The next three price indices are forestry-related assets. SSPA is the average price of southern pine pulpwood and sawtimber stumpage (Timber Mart-South). PNSPA is the average value of timber sold on national forests, the Pacific Northwest Region (Kling, 2008). And LUMBER stands for the Random Lengths Framing Lumber Composite Prices which is available online at the Random Length website. The stumpage prices are major sources of timberland returns, which is the reason to include them. The tenth portfolio is the long-term treasury bonds with maturity of 5-10 years (LT-BOND) which stands for the bond market. EXCHANGE is the broad dollar index which measures the value of the US Dollar relative to other world currencies. It is included because of the significant forest products trade between the US and other countries. The data is available on Broad of Governors of the Federal Reserve System website. The last three assets are three metals. Aluminum (ALUM) and steel (STEEL) are chosen because they are the substitutes of wood products. Gold (GOLD) is a good tool to hedge against unexpected inflation, which shares the similar characteristic as timberland investment does. The prices are obtained from the CRB commodity year book.

Empirical Results

Results for the CAPM

Equation (2) is applied to private- and public-equity timberland investments. Table 1 presents OLS estimation of the CAPM.

Table 1 Estimation of the CAPM using five timberland return proxies from 1987Q1 to 2010Q4

Asset	α	P-value	β	P-value	R^2
NTI	2.3075	<0.0001	-0.0042	0.9307	0.0005
NTI-S	1.5737	<0.0001	-0.0120	0.5931	0.0030
NTI-NE	0.9731	0.0534	0.0662	0.2269	0.0220
NTI-PNW	3.2742	<0.0001	0.0057	0.9465	0.0000
PUBLIC	0.5902	0.5210	0.9469	<0.0001	0.4753

Significant positive α's from the CAPM indicate that private-equity timberland investment has superior risk-adjusted excess returns. For the national level NTI, the excess return is 9.23% (2.31%×4) per year. The excess returns of the South, the Northeast and the Pacific Northwest regions are about 6.28%, 3.88% and 13.10% per year respectively. Market β's from the model are not significantly different from 0 but are significantly different from 1. The R^2s are close to 0. The results indicate that the private-equity timberland investment has lower risk level than the market and is weakly correlated with the market. Public-equity timberland investment performs differently. The abnormal performance is not significantly different from 0, and the sensitivity coefficient β is significantly different from 0 but not from 1 which demonstrates that it acts similarly to the overall market.

Results for the APT

Unlike the CAPM which includes only one risk factor, multi-factors are employed in the APT. This makes the estimation process more complex. In the first step, the 19 price indices and portfolios including the timberland assets to be studied are employed to determine the number of factors. There are several criteria for selecting the number of factors. Percentage of variance, which is related to the latent root criterion, is frequently used. Eigenvalues in Table 2 show the amount of variance explained by each factor. The cumulative variance shows that with 5 factors, more than 90 percent of total variation can be explained, which satisfies the common cut-off value of choosing factors.

Table 2. Eigenvalues of the covariance matrix

# of factors	Eigenvalue	Difference	Proportion	Cumulative
1	829.127	140.360	0.336	0.336
2	688.767	252.117	0.279	0.615
3	436.650	223.830	0.177	0.792
4	212.821	143.533	0.086	0.878
5	69.288	16.572	0.028	0.906
6	52.716	10.687	0.021	0.927
7	42.029	5.433	0.017	0.944
8	36.596	10.206	0.015	0.959
9	26.390	2.621	0.011	0.970
10	23.770	7.926	0.010	0.979
11	15.843	3.624	0.006	0.986
12	12.220	2.678	0.005	0.991
13	9.542	4.463	0.004	0.995
14	5.079	0.876	0.002	0.997
15	4.203	1.764	0.002	0.998
16	2.440	0.578	0.001	0.999
17	1.861	1.824	0.001	1.000
18	0.037	0.037	0.000	1.000
19	0.000		0.000	1.000

Asset	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
NTI	-9	50	2	-4	-5
NTI-S	-13	37	-1	-11	-8
NTI-NE	4	44	9	-4	-12
NTI-PNW	-3	50	5	9	0
PUBLIC	93	17	2	0	4
WOOD	89	-16	22	-1	3
PAPER	91	16	14	-8	-1
CHAIR	85	-35	19	9	6
JHTI-US	2	42	-5	4	6
NONUS	12	34	6	8	10
GLOBAL	5	44	-2	5	8
SSPA	11	26	16	0	2
PNSPA	-10	4	-2	99	-1
LUMBER	5	-48	37	12	9
EXCHANGE	-44	-25	-1	13	-14
LT-BOND	-29	7	-37	1	-8
ALUM	18	32	91	-5	17
STEEL	13	7	25	0	96
GOLD	6	47	1	-8	15

Table 3. Rotated factor loadings through principle component analysis
Note: All the values in the table are multiplied by 100

Estimation of factor loadings is followed. Factor loadings are correlation coefficients between variables and factors. Table 3 shows the rotated factor loadings for each factor. We can assign the meaning to each factor based on the pattern of the factor loadings. For example, ALUM and STEEL have significant large loadings on factors 3 and 5, which show great importance in interpreting the factors. This is reasonable because aluminum and steel are regarded as important substitutes of timber. They are important factors to influence the returns of timberland investments. Factor 1 is mainly loaded on assets PUBLIC, WOOD, CHAIR and PAPER. This means they are similar assets, and factor 1 can be interpreted as "forest products".

The next step is to estimate sensitivity (beta) coefficients of equation 4. Like the one in the CAPM, sensitivity coefficients in the APT provide information of the relationship between risk and return. While the APT is a multi-factor model, it has the potential to measure required returns more accurately.

Factor scores are used in the estimation of sensitivity coefficients. They are values of each factor in any given period. Factor scores are linear combinations of each variable weighted by their factor loadings in Table 3. Sensitivity coefficients are estimated using equation:

(5) $R_{it} = \alpha_{i0} + \mathrm{b}_{i1}\delta_{1t} + \ldots + \mathrm{b}_{i5}\delta_{5t} + \varepsilon_{it}$

where R_{it} is the actual return of asset *i*, δ_{jt} is the factor score calculated through factor loadings. The estimated sensitivity coefficients are presented in Table 4.

Table 4. Estimated sensitivity coefficients of the APT

Asset	β_1	β_2	β_3	β_4	β_5	R^2	Adj-R^2
NTI	-0.295	1.570	0.049	-0.130	-0.147	0.263	0.204
NTI-S	-0.444	1.286	-0.018	-0.383	-0.266	0.174	0.108
NTI-NE	0.170	1.813	0.365	-0.150	-0.483	0.216	0.153
NTI-PNW	-0.139	2.105	0.224	0.379	0.019	0.260	0.202
PUBLIC	11.182	2.023	0.186	0.010	0.530	0.890	0.882
WOOD	0.043	1.030	-0.123	0.087	0.149	0.184	0.119
PAPER	0.431	1.217	0.230	0.291	0.349	0.150	0.082
CHAIR	0.121	1.068	-0.052	0.127	0.189	0.203	0.140
JHTI-US	12.214	-2.154	3.057	-0.116	0.429	0.876	0.866
NONUS	10.766	1.866	1.617	-0.917	-0.158	0.876	0.866
GLOBAL	12.216	-5.067	2.753	1.238	0.802	0.895	0.887
SSPA	0.645	1.538	0.926	-0.016	0.131	0.103	0.032
PNSPA	-2.802	1.029	-0.411	27.182	-0.209	1.000	1.000
LUMBER	0.299	-3.096	2.356	0.780	0.551	0.394	0.346
EXCHANGE	-1.075	-0.598	-0.031	0.309	-0.343	0.291	0.235
LT-BOND	-0.857	0.202	-1.099	0.022	-0.250	0.227	0.165
ALUM	3.195	5.699	16.294	-0.886	3.002	0.998	0.998
STEEL	2.932	1.649	5.540	-0.094	21.336	1.000	1.000
GOLD	0.392	2.916	0.040	-0.477	0.901	0.255	0.196

All assets are sensitive to at least one factor and as many as four. ALUM and STEEL show largest sensitivities to factors 3 and 5. This is consistent with the result of factor loadings for each factor in Table 3. Both private- and public-equity timberland investments show that factor2 has dominant effect on these assets.

The last step is the calculation of risk premium with each risk factor. It is calculated as the average value of the risk premiums from cross-sectional regressions of asset returns on sensitivity coefficients:

(6) $$R_{it} = \lambda_{0t} + \beta_{i1}\lambda_{1t} + \beta_{i2}\lambda_{2t} + \ \ldots\ + \beta_{in}\lambda_{nt} + \eta_{it}\,, \quad \lambda_i = \sum_{t=0}^{T} \lambda_{it} / T$$

where λ_{0t} is the intercept in quarter *t*, λ_{nt} is the estimated risk premium for factor *n* in quarter *t*, β_{in} is the sensitivity coefficient for asset *i* to factor *n*, and η_{it} is the error for asset *i* in quarter *t*. The mean values of risk premiums are:

$\lambda_0 = 1.9605$, $\lambda_1 = 0.1245$, $\lambda_2 = 0.1040$, $\lambda_3 = -0.0407$, $\lambda_4 = 0.0523$, $\lambda_5 = 0.0547$ with the sensitivity coefficients for each asset from step 3 and risk premiums, the required return $E(R_i)$ for each asset can be calculated using equation (7)

(7) $$E(R_i) = 1.9605 + 0.1245\beta_{i1} + 0.1040\beta_{i2} - 0.0407\beta_{i3} + 0.0523\beta_{i4} + 0.0547\beta_{i5}$$

Comparisons of the CAPM and the APT

The required returns of private- and public-equity timberland investments from 1987Q1 to 2010Q4 are compared using both the CAPM and the APT model. Equation (1) and (3) are used to estimate the required returns. Table 5 shows the result of the comparisons.

Table 5. Annual historical and required returns: the APT vs. the CAPM

Asset	Historical annual rate of return	Required annual rate of return		Excess return percentage	
		CAPM	APT	CAPM	APT
	I	II	III	(I-II)/II	(I-III)/III
NTI	13.18	3.95	8.28	234	59
NTI-S	10.14	3.94	8.02	157	26
NTI-NE	7.63	4.18	8.48	82	-10
NTI-PNW	17.11	4.00	8.70	327	96
PUBLIC	12.95	10.59	14.34	22	-9

Several results can be obtained from the comparisons of the required rates of return. First, private-equity timberland investment has lower required return than public-equity timberland investment. This indicates that private-equity timberland investment bears lower risk. Moreover, except for the Northeast region, all regions obtain positive excess returns under both the CAPM and the APT. Third, under the APT, the required rates of return are higher than under the CAPM. This suggests a higher requirement the APT has. With more risk factors considered, the APT bears more risk, which leads to higher required returns.

In addition, the APT explains the risk return tradeoff better than the CAPM. The CAPM has weak ability to explain the relationship between risk and return which is shown by the small adjusted R^2s, especially for private-equity timberland assets. With more risk factors included, the APT gains more explanatory power. Meanwhile, at least one of the sensitivity coefficients is significant at the 10% level for the APT. However, for the CAPM, the sensitivity coefficients are not significant for any of the private-equity timberland assets. All the comparison results suggest that the APT provides more accurate and reasonable results than the CAPM does.

In the most recent decade, substantial structure changes in the timberland market as well as turmoil in the traditional financial market have happened. For example, Plum Creek converted itself into timber REITs in 1998, Rayonier, Potlatch, and Weyerhaeuser did so in 2003, 2005 and 2007 (Mendell, 2008). In order to study these effects on timberland investment, financial performances in the early period and the recent period are compared. Because of better explanatory power, only the APT model is used in this step. The whole period is divided into two sub-periods: 1987Q1-1999Q4 and 2000Q1-2010Q4. The performance of timberland assets in each period is examined using the APT followed by the previous steps. The annual historical returns and required returns are compared.

Table 6. Comparison of the annual historical and required returns between 1987-1999 and 2000-2010 using the APT

Asset	Historical annual rate of return		Required annual rate of return		Excess return percentage	
	87-99	00-10	87-99	00-10	87-99	00-10
NTI	18.74	6.61	10.66	4.70	76	41
NTI-S	13.38	6.31	11.21	4.69	19	35
NTI-NE	14.63	3.82	10.60	4.59	38	-17
NTI-PNW	24.98	7.81	9.81	4.77	155	64
PUBLIC	16.00	9.34	14.99	12.67	7	-26

In the light of the comparisons between the two sub-periods, it is important to notice the obvious declines of the required returns for the private-equity timberland investment. The declines are more dramatic from the first period to the second than the returns for public-equity timberland investment. By contrast, the change of the required returns for public-equity timberland investment is not significant. It can be explained by the fact that, this investment is publicly traded and are more exposed to the market. Their performance should be similar to the financial market and will not be affected much by the changes of the timberland market.

Discussions and Conclusions

This study evaluates the financial performance of private- and public-equity timberland investments using the CAPM and the APT. Under the framework of the CAPM, private-equity timberland investment outperforms the overall market. Moreover, implied by insignificant betas and small R^2s, private-equity timberland investment is less risky and weakly correlated with the market. This provides private-equity timberland investment a good opportunity for portfolio diversification. By contrast, public-equity timberland investment performs similarly to the market. The APT produces similar but more robust results. In the study, five risk factors are used to estimate the required rates of return. Both the beta significance and result of goodness of fit test are improved using the APT.

The historical and required returns of private- and public-equity timberland investments during 1987Q1-2010Q4 are compared under the CAPM and the APT. Both models show that private-equity timberland investment has positive excess returns. This superior performance suggests private-equity timberland investment to be a good investment for investors.

Moreover, the comparison results for timberland assets between each sub-period show that higher historical and required returns are obtained during the first period. It is due to the inefficiency and lack of regulations in the early period. During that time, prices did not fully reflect the risk of investments. Uncommonly high profits were obtained during that time. However, as more investors get involved, the timberland market becomes more competitive which causes the decline of the required returns in the most recent 10 years. Meanwhile, with global financial crisis happened during the second period, historical returns decline dramatically and causes much lower excess returns.

It should be noted that the results should be carefully interpreted. First, all the coefficients estimated using the CAPM and the APT in the study are constants. However, in the real world, assets' rates of return change overtime and the values of those coefficients should also be time-varying. Moreover, for the APT, there is no clear criterion about choosing factors. The factors used in the study are from common sense and not from theory. Further study will focus on exploring more assets to derive factors.

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Applied Ecosystem Services in Working Forests: A Direct Market Valuation

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ABSTRACT

Ecosystem services, or the benefits humans obtain from natural ecosystems, have long been recognized as critical to human health. A number of scientists and managers have estimated the non-market values of these services but few have offered a direct market valuation. Increasing awareness, scarcity, and regulation have fostered transactions, and markets are emerging that can allow for direct valuation and could provide landowners the opportunity to merchandize this natural capital. This paper provides a valuation and comparison, as a case study, of a traditional management scheme, including the marketing of fiber and recreational leases, and an ecosystem services management scheme including the marketing of fiber, recreational leases, carbon sequestration, watershed services, and biodiversity. The traditional forest management scheme provided an estimated present value at three pricing scenarios ranging from "pessimistic" at $538,714.63 to "optimistic" at $868,528.27 for the 3,976-acre project area. The ecosystem services management scheme produced an estimated present value at three pricing scenarios ranging from "pessimistic" at $621,508.61 to "optimistic" at $1,363,628.13 for the same project area. As a result, an ecosystem services management scheme, even in these early stages of ecosystem markets, may offer more revenue to landowners than a traditional management scheme.

UNEVEN-AGED MANAGEMENT, ECONOMICS, TREE DIVERSITY, AND THE SUPPLY OF CARBON STORAGE

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ABSTRACT

This study sought optimal, sustainable, multi-objective management of uneven-aged Norway spruce-dominated stands. The two main criteria were financial returns and CO_2 storage, supplemented by diversity of tree size and species. At prevailing timber prices, costs, and interest rates, uneven-aged management was profitable. Without CO_2 constraint the net present value in steady state was about 5,000 Euros ha^{-1} with a 5 year cutting cycle. Lengthening the cutting cycle to 20 years decreased the NPV by 10%, but raised the carbon storage by 21%, the tree species diversity by 32%, and the tree size diversity by 24%. Seeking maximum CO_2 storage called for practically no harvest, led to an almost pure spruce stand, and reduced the NPV by approximately 22,000 Euros ha^{-1}. A compromise policy maximized CO_2 storage, while maintaining a rate of return on the capital of standing trees equal to the private or social interest rate. A derived supply curve for CO2 storage shows how much forest owners would be willing to store at various CO2 prices. Up to 200 Mg ha^{-1} of CO2 storage could be induced at zero price and the supply increased almost linearly up to 500 Mg ha^{-1} at a price of 50 Euros Mg^{-1}.

A full version of this paper is forthcoming in the Scandinavian Journal of Forest Research.

AN EVALUATION OF LOBLOLLY PINE MANAGEMENT REGIMES UNDER CARBON CREDITS

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ABSTRACT

Natural even-aged, natural uneven-aged, and plantation loblolly pine stands of Arkansas were evaluated for the economic returns from timber and CO_2 sequestration. The intensive pine plantation stand sequestered most rapidly at a rate of 14.00 Mg/ha/yr in a 25-year rotation followed by natural even-aged stand with an average of 8.00 Mg/ha/yr in a 52-year rotation. The natural uneven-aged stands sequestered 0.75 Mg/ha/yr over a 30 year period and -2.21 Mg/ha/yr in a 43 year period. When comparing all the management regimes under different CO_2 prices and interest rates, intensive plantation is most favored by a carbon contract. In an intensive pine plantation, a 20-year carbon contract that starts early in the rotation accrued highest NPV of $580 with a CO_2 price of $4/Mg and at 6% interest rate. The NPV of CO_2 increased to $632 when credit from long lived wood product (LLWP) was added to the contract. The lowest carbon revenue (-$234) was observed in intensive plantation again with the same CO_2 price interest due to final harvest and carbon buyback program. Timber returns from the uneven-aged stands had highest average SEV of $1,498/ha followed by plantation's SEV $1,495/ha in an average. The average SEV of natural even-aged stands was $1,070/ha. Longer contract with early enrollment were favored with minimal thinnings or cutting cycles. Generally, there were more choices in plantation pine to enter in a carbon contract followed by natural even-aged regime. Uneven-aged regime had least choices to enter in a carbon contract in carbon payment scheme.

The Forest Agent-Based Landowner Economy (FABLE)

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SUMMARY

Surveys of forest landowners reveal heterogeneity in the goals and motivations behind owning forest land. Interests range from a desire to sell timber to a plethora of activities associated with the amenities a forest provides. In addition to forest landowners having different goals, the stands that forest landowners own have heterogeneous characteristics. Underlying heterogeneity no doubt has an impact on the structure of timber markets, yet traditional methods are not well-suited toward making the connection. For example, an econometric approach is consistent with economic theory but tends to average out and hence diminish heterogeneity. Engineering-style models are good for aggregating land characteristics, but tend to ignore decision-making. Probit models are capable of aggregating a sample's heterogeneity, but may not represent a market process. As a result, forest economics has not made a clear connection between its observations on individual behavior and market behavior. This work seeks to demonstrate the market implications of aggregating forest landowner behavior using an agent-based model.

An agent-based model (ABM) is a computational method. ABM models in general are capable of modeling interactions between agents and their environment and interactions among agents. In dynamic models, agents are in effect capable of learning by updating the information set which informs their actions. The possibilities are limited by behavioral assumptions. The ABM approach is especially appropriate when an analytical solution to a problem is not readily available. In the context of aggregating forest landowner decisions, two factors make an analytical result difficult—(1) agents use different decision rules at the stand level, and (2) stand growth is nonlinear. The present model makes restrictive assumptions consistent with the economics and forestry literature. The first principle in model development is the aggregation mechanism. Aggregation occurs through a first-price sealed bid auction. By design, every agent submits a truthful bid based on their opportunity cost. Each agent calculates its opportunity cost based on discounted expected future revenue. This opportunity cost serves as a reservation price. If the market it not willing to meet the reservation price, the agent postpones harvest. There are no costs in the model.

There are two types of agents. One type of agent only values timber revenue. These agents are labeled "reservation price Faustmann" agents. The other type of agent values timber revenue but also places value on a standing forest in proportion to stand

age. These agents are labeled "reservation price Hartman." Each agent is assigned their own discount rate uniformly distributed from 3% to 8%. Stand ages are assigned to each agent from an initial distribution. Each agent projects future stand volume for the next 50 years using a deterministic forest growth model. They multiply volume in each future year by last year's price and then discount each value. The maximum of these values is divided by present stand volume to obtain their reservation price.

The model operates over discrete one year time steps and uses exogenous demand scenarios with an assumed demand elasticity of 0.5. Agents are ranked by reservation price from least to greatest. Starting with the agent having the lowest reservation price, agents harvest their stands until quantity demanded is met. The market clears at the lowest reservation price that meets this market clearing condition. The resulting price becomes the price that agents use in the next period for new reservation price calculations. The model outputs include price, removals, inventory, average harvest age and supply elasticity. The presented results represent a mix of Faustmann and Hartman landowners. FABLE demonstrates that the share of market participants using a given decision rule has an impact on the aggregate market dynamics. FABLE also endogenously produces a novel price bubble effect. The price bubble result is consistent with a market equilibrium occurring on the backward-bending portion of the industry supply curve.

A full description is available at:
http://repository.lib.ncsu.edu/ir/bitstream/1840.16/6770/1/etd.pdf

EVALUATING THE INFLUENCE OF PRIMARY MILL DEMAND ON HARVEST AND REGENERATION EFFORTS BY NON-INDUSTRIAL PRIVATE FORESTLAND OWNERS IN SOUTH CAROLINA

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ABSTRACT

As holders of a large portion of the timberland and providers of the majority of the timber harvest in the South, non-industrial forestland owners (NIPF) harvest and regeneration choices can significantly impact forest sustainability in the region. The following study uses a bivariate probit model to examine NIPF owners' harvest and regeneration response to roundwood demand from primary mills. The analysis uses forest inventory and primary mill surveys data from the USDA Forest Service Forest Inventory and Analysis Program for South Carolina, from 1999 to 2006. The approach allows joint estimation of the regeneration and harvest choices, to assess the probability of regeneration on harvested stands. Results show a weak response to mill demand, particularly for the regeneration efforts. The results suggest the need for tools other than timber markets to ensure continued NIPF regeneration efforts on their forestlands.

Global Timber Investments and Trends, 2005-2011

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ABSTRACT

We estimated financial returns in 2005, 2008, and 2011 for a range of global timber plantation species and countries. Excluding land costs, returns for exotic plantations in almost all of South America—Brazil, Argentina, Uruguay, Chile, Colombia, Venezuela, and Paraguay—were substantial. *Eucalyptus* species returns were generally greater than those for *Pinus* species in each country, with most having Internal Rates of Return (IRRs) of 20% per year or more, as did teak. The IRRs for *Pinus* species in South America were generally closer to 15%, except in Argentina, where they were 20%. IRRs were less, but still attractive for plantations of coniferous or deciduous species in China, South Africa, New Zealand, Australia, Mexico, and the United States, ranging from 7% to 12%. Land costs and environmental regulations reduced the plantation investment returns for all countries, but usually decreased returns most in Latin America, although their net returns remained greater than for plantations in temperate forests.

Trend analyses indicated that Brazil had the greatest increase in timber investment returns during the period examined; returns in other southern hemisphere countries remained fairly stable; and the U.S. South had substantial decreases in returns. New Zealand, Australia, the United States, Chile, and Mexico had the best rankings regarding risk from political, commercial, or government actions and for the ease of doing business. Conversely, Venezuela, Indonesia, Colombia, and Argentina had high risk ratings, and Brazil and Venezuela were ranked as more difficult countries for ease of business. Recent government actions in several countries in South America, except Colombia, have discouraged foreign investments in agricultural land, which has adversely affected forestry as well. Past investors appear to making excellent returns now based on cheap land costs decades ago; new investments in most countries and plantation species will have smaller rates of return, but still compare favorably with other asset classes.

Key words: timber investments, benchmarking, global, trends

Introduction

For almost a decade we have performed research analyzing the returns to timber investments in selected countries around the world, expanding from plantation and natural forests in the Americas to various other key countries with substantial areas of forest plantations. This research serves as a "benchmarking" exercise that helps identify comparative advantages among countries for timber investment returns, as well as other institutional, forestry, and policy factors that affect investments.

This proceedings paper provides an update of that ongoing research, including results on timber investment returns, risk, and policy factors as of 2011. It focuses on a few key tables and outcomes, which can be brief enough to fit in this format.

The objectives of this project have been to: (1) estimate comparative timber investment returns, not including land costs, for important forest species and countries throughout the world; (2) synthesize quantifiable literature on risks among those countries; (3) estimate the effects of land costs, environmental regulations and forest productivity on the base returns estimated in objective 1; and (4) examine the trends in these forest and plantation returns over time.

Methods

Per the objectives, the co-authors have cooperated in identifying the most important forest species in their countries and collecting forest productivity and cost data to estimate returns to timber investments. The effort over the last eight years has focused largely on estimating returns for forest plantations, but selected examples of investment returns to native species in natural stands or in plantations also have been collected for comparison, or for cases where they are a substantial part of domestic production.

We have estimated productivities based on using a common Mean Annual Increment (MAI) for growth rates based on typical or representative stands for each species in the relevant region of the country. Then we estimated typical costs for establishment, stand management, administration, or other factors for each species/region. Similarly, relevant information on timber prices by product size was gathered from available literature or personal contacts with colleagues in the timber sector. These data were then used to calculate timber investment returns for forest landowners based on growing timber for typical rotations and selling stumpage. Common discounted cash flow analyses and capital budgeting criteria, including net present value (NPV), land expectation value (LEV), and internal rate of return (IRR), such as described in Wagner (2012) for reference, were used for measuring timber investment returns.

The data collection and entry was standardized by use of a common spreadsheet with appropriate cells for each researcher to fill in with information for their species/country. The spreadsheet was a template with cells for species, country, management costs, timber productivity, and timber returns, which it then used to calculate various capital budgeting criteria. The template is available on request from the lead author, and its approach and capital budgeting formulas are described (in Spanish) by Cubbage et al. (2011). A similar English version publication is pending and should be available on request as well in 2012. Several researchers adapted the template to work best in their situation, such as modifying timber prices from a stumpage basis to a mill basis; adding more product classes; or adding more analyses of land or other factors.

In a few cases, several researchers worked in the same country, although not always with the same species. Where more than one individual was familiar with a species, a synthesis of data and inputs was used and reviewed by the relevant researchers for that country. In addition, all the spreadsheets and calculations were reviewed by the lead author and any anomalies were noted and verified or rectified through an iterative process with lead researchers in each country.

Subsequent analyses of the effects of land, regulations, and productivity were performed after the base results were established for each country, based on just a few key countries to date. Data on macroeconomic, institutional, forestry, or policy factors were collected from available sources. Then the final tables of inputs, costs, yields, and investment returns were assembled and reviewed by all the co-authors, and any suggestion or corrections made to settle on the final results for each year that this benchmarking exercise was performed—2005, 2008, and 2011.

Last, simple summaries and conclusions about the trends in these returns were made. This trend analysis includes an overview of the economic factors in each country and the timber investment returns. However, despite having investment return data for many countries and years, a statistical cross sectional/time series/panel data analysis was not possible, or at least not wise. The benchmarking data are still too different among years and countries for sound statistical analysis, and there are missing countries and species in each year.

Results

Table 1 summarizes the key inputs and outcomes for the analysis of the 2011 timber investment management regimes and capital budgeting returns. Table 2 summarizes the trends in LEV and IRR for some the key countries. Table 3 summarizes the sensitivity analysis of these returns for the effects of land prices, productivity rates, and environmental regulations for the key countries in the Southern Cone of South America and for the United States. Table 4 summarizes some selected risk estimates as of 2011 for most of the countries analyzed. In total, these provide a wealth of information about timber investment returns over the last seven years.

The results indicate that excluding land costs, returns for exotic plantations in almost all of South America—Brazil, Argentina, Uruguay, Chile, Colombia, Venezuela, and Paraguay—were substantial. *Eucalyptus* species returns were generally greater than those for *Pinus* species in each country, with most having Internal Rates of Return (IRRs) of 20% per year or more, as did teak. *Pinus* species in South America were generally closer to 15%, except in Argentina, where they were 20%. IRRs were less, but still attractive for plantations of coniferous or deciduous species in China, South Africa, New Zealand, Australia, Mexico, Indonesia, and the United States, ranging from 7% to 12%.

Table 1. Plantation Investment Analysis Summary for Selected Species and Countries, 2011

		Rotation	MAI	Establishment Costs ($/Ha)			Land Cost	Prices per M3 ($) (at small end diameter)				Capital Budgeting Criteria		
Country	Species	Age (yrs)	m3/ha/yr	Site Prep	Planting	Tot Yr 0-5	($/Ha)	Biomass	Pulpwood	Medium	Large	NPV	LEV	IRR
								(~5 cm)	(~15 cm)	(~25 cm)	(~30 cm)	($/Ha@8%)		
Argentina	Pinus taeda - Misiones	18	25	210	580	1235	2000	2	5.6	20	30	1164	1552	12.5
Argentina	Eucalyptus grandis - Corrientes	12	40	131	424	917	2500		5	13	32.5	2750	4560	19.6
Australia	Pinus (sawlog)	28	25	250	500	1890	2000		15	35	85	-660	-746	6.7
Australia	Eucalyptus (pulpwood)	15	25	250	500	1290	2000		25			1110	1621	12.2
Australia	Eucalyptus (sawlog / veneer)	25	25	250	500	3390	2000		25	35	85	644	754	9.1
Brazil	Pinus taeda pulpwood/sawtbr	15	30	170	330	900	4500		18	26.32	49	4662	6809	23.2
Brazil	Pinus taeda sawtimber	25	25	170	330	1000	4500		18	26	49	4127	4833	19.2
Brazil	Eucalyptus urophylla pulpwod	6	40	326	472	1553	6000		26.52			2346	6344	26.6
Brazil	Eucalyptus grandis sawtimber	16	40	326	472	1614	3000	17.54	24.9	49	49	7712	10891	27.9
Chile	Pinus radiata sawtimber	22	30	340	230	915	2500	5	16	32	50	1764	2161	14.7
Chile	Pinus radiata pulpwood	16	20	190	215	675	1300	5	17			680	960	12.6
Chile	Eucalyptus globulus pulpwood	16	25	420	314	1074	2500	5	30			1804	2548	14.7
Chile	Eucalyptus nitens pulpwood	14	30	420	306	1066	2500	5	21.7			1382	2094	14.4
China	Pinus massoniana	21	10.5	310	157	1047	40		70	80	90	1090	1360	11.5
China	Eucalyptus	7	30	608	260	200	100		100	110	120	6723	16142	33.6
Colombia	Eucalyptus grandis	20	25	438	1382	3365	2000		19.1	82.1	76.6	2081	2649	10.9
Colombia	Pinus tecunumanii	20	25	438	1382	3611	2000		20.8	108.3	40.8	3936	5479	13.6
Colombia	Pinus maximinoi	20	24	290	1382	3343	2000		20.8	108.3	49.2	3710	4276	13.3
Colombia	Pinus patula	20	18	290	1382	3343	2000		20.8	134.6	77	-200	369	7.7
Costa Rica	Gmelina arborea	12	31	300	550	2375	5000			30	60	4324	5818	24.5
Ecuador	Balsa	5	40	384	677	2663	na			15	25	303	949	10.8
Ecuador	Pinus radiata	20	20	248	1196	1720	na		15.7	17.6	28.7	708	901	10.0
Indonesia	Tectona grandis	60	6	80	103	416	na	333	556	889	1111	1833	1851	11.2
Mexico	Pinus gregii	20	15	245	221	850	1250	10	12.5	37	58	1679	2137	13.2
Mexico	Eucalyptus grandis	8	30	185	207	730	1250	15	15	15		902	1962	18.4
New Zealand	Pinus radiata, no pruning	28	24	356	490	1506	2000	10	42	42	65	-20.5	-23.19	7.98
New Zealand	Pinus radiata, with pruning	28	22	356	495	1951	2000	10	40	40	60	-1415	-1601	6.6
Paraguay	Eucalyptus sp. clones	14	30	88	617	1551		9	13	19	30	1683	2552	14.2
Paraguay	Eucalyptus sp. seedlings	14	26	88	397	1084		9	13	19	30	1288	1952	14.2
Uruguay	Eucalyptus globulus	9	22	300	350	990	2500		25			1281	2563	17.9
Uruguay	Eucalyptus grandis pulp	10	28	190	340		2500		14			975	1816	17.7
Uruguay	Pinus taeda	22	18	246	316		3000	4		23	39	999	1224	13.7
Uruguay	Eucalyptus grandis sawtimber	16	25	220	350		3000	5	10	20	30	1746	2465	14.5
USA	Pinus taeda South/Low Intensity	25	10	803	332	1135	3000	3	10	16	27	-650	-761	5.3
USA	Pinus taeda South/High Intensity	25	12.75	803	332	1345	3000	3	10	16	27	-720	-843	5.4
USA	Psuedotsuga menziesii Site II	40	13	185	716	1236	1500			51.2	58.53	-592	-621	6.7
USA	Psuedotsuga menziesii Site I	40	17	185	716	1236	2100			51.2	58.53	-201	-211	7.7
Venezuela	Pinus caribaea	12	18	156	1983	3302	1000		47			189	314	8.47
Venezuela	Eucalyptus urophylla	7	25	156	2066	3350	1000		42			560	1343	10.4

Investment Returns, 2011

We had the most information for our countries in 2011, as the set of cooperators in different countries expanded over time. In that year, all of the species in Latin America had positive LEVs at the 8% discount rate. The LEVs in Australia and New Zealand were positive for *Eucalyptus* sp. and slightly negative for *Pinus* sp., indicating they had IRRs slightly less than 8%. The U.S. had the lowest LEVs—all were negative—and IRRs of about 5.3% to 7.7%.

These base investment returns in 2011, excluding land costs, favor countries in South America, which have fast growth rates and reasonable timber prices. Other developing countries and the Asia-Pacific region had lower rates of return, but still attractive, based on the still prospering economy in Asia. North America, especially the U.S. South, had the lowest calculated rates of return due to modest growth rates and low timber prices.

Table 2. Trends in Plantation Investment Returns for Selected Species and Countries, 2005-2011

Country	Species	MAI	Land Expectation Value (LEV)			Internal Rate of Return (IRR)		
		m3/ha/yr	2005	2008	2011	2005	2008	2011
			- - - - $/Ha@8% - - - -			- - - - - - - % - - - - - - -		
Argentina	Pinus taeda - Misiones	20-30	1462	3202	1552	12.9	20.0	12.5
Argentina	Eucalyptus grandis - Corrientes	35-40	1241	3178	4560	13.8	18.2	19.6
Australia	Pinus sawlog	25			-746			6.7
Australia	Eucalyptus pulpwood	25			1621			12.2
Australia	Eucalyptus sawlog / veneer	25			754			9.1
Brazil	Pinus taeda pulpwood/sawtbr	30	2495	5242	6809	16.0	20.8	23.2
Brazil	Pinus taeda sawtimber	25			4833			19.2
Brazil	Eucalyptus sp. pulpwood	40	5427		6344	22.7		26.6
Brazil	Eucalyptus grandis sawtmbr	40		8311	10891	25.5		27.9
Chile	Pinus radiata sawtimber	22-30	3345	2782	2161	16.9	15.6	14.7
Chile	Pinus radiata pulp	20		894	960		13.1	12.6
Chile	Eucalyptus nitens pulp	30			2094			14.4
China	Pinus massoniana	9.5-10.5		92	1360		12.1	11.5
China	Eucalyptus	30			16142			33.6
Colombia	Eucalyptus grandis	25-30		5380	2649		16.6	10.9
Colombia	Pinus tecunumanii	25-31		5353	5479		15.5	13.6
Colombia	Pinus maximinoi	24-25		4125	4276		14.7	13.3
Colombia	Pinus patula	18-19		1594	369		11.2	7.7
Costa Rica	Gmelina arborea	31			5818			24.5
Ecuador	Balsa	40			949			10.8
	Pinus radiata	20			901			10.0
Mexico	Pinus gregii	15			2137			13.2
Mexico	Eucalyptus grandis	30			1962			18.4
New Zealand	P radiata, no pruning	24			-23.19			8.0
New Zealand	P radiata, w/ pruning	17-22		-230	-1601		7.6	6.6
Paraguay	Eucalyptus sp. clones	30			2552			14.2
Paraguay	Eucalyptus sp. seedlings	26		4233	1952		21.4	14.2
Paraguay	Pinus taeda	32		1648			12.0	
South Africa	Pinus patula	14		1862			11.1	
South Africa	Eucalyptus grandis	32		2872			12.4	
Uruguay	Eucalyptus globulus	18-22	593	2358	2563	12.8	22.9	17.9
Uruguay	Pinus taeda sawtimber	18-20	2003	1048	1224	15.1	12.8	13.7
Uruguay	Eucalyptus grandis sawtimber	25-30	4081	1389	2465	21.9	13.9	14.5
USA	Pinus taeda South / Low Intens.	10-12	408	-324	-761	9.5	6.9	5.3
USA	Pinus taeda South / High Intens.	12.75-15		171	-843		8.5	5.4
USA	Psuedotsuga menziesii Site II	13-14		-779	-621		6.5	6.9
USA	Psuedotsuga menziesii Site I	17-18		-29	-211		8.0	7.7
Venezuela	Pinus caribaea	18		2504	314		15.0	8.5
Venezuela	Eucalyptus urophylla	25		2905	1343		22.4	10.4
Venezuela	Gmelina arborea	25		1439	-352		18.8	7.2
Venezuela	Tectona grandis	25		9800			21.2	

Trends in Investment Returns

The trends in investment returns during the period from 2005 to 2011 varied unpredictably by country. The LEVs and IRRs in Brazil increased consistently throughout the period, which seems to mirror the large domestic and export demands, and the rapidly expanding Brazilian forest products sector. Argentina returns increased from 2005, and peaked in 2008. IRRs in Chile decreased slightly during the period, probably reflecting the depressed world economy where they export most of their product. This also was true in Colombia, although maybe for less clear reasons. Venezuela investment returns seemed to be less in 2011, but the estimates were difficult to make due to high inflation and large fluctuations in exchange rate, so not much can be concluded from their three year trend.

The Uruguayan market is almost entirely dependent on exports, which probably caused the decreased returns from 2005 to 2011. New Zealand and China also had slightly lower IRRs in 2011 than 2008. The U.S. South had the worst trends in timber investment returns based on current costs and stumpage prices, with significant decreases from 2005 to 2011. This obviously reflects the poor timber markets that have reached modern low price levels during the U.S. economic recession and enduring housing slump. The U.S. Pacific Northwest actually had stable investment returns, perhaps due to better sawtimber prices, beginning with exports to China in 2011.

Effects of Land Prices, Environmental Protection, and Higher Productivity

Table 3 summarizes the results of the analyses of the effects of land prices, environmental protection, and higher productivity and timber prices. Each of these variables were analyzed at the typical land purchase price and environmental reserve requirements, or likely increases in timber growth rates. The directional effects of these factors are obvious. Greater land costs and environmental protection requirements for land set asides or buffers reduce investment returns; higher productivity and price increase returns. The magnitude of these effects differs by country and by each factor, however, which is the key to net returns.

With the addition of land costs alone, the IRRs for the key species in the Southern Cone countries of Argentina, Brazil, and Uruguay approach 8% rather than the high teens. Brazil has rates that just exceed 8% at about 8.2%; Argentina and Uruguay had returns of 7.8% and 7.3%, respectively. The addition of land costs dropped the U.S. Pacific Northwest returns to 5.7%, and the U.S. South returns to 2.6%. As an interesting validation note, a recent independent timberland investment analysis by a U.S forest consultant (Thomas 2012) calculated a very close 2.8% IRR for southern timber investments, and he made the same $2500 per hectare land cost assumption.

Table 3. Plantation Investment Sensitivity Analysis Summary for Selected Species and Countries, 2011

Country	Species	Rotation Age (Yr)	Land Cost ($/ha)	Available Land (%)	Capital Budgeting Criteria NPV	AEV	IRR
					($/Ha@8%)		(%)
Argentina	Pinus taeda - Misiones						
	Base	18	0	100	1211	129	12.6
	Base with Land Costs		2000	100	-85	-9	7.8
	Environmental Protection		0	65	418	45	10.3
	Land and Environmental Protection		2000	65	-1081	-115	5.2
	High Yield, High Price 25% more		0	100	3989	426	18.3
	Hi Yield, Price, Land, Environment Protection		2000	65	-631	-67	6.5
Brazil	Pinus taeda sawtimber						
	Base	25	0	100	4127	386	19.2
	Base with Land Costs		4500	100	279	26	8.29
	Environmental Protection		0	50	1888	177	17.8
	Land and Environmental Protection		4500	50	-1954	-183	5.4
	High Yield, High Price 25% more		0	100	5668	531	21.96
	Hi Yield, Price, Land, Environment Protection		4500	50	-1684	-157	5.78
Brazil	Eucalyptus grandis pulpwod, S.P.						
	Base	6 (24)	0	100	2346	507	26.6
	Base with Land Costs		6000	100	215	17	8.2
	Environmental Protection		0	50	1143	247	26.3
	Land and Environmental Protection		6000	50	-2639	-211	4.7
	High Yield, High Price 25% more		0	100	4602	996	36.9
	Hi Yield, Price, Land, Environment Protection		6000	50	-1497	-119	6.19
Uruguay	Eucalyptus grandis solid wood	16					
	Base		0	100	1745	197	14.5
	Base with Land Costs		3000	100	-378	-43	7.3
	Environmental Protection		0	70	1136	128	13.94
	Land and Environmental Protection		3000	70	-988	-111	6
	High Yield, High Price 25% more		0	100	3415	386	18.25
	Hi Yield, Price, Land, Environment Protection		3000	70	-405	-46	7.23
USA	Pinus taeda South / High Intensit	25					
	Base		0	100	-720	-67	5.4
	Base with Land Costs		3000	100	-3407	-273	2.6
	Environmental Protection		0	65	-582	-54	4.99
	Land and Environmental Protection		3000	65	-3144	-294	2.1
	High Yield, High Price 25% more		0	100	-336	-30	7.02
	Hi Yield, Price, Land, Environment Protection		3000	65	-2894	-232	3
USA	Psuedotsuga menziesii Site I	40					
	Base		0	100	-201	-17	7.66
	Base with Land Costs		2100	100	-2204	-184	5.7
	Environmental Protection		0	85	-321	-27	7
	Land and Environmental Protection		2100	85	-2324	-194	5.4
	High Yield, High Price 25% more		0	100	218	18	8.3
	Hi Yield, Price, Land, Environment Protection		2100	85	-196	-16	6

The countries in our analysis have varying legal requirements on forest land use, ranging from requirements for legal reserves in Brazil to use of buffers around streams in most countries to use of best management practices in the U.S. South. Of the forest land area available, regulations effectively take out about 15% of the productive land base in the Pacific Northwest to up to 50% of the productive land bases in Brazil (Table 3). Our estimates of land costs for areas that have complete environmental restrictions are imprecise. U.S. land costs of about $2500 per hectare include an average mix across all land. In Brazil and Argentina, one probably can pay much less for land that has absolute prohibition of forestry activities, but this amount is not clear. But this fact would tend to make net rates of return with land costs in Brazil and Argentina somewhat higher than we calculated, but so indeterminate that our assumption of one base forest land price in each country is best.

The costs of reserving a share of the land base for environmental protection alone on existing lands did not decrease investment rates of return as much as the purchase of the land did at prevailing rates in each country, generally only decreasing the IRRs by one or two percentage points. This is mostly because if one assumes that you already own your land, and you do not need to pay to site prepare, plant, and manage a stand, the loss of a share of that land is not a large opportunity cost compared with buying new land. However, coupling environmental protection requirements in each country with land purchase costs dropped all the IRRs to 5.4% to 4.7% in Brazil and Argentina and the Pacific Northwest, and to 2.1% in the U.S. South. Some of these countries decreased returns more due to the greater amount of land that would be withdrawn from production due to environmental constraints.

Higher yields and prices had the opposite effect, and improved the returns in the Southern Cone countries the most. Without land costs, IRRs with improved productivity ranged from 18% to 37% in the Southern Cone, and were 7% and 8%, respectively, in the U.S. South and Pacific Northwest. Including all the factors of land costs, environmental protection requirements, and potential productivity requirements, the IRRs were not that different among the Southern Cone countries (5.8% to 7.2%) and the PNW (6.0%), although the South still lagged noticeably (3.0%).

Investment Risk and Ease of Doing Business

Table 4 summarizes key macroeconomic or political factors that affect country investments. The Organization for Economic Cooperation and Development (OECD) Export Risk, and Belgium Export Credit Agency (ONDD) Political Risk, and ONDD Risk of Expropriation all measure country risk with a low of 0 or 1 (lowest risk), and high of 7 (worst). Since these data are readily accessible, unlike our timber investment returns estimates, other key forestry countries are listed for reference.

These data confirm the impressions that one might have about relative country level risk, but make the gradations more clear. Australia, Chile, New Zealand, and the United States had the best risk ratings, as the most stable OECD countries. Of the non-OECD countries, Brazil, China, Mexico, and South Africa have the best ratings, of about 3. Colombia, Indonesia, and Uruguay fell in the next tier, with a common rating of about 4. Paraguay is in the next group, largely alone with political and export risks of a 5, but less expropriation risk, perhaps based on its long history of private ownership. Then Argentina, Ecuador, and Venezuela rank last, rated the worst possible, with a 7 for most risk ratings. Each of these countries has nationalized some private industry, including the nationalization of some forest land in Venezuela.

The Standard & Poor foreign risk ratings divide countries between those termed "Investment Grade" (BBB- or better) and Speculative Grade (BB+ or less). Thus countries such as Australia and Canada and Finland rate best (AAA); New Zealand and U.S. are one step below them (AA+). Other major forest plantations countries at Investment Grade include China, Chile, South Africa, Brazil, and Colombia. Brazil, Colombia and Peru were all just upgraded to this level in 2010 and 2011. Costa Rica, Indonesia and Uruguay have S&P ratings of BB or better, and also have been upgraded recently. In forest plantations, Uruguay has received investments far above its nominal S&P and risk ratings, perhaps because of its perceived low corruption and high literacy/education levels.

Table 4. Selected Risk Measurements for Major Forest Plantation Investment Countries, 2011

		ONDD Risk Ratings					
	OECD Export Risk	Political Risk Medium/Long Term	Commercial Risk	Expropriation/ Government Action	S&P Country Rating	World Bank Ease of Business Rank	World Bank Days to Start a Business
Argentina	7	7	C	5	B	115	26
Australia	0	1	B	1	AAA	11	2
Brazil	3	3	C	2	BBB-	127	120
Canada	0	1	B	1	AAA	8	5
Chile	2	2	A	1	A+	43	22
China	2	2	C	4	AA-	79	38
Colombia	4	4	C	3	BBB-	39	14
Costa Rica	3	3	B	2	BB	125	10
Ecuador	7	7	C	7	B-	130	56
Finland	0	1	A	1	AAA	14	1
Indonesia	4	4	C	5	BB	130	47
Mexico	3	3	C	2	BBB	35	9
New Zealand	0	1	A	1	AA+	3	1
Paraguay	5	5	C	4	B+	106	35
Russia	3	3	C	4	BBB	123	30
South Africa	3	3	B	3	BBB+	34	22
Sweden	0	1	A	1	AAA	15	15
United States	0	1	B	1	AA+	5	6
Uruguay	4	4	A	1	BB	124	65
Venezuela	7	7	C	7	BB-	172	141

Source: OECD 2011; ONDD 2011; World Bank 2011a, 2011b

The World Bank Ease of Doing Business rankings and Number of Days to Start a Business estimate do not favor Latin America countries. Out of 174 countries, Venezuela was almost the worst in the world. Indonesia, Ecuador, Brazil, Costa Rica, Uruguay, and Argentina all are in the lower third of the countries in the world for Ease Doing Business, saved only by the even worse record of most African countries. Similarly, they all take many Days to Start a Business, and conversations with forestry colleagues suggests that these are optimistic estimates. New Zealand, Colombia, Chile, China, and the developed OECD countries fare well on the Number of Days to Start a Business, and in the upper half to best in the world on Ease of Doing Business.

Several countries in Latin America are also becoming more inimical to foreigners buying land. Due to limited available land and loss of local owners (e.g., Uruguay); land purchase by the government of China (e.g., Brazil); or massive purchases by very rich foreigners (e.g., Chile, Argentina), each of the Southern Cone countries has either restricted purchase or is considering doing so. In Brazil in 2010, the Attorney General offered an opinion that the Constitution effectively restricts direct future foreign ownership of agricultural, including forest land. Various vehicles have been proposed or used to skirt this ruling, and indeed many believe that it is an incorrect interpretation of the Brazilian Constitution. However, the ruling has been explicitly restated in 2011, casting doubt on rural land investments without having a majority Brazilian investor, which is causing severe problems and deterring investments.

In December 2011, Argentina passed a "Ley de Tierras", which prohibited direct foreign ownership of land of more than 1000 hectares. Uruguay has not prohibited foreign ownership, but its president has opined against building any more large pulp mills in the country. Chile is not restrictive per se, but has little available land for forest plantation investments, and the two major forest products firms do not want to lose their core land base to new investors. In addition, the recent run up in agricultural commodity prices has caused large pressures for many good forest sites to be converted to crops throughout the world. Despite concerns in other countries, Colombia on the other hand is encouraging foreign direct investment, and Ecuador is actively seeking to make major new forest plantation investments.

Conclusions

This overview summarizes the global investment returns for key forest plantation countries in the world based on selected cross sectional/time series data. The data focuses on returns to investments assuming that one owns land already, which would be typical for existing investors. But it adds a component to estimate returns with land costs for the key Southern Cone and U.S. regions and species.

The results indicate that the fast growth rates and higher reported timber prices drive the best timber investment returns. South America had the highest returns for existing investors, without the cost of land, and Brazil was consistently the best and improving during the period from 2005 to 2011. Opportunities for high rates of return and present values also existed for current landowners in each of the other Latin America countries. Existing owners could achieve reasonably attractive plantation investments of about 7% to 12% real IRRs. Reasonable real rates of return also could be made in almost all of the other regions analyzed, except the U.S. South, which was closer to 5% IRRs. However, most of these investments could be similar to or better than existing returns than other asset classes have had since 2007.

The results indicate that for purchasers of new land, the rates of return would be much lower—close to the 8% real discount rate, and closer to 6% with the costs of environmental protection considered. Environmental protection costs alone did not decrease costs for present owners where land was a sunk cost. They mostly removed the land from production, but did not add more management costs. Higher productivity could compensate for some of the land and environmental costs, again raising most returns except the U.S. South to the 6% to 8% IRR level.

Land costs are of course a key to determining net returns for new investors. We assumed a fixed rate for land costs at their typical sale price per ha as of 2011. However, these are in considerable flux, based some depression in timberland markets currently, and the reverse for agricultural land markets. Land prices in the last decade increased rapidly in most of the countries examined, albeit for different reasons. The U.S. had increased timberland prices with more demand, high rates or development for urban uses, and good timber prices up until the recession of 2008. Many of those factors were similar in South America and Asia, and land prices there have been further fueled by rapid increases in prices for agricultural land, especially for soybeans, which can use converted forest land in some cases. In addition, given the Southern Cone financial crises in 2001 and 2008, investments in land were perceived as more secure than other investments.

Investors will assess overall global market demand, local demand, and their effects on timber and land prices. The financial crisis of 2008, leading to the U.S. and southern European housing market crash, has depressed sawtimber prices in most OECD countries, with only Asia escaping this trend. Local market demand has increased in the Southern Cone countries of Brazil and Argentina. Western South America has large populations but historically unstable macroeconomic factors; but they are improving, thus forestry investments might be more attractive in the future. And the pressure for agricultural land might also make at least existing forest investments more valuable everywhere, just by decreasing available land for forests.

Overall, these results are encouraging in that they indicate the opportunity for reasonable but not unrealistic rates of returns in forest plantation investments in many parts of the world. The more temperate forests with slower tree growth rates do have somewhat lower rates of return, but still competitive with most other asset classes currently. In the face of increasing land costs and somewhat depressed timber markets, especially in North America, forest investors will have to be better than average managers via maximizing returns per unit of input.

In order to achieve the highest rates of return, new investors must choose countries with higher levels of political and investment risk, more difficulty in doing business, more environmental regulation, and higher transactions costs. In addition, the timber prices reported here for many countries are based on very thin markets, and probably less predictable or assured than in the more developed markets such as the U.S. South and Pacific Northwest. This timber market uncertainty in new regions may be offset in the larger countries such as Brazil and China where they have substantial domestic timber demand, and are less dependent on export demand and prices.

Many investors are being courted for new regions in Brazil, Colombia, Ecuador, Southeast Asia, or even Africa. Land costs are cheaper there, which can make returns better, but the development of timber markets really is conjecture, and apt to be linked to one or two major mills. Decades ago, many vertically integrated forest products firms and large investors bought forest land at much cheaper prices than currently available, and established forest plantations in each of the countries analyzed here. Our analyses indicate that there are attractive returns for those old investments, not including the costs of the land in the analysis today. One challenge for those investors today is to decide whether to keep obtaining high rates of return on their forest investments assuming essentially no land costs—sunk costs from previous investments—or whether to sell their productive forest lands at high prices and to be converted to agriculture crop production.

New forestry investors also can achieve reasonable rates of return in forest investments, but more in parity with reduced returns for most investments in the 2000s. These opportunities will be tempered by the challenge of extending smaller scale investments to new regions and new countries without the vertically integrated manufacturing advantage. They also must weigh the prospects for continued market expansion of forest products, and the competition with agriculture land, and concerns of target countries with limited land resources. Finding the balance among investment returns, investment risk and difficulty, market opportunities, and willing host countries will continue to challenge and reward forest investors and managers in the 2010s as well.

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TIMO INVESTMENTS IN BRAZIL: CURRENT STATUS AND PROSPECTS FOR THE FUTURE

Bruno Kanieski [a], Silvana R. Nobre [b], Luiz C. E. Rodriguez [c], Christopher Singleton [d], John Welker [e].

ABSTRACT

Over the past decades American investment funds have included forest assets in their portfolios due to attractive long-term returns with relatively low risk. In order to find higher investment returns for institutional investors, American TIMOs (Timberland Investment Management Organization) have looked for timberland acquisitions overseas, e.g. in South America and Indonesia. Although seen by many as countries with greater political uncertainty and higher risk, tropical and subtropical countries in South America and Indonesia, that have already established fast growth plantations of exotic tree species, present higher returns than similar investments in temperate zones. Brazil is one of the countries with the greatest potential for good returns from investments in forest plantations. The purpose of this paper is to investigate the current scenario of investments in forest plantations and the role of TIMOs in Brazil. In 2001, Global Forest Partners (GFP) made the first big acquisition buying Pine plantation on the State of Parana, in Brazil. Since then, other TIMOs have invested in timberland and land for timber production in Brazil. The main factors that have negatively affected the rate of growth of investments in the Forest sector in recent years in Brazil are: (1) the global crises in 2008 which delayed the expansion of some pulp mill plants and (2) the federal law that made land acquisition by foreign groups more restrictive. Even with these factors, new forestry projects for energy purposes are underway and TIMOs are looking to new places to invest, especially, where the land price is still attractive as is the case in the north and west central regions of Brazil.

Key words: Latin American investments; portfolios diversity; forest expansion.

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Introduction

Forest asset investments are well known long-term alternatives, with relative low risk and attractive returns. These features have encouraged institutional investors to manage timberland investments, consequently, diversifying their portfolio and minimizing the market risk (Clements, Ziobrowski, & Holder, 2011; Hagenstein, 1984; Redmond & Cubbage, 1988)

The total area managed by TIMOs in Southern United States has increase. Between 2002 and 2010, the forest land that region had increased 3 million hectares(Cubbage & Siry, 2002; Mendell, 2011). Furthermore, this increasing trend has been completed by more investments overseas, which also occurs in parallel with a recent trend in the USA where industrial timberland is being transferred to Timberland Investment Management Organizations (TIMOs) (Clutter, Greis, Mendell, Newman, & Wear, 2005; Hagenstein, 1984). TIMOs purchase and manage forestland depending on how attractive is the market for certain products and services in the region, including the use for recreational and hunting purposes or for the management of fast growth forest plantations. Such interests have turned viable investments on a large spectrum of forestland types.

The rapidly increasing demand and competition for the best timberland acquisition in USA has pressured the land price upward and, consequently, American TIMOs started searching for new timberland investments overseas. Many funds have turned their interests into (or have already invested in) managing international timberlands. Currently, around 0.6 million hectares are managed by TIMO oversea, e.g., in Latin America, New Zeeland, Australia and Indonesia (Mendell, 2011).

Although economic risks and political stability may look lower in temperate countries, the usual uncertainty perceived in Latin America and Indonesia has been overcome by the higher rates of return in timberland investments observed in this region (Cubbage et al., 2006, 2010). Among others, Brazil has shown admirable rates of economic growth, favorable developments in its internal markets and present good economic perspectives, becoming one of the most promising countries for forest investments.

With 851 million hectares, Brazil is the largest country in South America and the 5th in the world. Its coastline opened to the Atlantic Ocean extends over 7,300 km (Figure 01). According to the Brazilian Institute of Statistics and Geography (IBGE), the economic growth was 7.5 % between 2010 and 2011 and turned Brazil the seventh largest economy in the world (GDP equal to US $ 2.3 trillions in 2011).

In Brazil, 510 million hectares, from a total of 516 million hectares with forests (60% of the territory), are still formed by natural forests (SBF, 2010). The total area with planted forests is approximately 7 million hectares, in which the main cultivated species are Eucalyptus and Pine trees (4.5 and 1.8 million hectares, respectively). The areas planted with these species correspond to 93 % of the total planted area.

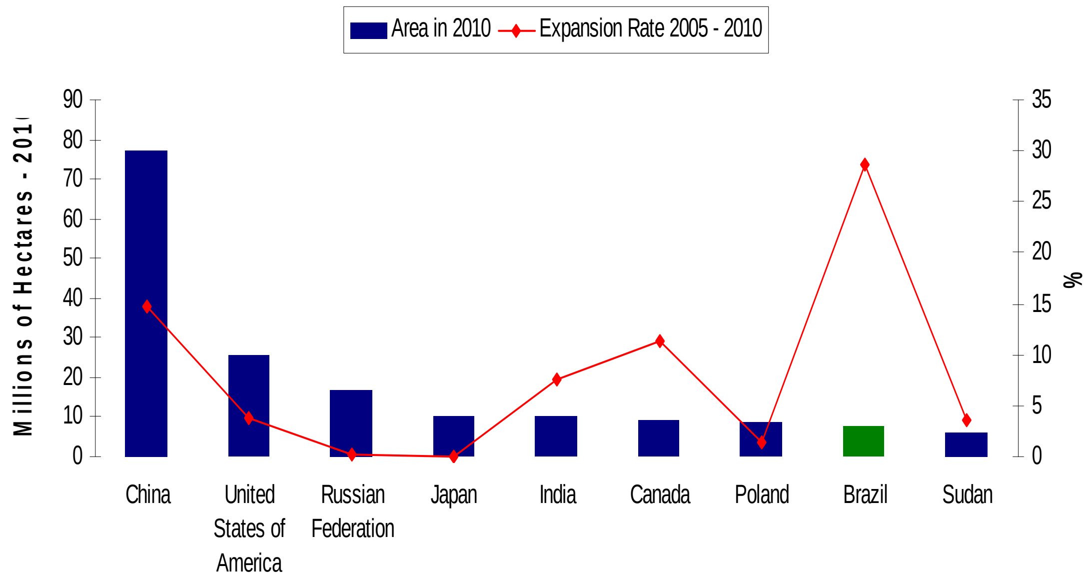
Most of the planted forest owners in Brazil are mainly pulp mills and steel and iron producers. In 2010, the total amount of round wood produced in Brazil reached 164 million cubic meters, as reported the Brazilian Institute of Statistic and Geography (IBGE).Land for the expansion of planted forests at reasonable prices is still available in Brazil, and a constant increase in the growth rate of timberland investments is still expected.

This paper analyses the current state of timberland investments in states where planted forests have been a reality for many years in Brazil and in new places where land prices have turned timberland acquisitions and future perspectives very attractive for North American TIMOs.

Picture 01 – Brazil.

Timberland Expansion

According to the Food and Agriculture Organization of the United Nation (FAO), Brazil had the 9th largest forest plantation area in the world in 2010. The Brazilian plantation area occupies 7.4 million hectares; it is 10 times smaller than China and 4 times than the USA. Although, Brazil does not have an expressive area compared with the main producers, the country has showed a significant expansion rate. Between 2005 and 2010, the planted area in Brazil grew 29 %; it is almost two times the growth rate of China (Graph 01).

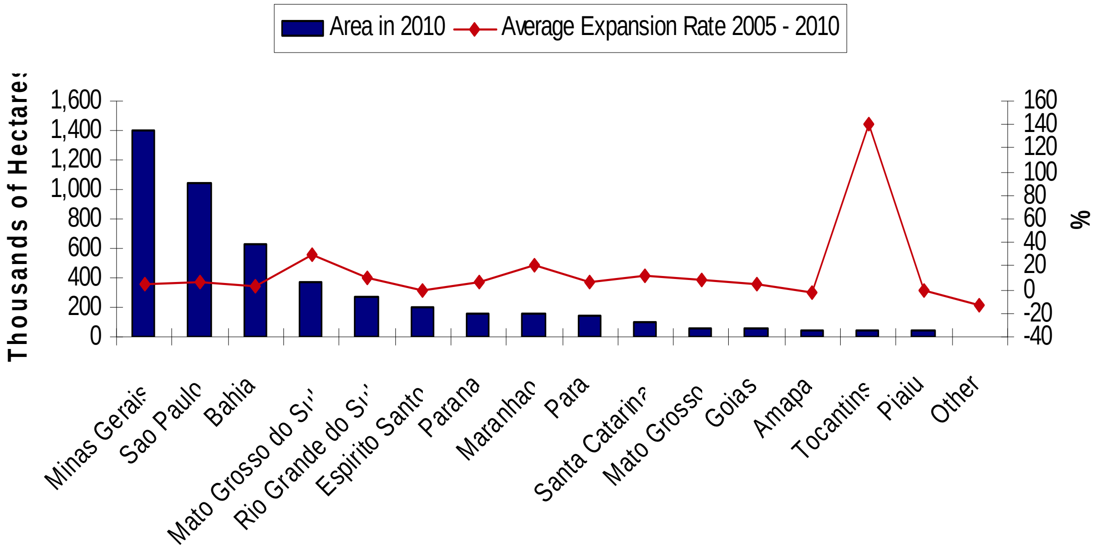


Graph 01 – Top 10 countries in forest planted area in millions of hectares in 2010 and the respective expansion rates between 2005 and 2010. Source: FAO,2011.

Eucalyptus and Pine tree are the main forest genus cultivated in Brazil. In 2010, the area occupied by them was equal to 6.5 million hectares, which in, 73 % of Eucalyptus and 27 % of Pine tree. In the last five years, the plantation area of this two genus has increased 23 % (ABRAF, 2011).

Since 2005, Eucalyptus plantation area has increased 37 % throughout the country. The states of Minas Gerais and Sao Paulo have more than half of the total area with Eucalyptus in the country. The areas occupied located in these states correspond to 29 % and 23 % of 4.7 million hectares respectively.

Although, most of the largest Eucalyptus consumers are located on the South and Southeast region, the states of Tocantins, Matogrosso do Sul and Maranhao have demonstrated rapidly expansion on Eucalyptus plantation. Along the last 5 years, these states have expanded the plantation area in 140 %, 29 % and 21 % respectively (Graph 02).

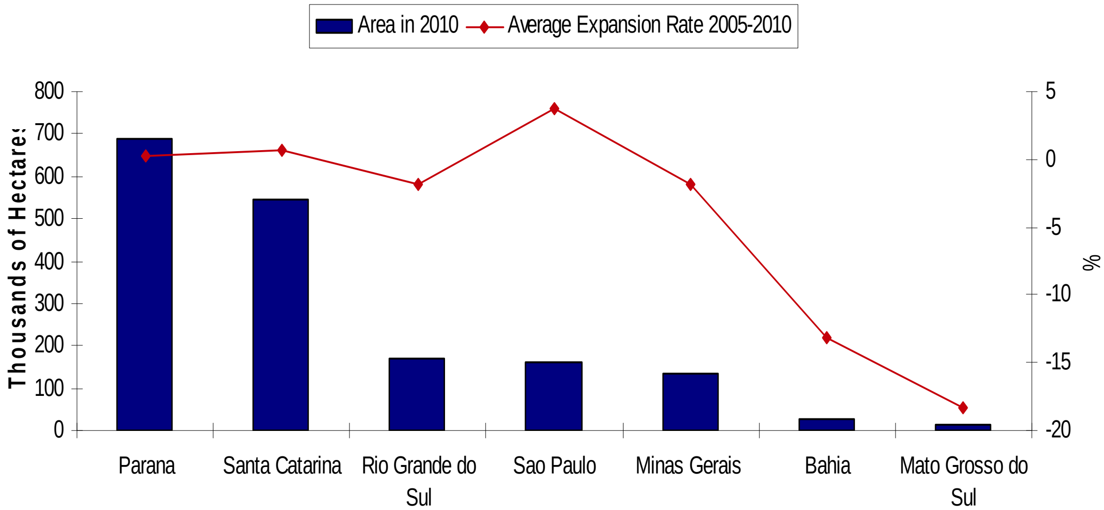


Graph 02 – Largest Eucalypt plantation area per state in 2010 and the respective average expansion rate between 2005 and 2010. Source: ABRAF, 2011.

Among other facts, lower land price, reasonable growth rates and good perspectives of regional economic has influenced the investment attractiveness in new Eucalyptus projects in Brazil. Therefore, the search for projects with higher returns has formed new timber market in regions little explored in the past eg., in Tocantins, Piaui and Maranhao.

New forest production areas have been arisen in Brazil on the past years. The state of Matogrosso do Sul is a solid example. Couple year ago, Matogrosso do Sul was well known by the cattle production. Nowadays, the state has a notable forest bases and good future perspectives on the sector.

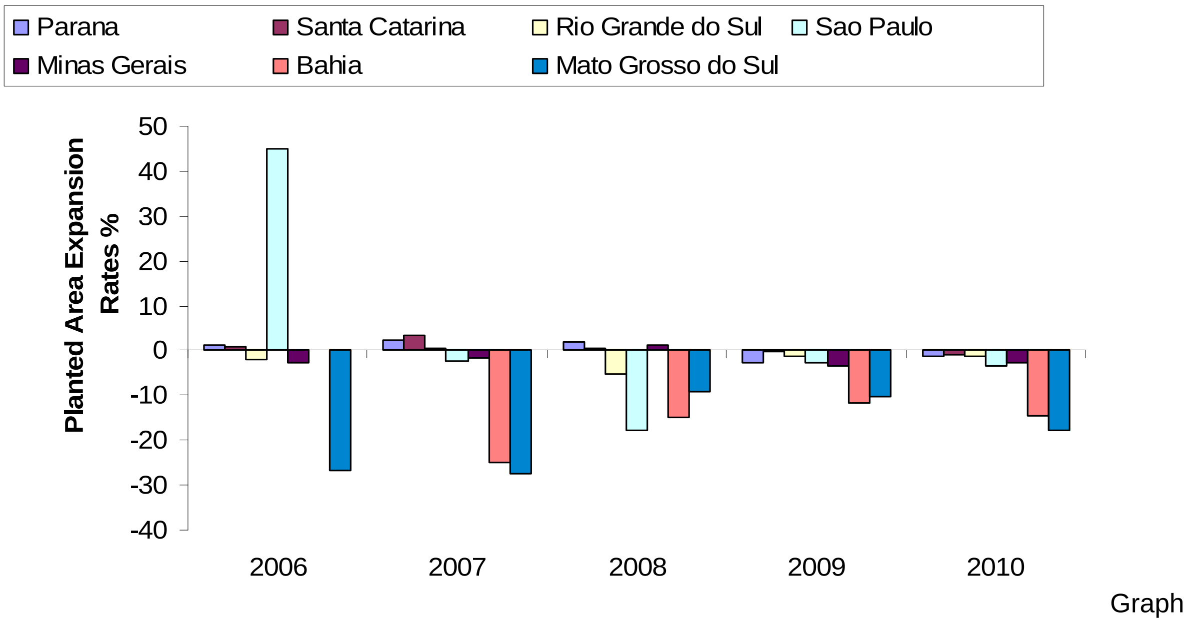
Whereas Brazilian forestry sector has presented an expansion on Eucalyptus plantation, Pine tree areas have increased slightly and, in some states decreased severely (Graph 03).



Graph 03 – Largest pine plantation area per state in 2010 and the respective average expansion rate between 2005 and 2010. Source: ABRAF, 2011.

In 2010, the states of Parana and Santa Catarina have 70 % of the Pine tree plantation (39 % in Parana and 31 % in Santa Catarina). These states showed no difference in the planted area extension between the years of 2010 and 2005. Furthermore, the planted area in Mato Grosso and Bahia has decreased 18% and 13 % respectively at the same period.

These results must be interpreted with caution. Although, the state of Sao Paulo has showed 5 % of growth between 2005 and 2010, Pine planted area has decreased annually in all states of Brazil since 2006. The exceptions are the states of Rio Grande do Sul, Santa Catarina and Parana. On these three states the Pine plantation started to decrease in 2007. Between 2007 and 2010, the Pine tree area decrease 8% in Rio Grande do Sul, 2% in Parana and 0.5% in Santa Catarina. (Graph04).



Graph 04 – Pine plantation area per state evolution – Source: ABRAF, 2011.

Further studies are necessary to evaluate the influence factors on Pine tree expansion. However, economic aspects indicated more competitiveness on project involving Eucalyptus (Cubbage et al., 2006; Rodigher, 1997; Vitale, 2010). Consequently, new Pine tree project has been discouraged and replaced by investments in Eucalyptus plantation. These conditions can be often observed in Pine tree plantation located in the Center and Southwest of the country. On the other hand, the strong internal market maintains the Pine trees project still attractive in some parts of Parana and Santa Catarina.

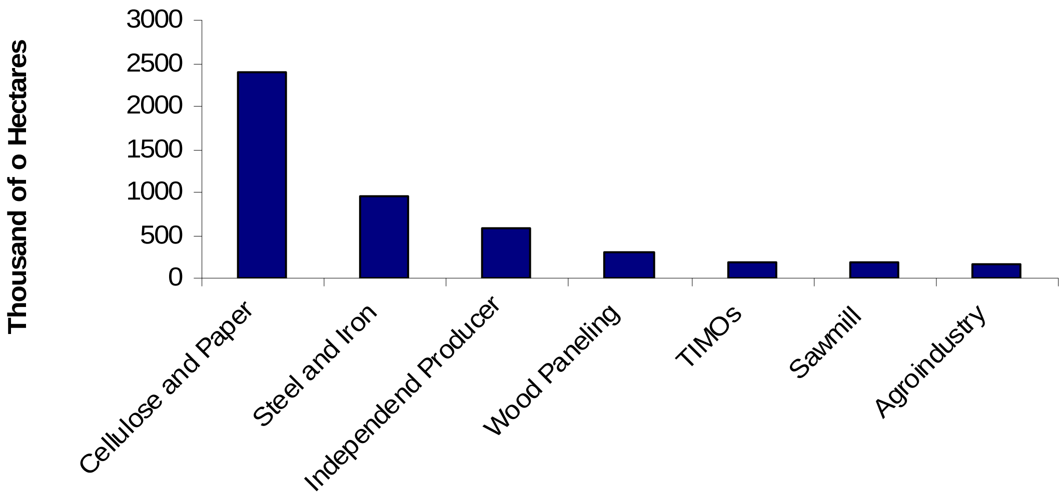
Brazilian tree plantation sector has attracted several investments around the world. Resents global crises and the land acquisition restriction by foreign groups are among the main factors which decelerated the investments in new forest projects in Brazil. Since 2007, the land purchase by foreign groups has been limited by national law requirement. Due to the presence of foreign capital in most of Brazilian forest industries investments, many of them canceled either the new mills building or the capacity expansion.

Brazilian government should have received around U$ 14 billons related to investments in new mills and U$ 8 billons related to new planted area in a scenario with no foreign investment restriction, (ABRAF, 2011).

Timberland Investment Management Organization in Brazil

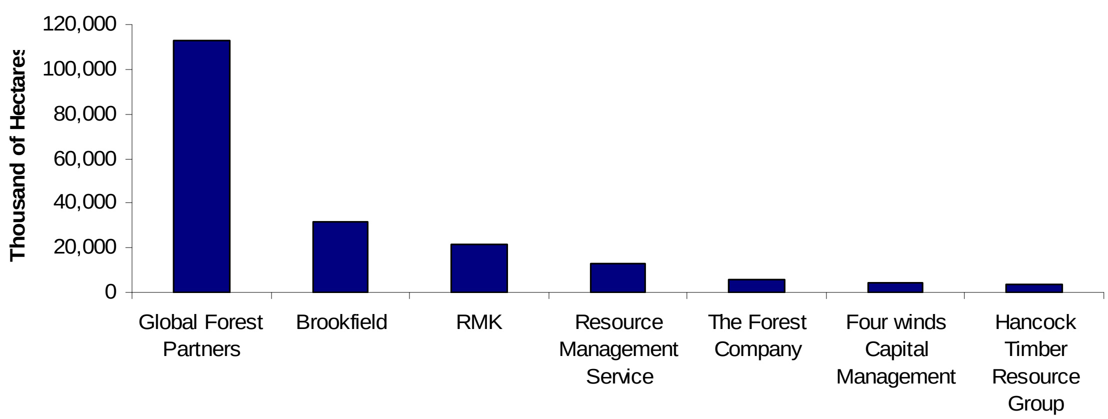
TIMOs are a small part of Brazilian forest sector. The structure of the forestland ownership in Brazil is: i) Cellulose, paper, steel and iron industries have more 70 % of the total forest plantation; ii) other producers owns 26 % and; iii) TIMOs own193 thousand hectares, 4 % of 4.5 millions hectares.

Compared to TIMO's timberland ownership in USA, the investments in Brazil are still begging; according to Binkley,2007, the American TIMOs have approximately 125 million hectares spread into the USA.



Graph 07 – Timberland Ownership in Brazil. Source: Poyry - Silviconsult, 2010. Adapted by the authors.

TIMOs have invested in Brazil since 2000. In 2001, Global Forest Partners (GFP) made the first big acquisition buying the Pines tree plantation in the State of Parana. Nowadays, the Global Forest Partners has the largest area with 113,100 hectares followed by Brookfield and RMK with 31,700 and 21,500 hectares respectively (Graph 08).



Graph 08 – TIMOs planted area. Source: Consulfor, 2009. Adapted by the authors.

It is interesting to note that most of TIMOs are located in the South region. Among the states with the largest forest asset, only Minas Gerais is not situated on that region. This fact can be correlated with the origin of most of American TIMOs.

They are from U.S. South where the climate condition is similar to south Brazil as well as the dominance of Pine tree plantation.

The fourth largest TIMOs have their forest asset located in more than one state. This fact may demonstrate a tendency of regional diversification and consequently decreasing the investment risk in the portifolio.

Conclusion

The land availability, effective planted area and high productivity are among main features of Brazilian silviculture. For these reason, the country are still attractive for futures forestland acquisition and investments.

As mentioned previously, Eucalyptus is the main specie cultivated in Brazil. The development of new clones has allowed the specie to growth throughout the country. Despite of the physiologic adaptation, Eucalyptus species has showed better economic responses than Pine tree plantation in most of the states. New investments in Pine tree must therefore, be analyzed precisely on regions where the market is not established. On this perspective, Parana and Santa Catarina State has showed better opportunities for this genus.

Even with global economic crises in recent years and the governmental restriction about land purchase by foreign capital companies, new forestry plants for energy generation, charcoal and pulp manufacture are being built. The actual macroeconomic aspects are favorable to investment in Brazil. In the past years the country has showed a constant economic development and consequently, increasing the investors' confidence.

The western and central-west regions of Brazil have been the main destiny of timberland investment. The combination of low land price and local incentives has attracted many investors from different areas on the region. Thus, TIMO's already established and new ones are looking to opportunities on these new frontiers in order to diversify their forest asset portfolio and get more attractive returns.

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DIRECT INVESTMENTS IN GLOBAL PLANTED FORESTS

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ABSTRACT

This study examined the macro-economic, institutional, and forest sector factors attracting direct investments (DI) in planted forests and forest plantations on a global scale. To assess factors contributing to investment, we drew from methods used by the Inter-American Development Bank (IADB), which developed a forest attractiveness index (IAIF) to "measure the business climate to sustainable forest business". The indicators used in that index, as well as results from previous studies of foreign direct investment (FDI), were used as a framework to develop set of independent variables to characterize DI in this study.

Date were collected for 42 different countries for the years 1990, 2000, 2005 and 2010 using mainly open for public resources such as Food and Agricultural Organization of the United Nations (FAO), International Momentary Fund (IMF) and World Bank web pages. Data on the area of planted were forests obtained from Forest Resource Assessment Reports published by FAO. The area of planted forests is the dependent variable which relationship with independent variables from macro-economic, institutional and forest sectorial categories will be explained by a multiple linear regression model. There are 30 independent variables of which 29 are numeric and 1 character, which data are matched for each year and country. A regression model was developed as:$DIplant_t = f(M_{it}, I_{it}, F_{it})$, where DIplant is the area of planted forests, M represents macro-economic factors, I institutional factors and F forest sector factors; i is the individual independent variable and t the time dimension.

The model was used to estimate investment characteristics, and to see if there are differences between the factors among countries with different social and economic structures. The countries were classed into two categories, based on whether they are Organization for Economic Co-operation and Development (OECD) member countries or non-member countries. Preliminary results and implications will be discussed.

Economic Contribution of Mississippi's Forest Products Industry over Time

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Economic Contribution of Mississippi’s Forest Products Industry over Time

Abstract

Monitoring the economic contribution of the forest products industry is very important as it provides baseline information for planners and policy makers. Time series analysis and documentation of economic data are helpful in addressing critical economic issues and in understanding important industry trends. With the advent of Impact Analysis for Planning (IMPLAN), an input-output modeling system, it has been much easier to model the economic impact of forest industries and observe changes in these sectors over time. This study uses IMPLAN to estimate the economic impact of the forest industry in Mississippi. Forests covering approximately 65% of total land area of Mississippi are one of the major contributors to the state economy. Over the past decade, Mississippi’s forest industries have experienced significant contractions. Examining the economic impact of the forest industry over this time period provides insights into how those changes have impacted the Mississippi economy and how the forest products industry’s contribution has changed over time. The proposed analysis will update baseline economic information on the contribution of the forest products industry to the Mississippi economy, and the results of this analysis will be useful to planners and policy makers concerned with strengthening the economic health of these sectors.

Keywords: input-output modeling, IMPLAN, economic impact

Introduction

Total economic value of global forest-based industry was US $468 billion employing 13.7 million people in 2006 (Forest product industry technological road map 2010). The southern United States is one of the largest producers of timber products in the world (Prestemon and Abt 2002). Among the southern U.S. states, the percentage of state employment engaged in the forest products industry is greatest in Mississippi (Tilley and Munn 2007). Thus, forest resources are a major economic asset for Mississippi.

Forestland covering 19.7 million acres (65%) of total land area of Mississippi (Oswalt and Bentley 2011) is one of the major contributors to the state economy. The forest products industry affects the state's economy in three major ways, direct (initial impact), indirect (secondary impact), and induced (impact generated by direct and indirect impact) effects. These impacts are measured by several factors such as employment, salaries and wages, value-added, and total industry output. As input-output modeling, developed by Wassily Leontief, includes all of these impacts (direct, indirect, and induced) on the economy, it is one of the best models to estimate the economic impacts of the forest products industry. With the development of Impact Analysis of Planning (IMPLAN) by the Minnesota IMPLAN Group (MIG), an input-output modeling system that is updated annually, it has been much easier to model the economic impact of industries and to estimate the changes over time.

In 1998, the forest products industry contributed $14.8 billion in total industry output and 151,632 jobs (direct, indirect and induced effects) to Mississippi's economy (Munn and Henderson 2002). In 2006 the industry contributed $17.4 billion in total industry output and 123,659 jobs (Henderson et al. 2008). The economic contribution of the forest products industry clearly changes over time. Changes in the forest products sectors have larger impacts on state, regional, and national economies. Over the past decade, Mississippi's forest industries went through significant contraction. Thus, monitoring economic contribution over time is necessary to update baseline economic information.

The purpose of this study is to estimate 2010 economic impacts of the forest products industry in Mississippi and to compare and contrast the study results with Munn and Henderson (2002) and Henderson et al. (2008). Results from this study will provide a detailed picture of how economic changes have impacted the Mississippi economy and how the forest products industry's contribution has changed over time. In addition, this study will also document important trends in the industry. Economic information pertaining to the forest products industry is essential for policy makers to address critical economic issues and to strengthen the economic health of these sectors.

Material and methods

Data specification

Primary data for the analysis of the forest products industry's economic impacts were obtained from MIG. MIG provides IMPLAN databases that are updated annually and software to analyze those data. IMPLAN is used widely in different economic-related fields because it is powerful, user friendly and is based on Leontief's input-output model. IMPLAN was originally developed by the USDA Forest Service in collaboration with the Federal Emergency Management Agency and the USDI Bureau of Land Management (MIG 2004). To estimate current 2010 economic impacts of the forest products industry in Mississippi, an input-output model of the Mississippi economy was constructed using IMPLAN and 2010 data. Results from the 2010 model were compared to 1998 (Munn and Henderson 2002) and 2006 (Henderson et al.2008).

Data analysis

This study aggregated 440 IMPLAN sectors into 31 sectors that consist of four major forest products sectors, one miscellaneous forest products sector, and 26 non-forestry related sectors. This procedure follows Barnett and Reinschmeidt (1996). But the major focus was given to the four major forest product sectors and the impacts were estimated as the direct impact made by those sectors and the indirect and induced impacts made by each of the forest product sector to the other 27 sectors. Impacts were measured in terms of employment, wages and salaries, total industry output, and value-added.

The four major forest product sectors were logging, solid wood products, wood furniture, and pulp and paper sectors. Estimation of economic impacts were first made for the individual forest products sectors and then for the forest products industry as a whole. Except for the logging sector, direct, indirect, and induced impacts were estimated using IMPLAN data (2010). For the logging sector, total industry output was obtained from 2010 Harvest of Forest Products (Henderson 2011). Data were analyzed using IMPLAN V3.0 software based on North American Industrial Classification System (NAICS). IMPLAN models were constructed for Mississippi to generate direct, indirect and induced impacts for four major forest products sector using 2010 IMPLAN data and all impacts were measured in 2010 dollars.

Results

A. 2010 Economic impacts of the forest products industry in Mississippi

In 2010, the forest products industry comprised 4.32% of Mississippi's total economy and generated about 2.4% of the state's total employment. Average annual wages in the industry were $5,897 greater than the state average. Total forest products industry output and value-added were $7.66 and $2.44 billion (Table 1). The wood furniture sector was the largest sector in the forest products industry.

Table 1. Direct effects of the forest products industry for the aggregated economic sector (2010).

Model Sectors	Employment	Wages and Salaries ($MM)	Total Industry Output ($MM)	Value-added ($MM)
Miscellaneous Forest Products	449	32.91	195.79	102.56
Logging	5,734	244.35	1,042.39	239.28
Solid Wood Products	8,443	391.06	1,710.46	541.64
Wood Furniture	17,882	654.90	2,654.62	937.44
Pulp and Paper	3,623	309.24	2,063.57	616.42
Non-forestry related sector	1,455,935	56,984.58	169,945.61	81,546.14
Total Sectors	1,492,066	58,617.05	177,612.44	83,983.49

Total economic impacts generated by each of the forest products industry sector

Logging

The logging sector includes commercial logging. In 2010, the value of Mississippi's timber harvest at the point of first processing was $1.04 billion (Henderson 2011). This total industry output value was used to construct an IMPAN model for the logging sector to generate indirect and induced impacts. 5,734 people were directly employed by the logging sector with $244.35 million wages and salaries, and value-added was $239.28 million (Table 1). The average annual wage was $42,614. Table 2 shows indirect and induced impacts generated by the logging sector in rest of the economy. Logging sector generated 10,474 additional jobs with $419.05 million wages. Additional total industry output was $1.53 billion and value-added was $512.74 million.

Table 2. Total impacts of the logging sector for the aggregated economic sector (2010).

Model Sectors	Employment	Wages and Salaries ($MM)	Total Industry Output ($MM)	Value-added ($MM)
Miscellaneous Forest Products	262	19.21	114.29	59.87
Logging [a]	5,734	244.35	1,042.39	239.28
Solid Wood Products	19	0.87	4.07	1.00
Wood Furniture	3	0.09	0.37	0.13
Pulp and Paper	1	0.05	0.28	0.08
Non-forestry related sector	4,740	174.70	491.91	273.46
Total Sectors	10,474	419.05	1,534.30	512.74

[a] Direct impacts of logging sector.

Solid Wood Products

The solid wood products sector includes sawmills and wood preservation; veneer and plywood manufacturing; engineered wood members and truss manufacturing; reconstituted wood products manufacturing; wood container and pallet manufacturing; prefabricated wood building manufacturing; all other miscellaneous wood product manufacturing; and custom architectural woodwork and millwork manufacturing.

The solid wood products sector directly provided 8,443 jobs with $391.06 million wages. Total industry output from the solid wood products sector was $1.71 billion and value-added was $541.64 million (Table 1). The average annual wage was $46,317.

Including indirect and induced effects, the solid wood products sector generated 17,321 jobs, $727.79 million in wages and salaries, $2.73 billion in total industry output, and $1.04 billion in value-added (Table 3).

Table 3. Total impacts of the solid wood products sector for the aggregated economic sector (2010).

Model Sectors	Employment	Wages and Salaries ($MM)	Total Industry Output ($MM)	Value-added ($MM)
Miscellaneous Forest Products	174	12.77	75.94	39.78
Logging	1,266	53.94	230.10	52.82
Solid Wood Products [a]	8,443	391.06	1,710.46	541.64
Wood Furniture	22	0.79	3.17	0.94
Pulp and Paper	4	0.24	1.46	0.35
Non-forestry related sector	7,413	268.99	712.51	403.68
Total Sectors	17,321	727.79	2,733.64	1,039.22

[a] Direct impacts of solid wood products sector.

Wood Furniture

The wood furniture sector includes wood windows and door and millwork manufacturing; wood kitchen cabinet and countertop manufacturing, upholstered household furniture manufacturing; non-upholstered wood household furniture manufacturing; and office furniture.

Direct impacts of the wood furniture sector are shown in Table 1. The wood furniture sector generated 17,882 jobs and paid $654.90 million in wages. The average annual wage generated by this sector was $36,623. Total industry output was $2.65 billion and value-added was $937.44 million.

Impacts of the wood furniture sector on Mississippi's economy are illustrated in Table 4. The wood furniture sector generated 28,867 total jobs and $1.05 billion wages. Total industry output was $3.84 billion and value-added was 1.55 billion.

Table 4. Total impacts of the wood furniture sector for the aggregated economic sector (2010).

Model Sectors	Employment	Wages and Salaries ($MM)	Total Industry Output ($MM)	Value-added ($MM)
Miscellaneous Forest Products	16	1.16	6.93	3.63
Logging	111	4.73	20.17	4.63
Solid Wood Products	516	24.45	110.06	30.68
Wood Furniture [a]	17,882	654.90	2,654.62	937.44
Pulp and Paper	30	1.83	11.01	2.51
Non-forestry related sector	10,313	371.49	1,044.22	566.90
Total Sectors	28,867	1,058.56	3,847.01	1,545.79

[a] Direct impacts of wood furniture sector.

Pulp and Paper

The pulp and paper sector includes pulp mills; paper mills; paperboard mills; paperboard container manufacturing; coated and laminated paper, packaging paper and plastics film manufacturing; all other paper bag and coated and treated paper manufacturing; sanitary paper product manufacturing; and all other converted paper product manufacturing.

Table 1 depicts the direct impact of the pulp and paper sector which generated 3,623 jobs and paid $309.24 million in wages. The average annual wage was $85,361. Total industry output was $2.06 billion and the value-added was $616.42 million.

Employment generated by this sector through direct, indirect and induced effects was 10,875 with wages of $ 592.82 million, total industry output of $2.90 billion, and value-added of $1.06 billion (Table 5).

Table 5. Total impacts of the pulp and paper sector for the aggregated economic sector (2010).

Model Sectors	Employment	Wages and Salaries ($MM)	Total Industry Output ($MM)	Value-added ($MM)
Miscellaneous Forest Products	16	1.16	6.92	3.62
Logging	273	11.64	49.68	11.40
Solid Wood Products	210	9.14	39.55	10.86
Wood Furniture	8	0.27	1.09	0.34
Pulp and Paper [a]	3,623	309.24	2,063.57	616.42
Non-forestry related sector	6,746	261.36	738.39	413.36
Total Sectors	10,875	592.82	2,899.20	1,056.00

[a] Direct impacts of pulp and paper sector.

Total forest product industry impact

Including direct, indirect and induced effects, the forest product industry sector generated 63,365 jobs and paid $2.63 billion of wages. Total industry output was $10.38 billion and value-added was $3.95 billion.

B. Impacts of the forest products industry over time

From 1998 to 2006, the forest products industry direct impacts were increasing. Except for direct employment which decreased by 20.66%, all other measures increased. Wages and salaries, total industry output, and value-added increased by 11.13%, 17.74% and 18.47%, respectively (Figure 1). Total impacts followed the same pattern as the direct impacts. Total employment decreased by 18.45% whereas

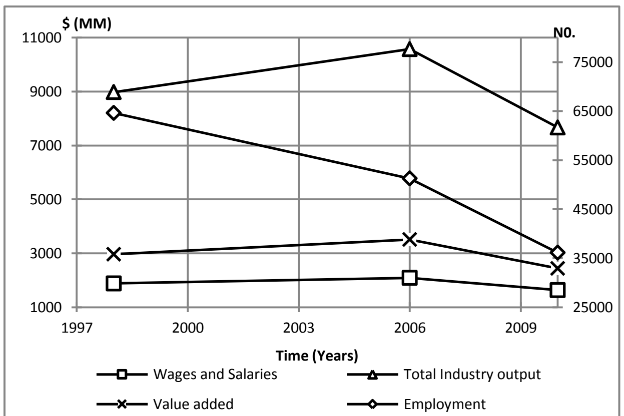

Figure 1. Direct impacts of the forest products industry over time

wages and salaries, total industry output, and value-added increased by 1.98%, 17.36% and 9.19%, respectively (Figure 2).

From 2006 to 2010, the forest products industry impacts severely declined. Direct impacts decreased by 21.81%, 27.50%, 30.57% and 29.55% in wages and salaries, total industry output, value-added, and employment, respectively (Figure 1). Decreases in total impacts were even more severe. Employment, wages and salaries, total industry output, and value-added decreased respectively by 48.46%, 39.83%, 40.27% and 44.63% (Figure 2).

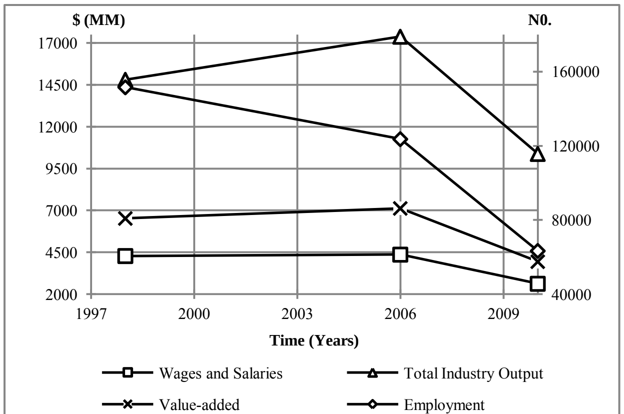

Figure 2. Total impacts of the forest products industry over time

As a percentage of the state's total economy, the contribution of the forest products industry decreased from 1998 to 2006 which further decreased severely by 2010. The forest products industry represented 10.24%, 12.44%, 13.23% and 11.22% to state's employment, wages and salaries, total industry output, and value-added in 1998. These measures decreased to 8.27%, 9.16%, 10.05% and 9.37%, respectively, by 2006 and further decreased to 4.25%, 4.48%, 5.84% and 4.70%, respectively, by 2010.

Discussion

The objective of this study is to estimate direct, indirect and induced impacts of the forest products industry to Mississippi's economy in 2010 and to compare the changes in economic contribution since 1998. The results depict two major findings 1) the forest products industry remains an important component of Mississippi's economy even though it accounts for a smaller percentage of the total state economy, and 2) the trend of the forest products industry's impact is decreasing severely after 2006.

Based on total industry output, the forest products industry in 2010 represents 4.32% of the total economy of Mississippi which was 8.02% in 1998 (Munn and Henderson 2002). Although the forest products industry represents 6.12% to total economy in 2006, which seemed to be decreased from 1998, economic contribution of the forest products industry increased by 17.74% from 1998 to 2006. However, it decreased by 27.50% by 2010. Therefore, we can say that the forest products industry has been severely affected after 2006. From 1998 to 2010, the wood furniture sector remained the highest direct employment generator among the entire forest products sector.

Comparing economic contribution of the forest products industry from 1998 (Munn and Henderson 2002) to 2006 (Henderson et al. 2008), the forest product industry is doing fairly well. However, after 2006, the trend of the forest products industry severely decreased. Sharp decline in housing and construction activities and the recent economic recession are the major factors that adversely affected the forest products industry. Solid wood products and wood furniture sectors are closely related with housing and construction. Thus, decrease in housing and construction made a severe impact on the forest products industry. In addition, the recession related decrease in advertising and packaging also negatively impacted the pulp and paper sector.

Conclusion

The findings of this study reveal that the forest products industry is one of the major contributors to Mississippi's economy; however, the size of that contribution over time is in a decreasing trend. This study provides an update to baseline economic information on the forest products industry, which is very helpful to policy makers to promote economic health of the forest products industry, address critical economic issues pertaining to these sectors and to return the forest products industry's economic contribution over time to a positive trend.

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