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Essays on economics of sustainable forest management

Pracha Koonnathamdee

University of Tennessee

To the Graduate Council:

I am submitting herewith a dissertation written by Pracha Koonnathamdee entitled "Essays on economics of sustainable forest management." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Natural Resources.

Donald G. Hodges, Major Professor

We have read this dissertation and recommend its acceptance:

Accepted for the Council:

Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

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Darryl E. Ray, Professor

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Essays on Economics of Sustainable Forest Management

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ABSTRACT

Forests contain characteristics of market (timber and forest products) and non-market goods (e.g. ecosystem and environmental services, outdoor recreation). The mixed characteristics of forests create difficulties in policy implementation, especially when sustainability of forests is an objective. Sustainable Forest Management (SFM), the global concept, is a challenging solution for forest uses and management combining social, economics, and environmental dimension. Due to several calls for research in SFM, particularly in trade in forest products and forest landowner behavior, this dissertation presents two empirical models with implications related to SFM.

Because some SFM opponents believe that applying SFM will lessen trade transactions and their forest products volume and value, the first essay applies a vector autoregression (VAR) model to clarify confusion surrounding trade and SFM, including the controversy of exchange rate depreciation policy. This study uses U.S.-Canada forest products trade data and exchange rate, and predicts the dynamic patterns of those factors when imposing a shock due to policy or other disturbances. The estimated results show that an alteration in exchange rate policy and changing forest conservation affect trade components both in the short run and the long run. Any calls for exchange rate depreciation policies should be rejected. Increasing forest conservation in the U.S. would discourage exports and increase the social price of wood products.

The second essay deals with fragmentation and parcelization of U.S. forests. Resolving the problems requires information about forest owners. This study utilizes a simultaneous-equation model to estimate interactions among ownership objective categories (non-timber benefits, monetary returns, farm or home site value, and bequest), willingness to harvest in the future, and interest in managing for non-timber uses.. The study estimates factors influencing ownership objective categories and planned behavior. The empirical results reveal that forest landowners are not homogenous and possess multiple ownership objectives. The interdependence

between ownership objective categories and behavior show that implementing incentives and revised U.S. forest policy with SFM objective should be considered in order to remedy the current forest problems.

TABLE OF CONTENTS

PART PAGE

LISTS OF TABLE

LISTS OF FIGURE

GENERAL INTRODUCTION

Forests are natural resources of critical economic importance. In addition to traditional wood products, forests provide a plethora of benefits (both market and non-market goods) that include a range of ecosystem services, biodiversity reserves, climate change protection or carbon sequestration, and outdoor recreation opportunities (Hanley et al., 2007; Kant and Nautiyal, 1996). Forests are diverse and complex. They range from plantation forests which often are managed as intensively as agricultural crops to natural forests comprised of several interdependent species of trees, plants, and animals. Forests possess characteristics of both renewable and nonrenewable resources. Plantation forests, for example, can be treated as a renewable resource since they can be harvested and regenerated frequently. Conversely, the unique characteristics and values of old growth forests or natural forests are better treated as nonrenewable resources in that the destruction of such forests could mean the loss of non-replenishable assets (Hanley et al., 2007). Therefore, forests must be analyzed separately from other renewable resources. The mixed characteristics of forests create difficulties in forest management and policy implementation, especially for sustainability.

There are several characteristics of market failure common to forest uses and management: externalities, public goods, common property resources, and hidden information. Forests provide positive externalities at the local level such as preventing flooding and soil erosion, improving water quality, and enhancing soil amelioration. Carbon sequestration or climate change mitigation offers one example of a positive externality at the global level (Kant and Berry, 2005). Ownership or property rights are the key to some market failure components, particularly with externalities and public goods (Coase, 1960). Due to the difficulties of revealing market failure components and of well-defined property rights, forests may not end up with social maximization so called the first best solution. However, the second best theory may be a solution for forest uses and management requiring both horizontal and vertical bargaining and institutional aspects (Koonnathamdee, 2008).

In the last two decades, people have realized that "trees are not forests and forests are much more than trees" (Kant, 2004). This simple sentence contains at least three economic implications. First, forests are not only timber and forest products. As a consequence, sustained yield timber management (SYTM) is economically inefficient because it ignores biodiversity values and other ecosystem aspects. In addition, timber and forest products could be sustained (in timber yield) only in plantation forests due to well-defined property rights, but not in common property natural forests where illegal logging would be a consequence. Under SYTM, natural forests may be valued only for land, timber, and forest products but not the total value of forests. As a result, forest areas could be changed into forest plantations or into agricultural areas or residential areas as a worst case scenario, eliminating biodiversity and ecosystem services permanently[1].

Second, the invisible hand of the market often does not work in the context of forests, resulting in market failure. In general, market failure occurs when (1) property rights are not defined clearly; (2) rights cannot be transferred freely; (3) others cannot be excluded from using the good; or (4) rights to use the good cannot be protected (Hanley et al., 2001, 2007). Under these conditions, free exchange does not lead to a socially desirable outcome. For instance, because everyone 'owns' the right to clean air and good climates and biodiversity, no one owns it (Gordon, 1954). In the context of these failures in the transactions of forest values, it is impossible for people to trade some forest products and services freely, for example some of non-timber products, amenities, soil protection, good climate, etc. In addition, the market system is incomplete particularly for the problem of missing markets. Therefore, relying only on the market without correcting for these problems leads to economic inefficiency.

[1] Evidence abounds relative to this problem, no matter where developed or developing countries e.g. 'cut and run', 'slash and burn', and illegal logging. In addition, the significant issues in many areas are urban sprawl due to fragmentation and parcelization of the forests creating burden to related communities.

Third, not only differences in terms of local and global levels of forests, but also different areas with the same levels have different impacts on communities. Forest management and policy should incorporate these issues. Therefore, a single forest management model cannot be globally applied to all forests. These three economic implications are consistent with the economic concepts of sustainable forest management (SFM).

The concept of SFM arises primarily from the notion of sustainable development that has gained increasing recognition worldwide since the late 1980s (Wang, 2004). SFM has evolved through several international efforts in global development, including the 1992 United Nations Conference on Environment and Development (UNCED) or Agenda 21 held in Rio de Janeiro, Brazil, the Intergovernmental Panel on Forests (IPF) during 1995–1997, the Intergovernmental Forum on Forests (IFF) during 1997–2000, and the United Nations Forum on Forests (UNFF) in 2001. The broad concept of Sustainable Forest Management from UNCED was generally called "*Forest Principles*". The guiding objective of the principles is to contribute to the management, conservation, and sustainable development of all types of forests and to provide for their multiple and complementary functions and uses. It is worth noting Principle 2b[2] which identifies that *"Forest resources and forest lands should be sustainably managed to meet the social, economic, ecological, cultural and spiritual needs of present and future generations…"* (FAO, 2003).

A globally agreed-upon definition of SFM was developed in 2003. From the International Conference on the Contribution of Criteria and Indicators for Sustainable Forest Management (CICI-2003) in Guatemala, SFM comprises seven common thematic areas: (1) extent of forest resources, (2) biological diversity, (3) forest health and vitality, (4) productive functions of forest resources, (5) protective functions

[2] In addition, Principle 2b discusses forest resources as forest products and services including wood and wood products, water, food, fodder, medicine, fuel, shelter, employment, recreation, habitats for wildlife, landscape diversity, carbon sinks and reservoirs, and other forest products.

of forest resources, (6) socio-economic functions and (7) legal, policy and institutional framework (FAO, 2003). Although the degree of implementation of criteria and indicators at the national level varies considerably, the concept of SFM has influenced many initiatives at various levels. It has led to the revision of forest policies and legislation and has been mainstreamed by local, national, and international forestry organizations (FAO, 2003). Therefore, the concept of SFM incorporates multiple stakeholders at multiple levels, from local to global. In addition, SFM deals with ecologically sound practices to maintain forest ecosystem integrity, productivity, resilience, and biodiversity (FAO, 2003; Kotwal et al., 2008; Wang and Wilson, 2007). SFM contains multiple equilibria (Kant, 2003), interdisciplinary, heterogeneous, less hierarchical, and more socially accountable than STYM (Wang, 2004; Kant, 2007).

Most of the SFM literature emphasizes the conceptual and theoretical aspects, and discusses the trend of SFM within existing conditions. However, there are several calls for research, particularly in trade in forest products and forest landowner behavior. In order to serve those inquiries, this dissertation presents two econometric models with implications for SFM.

The first essay applies a time series model to the SFM literature and clarifies confusion surrounding trade and SFM. Specifically, some SFM opponents believe that applying SFM will lessen trade transactions and their forest products volume and value. In addition, an inquiry for exchange rate depreciation policy to improve industries competitiveness is another controversy which must be examined. This study employed a vector autoregression (VAR) model in order to illustrate sustainability in U.S.-Canada forest products trade components and to predict the dynamic patterns of those factors when imposing a shock due to policy or other disturbances. With impulse response functions, this paper demonstrates that altering exchange rate policy and forest conservation affect trade components, both in the short run and the long run. This essay discusses implications for SFM in several aspects including offering clarification to forest industries about their profits. Based on the estimated results, however, a call for depreciation policy should be rejected because the policy would not improve industry competitiveness.

The second essay, on the other hand, deals with micro-level problems. With the fact that forest ownership objectives lead to actions, the second essay extracts forest landowner objective categories for owning forestland from the 2007 Cumberland Plateau Landowner Survey, and estimates the probability of holding forest with specific objective categories. This study illustrates a simultaneous-equation model to estimate interactions among ownership objective categories and planned behavior. This essay categorized ownership objectives based on factor analysis including dimensions of non-timber benefits, monetary, farm or home site values, and bequest. Then, factors influencing those categories were estimated and discussed. The study extends the interaction among forest landowner objective categories, willingness to harvest in the future and interest in managing for non-timber uses. The empirical results substantiate the requirement of SFM that forest landowners are not homogenous and containing multiple objectives. In addition, forest ownership objective categories affect planned behavior differently.

PART 1 DYNAMIC PATTERNS IN THE U.S.-CANADA FOREST PRODUCTS TRADE: IMPLICATIONS FOR SUSTAINABLE FOREST MANAGEMENT

ABSTRACT

Because some Sustainable Forest Management (SFM) opponents believe that applying SFM will lessen trade transactions and their forest products volume and value, this study applies a forecasting model to clarify confusion surrounding trade and SFM. In addition, exchange rate depreciation policy to improve industry competitiveness is examined also. This study employed a vector autoregression (VAR) model in order to illustrate forest sustainability in U.S.-Canada forest products trade components and to predict the dynamic patterns of those factors when imposing a shock due to policy or other disturbances. Impulse response functions were calculated, and reveal that altering exchange rate policy and forest conservation affected trade components both in the short run and the long run. Based on the estimated results, a call for exchange rate depreciation policies should be rejected because the policy would not improve the competitiveness of the industries. This study offers empirical evidence of the impact of U.S. sustainable forest management. Increasing forest conservation in the U.S. would discourage exports and increase the social price of wood products in both the short-run and the long-run.

1.A INTRODUCTION

Forest products are an important component of the U.S. economy through consumption, investment, and trade. With rapid economic growth globally until 2007, and with new trade liberalization policies, the volume and value of the forest products trade in the U.S. had been increasing (Figure 1 (a)). Conventional wisdom holds that at least two factors affect the profitability of the forest products industry, exchange rates relative to trading partners, and environmental and forest policies such as those related to forest certification, product labeling, and carbon emissions.

The exchange rate has been commonly perceived as the most important macroeconomic variable affecting the trade flow of forest products. For example, U.S. forest products companies competing internationally have argued strongly for depreciation policies, as this would most probably improve their competitiveness in global markets (Bolkesjø and Buongiorno, 2006). However, depreciation policies may not be a generic solution for competiveness improvement. The bilateral trade of the U.S. and Canada demonstrates that the U.S. forest products trade has been in a deficit since 1989 (Figure 1 (a)), while the value of the U.S. dollar, on average, appreciated against the Canadian dollar in 1992-1995, 1997-1999, and 2000-2002 (Figure 1 (b)). In addition, with the depreciation in the value of the U.S. dollar since 2002, the U.S. trade deficit has broadened to its peak in 2005 of approximately $17 billion, up 56.14% from 2002. This implies that the U.S. forest industries may slightly grasp a price advantage from depreciation or there might be factors affecting the industries' competitiveness other than the exchange rate.

Unlike the depreciation in exchange rates, forest and environmental policies on sustainable development and sustainable forestry are sometimes perceived as trade barriers. For example, Mersmann (2004) notes that forest certification and product labeling have been perceived by exporting countries in the tropics as trade barriers, because the policies directly affect both volume of trade and product composition. In fact, the impacts of forest trade policies toward sustainable forest management (SFM) and other environmental policies are complex, and depend on several factors such as institutions and forest management quality (Richards, 2004). Two major forest certification schemes, Forest Stewardship Council (FSC) created in 1993 and Sustainable Forestry Initiative (SFI) created in 1995, are available for U.S. landowners. Although certification is voluntary for producers, it may be required domestically for green consumers in the U.S. and internationally for trade with certain countries. Therefore, many stakeholders, particularly forest industries, are concerned about the potential impacts of SFM on trade values.

This paper analyzes the effects of exchange rate policies and the increasing forest conservation[1] or SFM measures on forest products imports, exports, and domestic prices. In this study we analytically identified that increasing SFM measures would directly affect the domestic price of wood products. The study hypothesizes that there are not only contemporaneous, but also long-term relationships between forest products trade and these policies. Vector autoregression (VAR) models were utilized, which allowed us to observe the dynamic patterns of forest products trade response to an innovation or a shock in exchange rate and price by calculating impulse response functions (IRFs). The contributions of this study are to provide and discuss the linkages between trade and SFM, and to clarify the controversies regarding trade, exchange rates, and SFM.

The next section reviews the relevant literature. Data used in this study are discussed in section 1.C, followed by discussion of the model. Section 1.E presents empirical results including short-run and long-run effects, implications for sustainable forest management, and sensitivity analysis. The last section discusses policy issues, advantages and disadvantages of the model, and concluding remarks.

1.B RELEVANT LITERATURE

Previous studies on the relationship between exchanges rates and international forest products trade have provided conflicting results. The studies mainly have been focused on the impacts of exchange rate changes on forest products trade volume and/or prices. The earliest empirical studies defined import price elasticity as the elasticity of imports with respect to exchange rates (Adams et al., 1986; Buongiorno et al., 1979). Employing the vector autoregression (VAR) model, previous studies revealed no exchange rate effect on U.S. lumber imports from Canada between 1974 and 1985 (Buongiorno et al., 1988), only some short term exchange rate effects on Swedish and Finnish forest products exports to the U.S. (Uusivuori and Buongiorno,

[1] The forest conservation concept referred in this paper is defined as measures and regulations toward SFM, for example forest certification, zoning, etc.

1990), and both short- and long-run exchange rate effects on U.S. forest products trade (Bolkesjø and Buongiorno, 2006). Other analyses examine the impact of exchange rate changes on export or import prices, or pass-through of exchange rates (Hanninen and Toppinen, 1999). McCarl and Haynes (1985) explain that exchange rates influence the softwood lumber trade between the U.S. and its trading partners. The authors summarize that an increasing exchange rate encourages imports and discourages exports to the country, which acts as an implicit import subsidy (tax) for foreign (domestic) producers.

Jennings et al. (1991) employ VARs with U.S.-Canada trade, and do not find a strong exchange-rate effect in the Canadian lumber sector. Sarker (1993) finds no short-term effect, but a significant equilibrium relationship between Canadian lumber exports and the Canada–U.S. exchange rate. Jee and Yu (2001) include exchange rates in a multivariate cointegration model of U.S. demand for Canadian newsprint, and find a significant long-run exchange-rate elasticity of -1.46, with monthly data from May 1988 to December 1996. Wisdom and Granskog (2003) conclude that exchange rates are an important determinant of southern pine exports because changes in exchange rates affect southern pine exports by changing the cost of southern wood in the foreign market. Only two studies have investigated the effect of changes in the exchange rate on the U.S. forest products trade balance. Kaiser (1984) finds that the depreciation of the U.S. dollar is one of the most effective trade policies to increase U.S. forest products exports and thus to stabilize the U.S. trade balance. Conversely, Baek (2007) adopts an autoregressive distributed lag (ARDL) approach to cointegration, which estimates quarterly bilateral trade data between the U.S. and Canada from 1989 to 2005. He finds that in the short run a change in the value of the U.S. dollar does not significantly influence U.S. trade in forest products. No related study exploring the dynamic patterns of forest products trade exists, other than that assessing the long run exchange rate effects (Bolkesjø and Buongiorno, 2006) or no exchange rates effects on the U.S. trade balance (Baek, 2007).

Few studies address the consequences of SFM on timber and forest products markets. Sedjo et al. (1994) and Sohngen et al. (1999) studied the costs connected to forest conservation and the consequences on trade. Barbier et al. (1995) examined the links between trade in tropical timber products and deforestation in Indonesia. The authors analyzed the economic effects of imposing SFM using a simulation approach. The dynamic effects of forest conservation measures were examined by Linden and Uusivuori (2002). The authors employed historical data from Finland, and calculated both short-run and long-run impacts of forest conservation. Their results reveal that timber markets are influenced by forest conservation. Forest conservation interpreted as an exogenous shock reduces traded quantities and increases timber prices. Leppänen et al. (2005) confirmed that conservation increases timber prices and decreases the harvest by using a dynamic econometric model with Finnish data. However, the impacts on forest industrial output and timber imports were projected to be less than the *a priori* expectations (Leppänen et al., 2005). Finally, Bolkesjø et al. (2005) analyzed the economic consequences, in terms of prices, quantities, trade-flows, income effects, and costs, of increasing forest conservation in Norway. With a partial equilibrium forest sector model, the authors found that increasing conservation mostly reduces production and increases prices. In addition, the study concluded that due to substituting domestic for imported fiber in the Norwegian forest industry, forest conservation in Norway would imply increased harvests in other regions (Bolkesjø et al., 2005).

1.C DATA

The general trends in the U.S.-Canada forest products trade are depicted in Figure 2. In panel (a), imports of total forest products from Canada far exceed exports to Canada. The bilateral trade in forest products illustrates the trade balance deficit since 1989, which has widened since 1994 when the North America Free Trade Agreement (NAFTA) was implemented. Panels, (b) and (c) depict the share of

Canadian forest products imports and exports to the total U.S. forest products imports and exports.

The trade data employed in this article are monthly U.S.-Canada export and import quantity and export unit value of selected forest products from January 1989 to October 2008 (238 observations in each series), gathered from the United States Department of Agriculture (USDA) Foreign Agricultural Service (FASOnline) database. We selected three categories[2] from the Bulk, Intermediate, and Consumer-Oriented (BICO) code (softwood lumber, hardwood lumber, and panel/plywood products). The data are available at http://www.fas.usda.gov/ustrade/. The exchange rate data, values of the Canadian currency in U.S. dollars, are monthly averages, compiled from Federal Reserve Bank of St. Louis and Board of Governors of the Federal Reserve System (available from http://research.stlouisfed.org). Table 1 presents descriptive statistics of the data.

Figure 3 illustrates each data series. Generally, imports in each market behave in response to increases and decreases in the exchange rate. The export data exhibit some unique characteristics. Hardwood lumber exports have the same pattern of exchange rate trends, while Panel/Plywood exports depict a gradually increasing trend. Softwood lumber export data reveal an inverse relationship to exchange rates. Hardwood and softwood lumber price data exhibit an increasing trend throughout period of study while the Panel/Plywood data reveal mixed price trends.

To produce consistent estimates, the data must be stationary across time meaning that it must display neither a trend nor a unit root. We therefore performed the Augmented Dickey-Fuller (ADF) unit root test for stationary testing. All data series are difference stationary where the error term in each series has white-noise properties tested with Ljung-Box's Q. The first difference of the natural logarithm in each series equals the relative change or growth from one period to the next. The notation of variables is provided in Table 1 and For example, $DIMP_{HDWD}$ indicates the

[2] We did not employ the other two categories (logs and chips and other wood products) because their limitation of monthly data and mixed units of measure.

relative change of Hardwood Lumber import quantity; $DEXP_{HDWD}$ indicates the relative change of Hardwood Lumber export quantity; $DPRI_{HDWD}$ indicates the relative change of unit price of Hardwood Lumber; and DEXCH indicates the relative change of exchange rate. The subscripts $_{PPLY}$ and $_{SFTWD}$ are used to indicate Panel/Plywood products and Softwood Lumber, respectively (Table 1).

1.D THE MODEL

The VAR model treats all variables as jointly endogenous. That is, each variable is allowed to depend on its past realization and the real past realizations of all other variables in the system. In addition, the most basic form of a VAR treats all variables symmetrically, without making reference to the issue of dependence versus independence (Enders, 2004). Although this VAR is not derived from any theoretical model, its tools (i.e., Granger causality, impulse response analysis, and variance decompositions) can be helpful in understanding the interrelationships among economic variables and in the formulation of a more structured economic model[3] (Stock and Watson, 2001; Enders, 2004).

The VAR model in this study employs a structural model of disaggregated trade components. Because different categories of forest products may behave in different ways, analyzing by category is critical. To mitigate this problem, this research estimated three VAR models for three selected categories of the bilateral trade of the U.S. and Canada forest products. We imposed shocks or innovations to the system of equations, and then IRFs were calculated to describe the response of trade components. Because the impacts of an innovation may play out over several periods, a cross-section model or any trade models without lag variables will underestimate the total effect of the shocks.

A shock is an unexpected shock that results from unexpected instruments or regulations measured by one standard deviation of the residual. A shock in the

[3] See Enders and Sandler (1991) for application to the impact of terrorism on tourism in Spain and Koonnathamdee (2008) for application in six selected categories of the U.S.-Canada forest products.

exchange rate, for example, may result from a regulation change in holding reserves or any new financial instruments affecting capital flows. We assumed a linkage between SFM and the price of wood products. Therefore any increase in management costs due to voluntary or mandatory adoption of new activities to comply with SFM standards will affect directly the price and transmit this effect to other variables in the systems of equations. Imposing a one standard deviation shock of the residual is the typical practice for employing the unrestricted VAR. The standard deviation represents a one-unit change of the average value. However, a shock may be a discrete change, such as that demonstrated by Enders and Sandler (1991) in investigating the impact of terrorism on tourism in Spain. A shock in their study was an incident relating to terrorism. This study imposes a one standard deviation shock of the residual in exchange rate and price to each variable, which directly affects its own variable and is also transmitted to all of the endogenous variables through the dynamic structure of the VAR.

1.D.1 Theoretical Model

Suppose we have three variables; we can let the time path of each variable be affected by current and past realizations of each variable sequence. Consider the simple system with one lag:

$$x_t = b_{10} - b_{12}y_t - b_{13}z_t + \gamma_{11}x_{t-1} + \gamma_{12}y_{t-1} + \gamma_{13}z_{t-1} + \varepsilon_{xt} \tag{1}$$

$$y_t = b_{20} - b_{21}x_t - b_{23}z_t + \gamma_{21}x_{t-1} + \gamma_{22}y_{t-1} + \gamma_{23}z_{t-1} + \varepsilon_{yt} \tag{2}$$

$$z_t = b_{30} - b_{31}x_t - b_{32}y_t + \gamma_{31}x_{t-1} + \gamma_{32}y_{t-1} + \gamma_{33}z_{t-1} + \varepsilon_{zt} \tag{3}$$

where it is assumed that all left hand side (LHS) variables are stationary. The error terms, ε_{xt}, ε_{yt}, and ε_{zt}, are uncorrelated white-noise disturbances with standard deviations of σ_x, σ_y, and σ_z respectively.

Equations (1)-(3) are the structure of the system incorporating feedback. The LHS variables are allowed to contemporaneously and continuously (long run effect) affect each other. ε_{xt}, ε_{yt}, and ε_{zt}, are pure innovations (or shocks) in x_t, y_t, and z_t respectively. In addition, for example, ε_{xt} could have an indirect contemporaneous effect on y_t and/or z_t if b_{12} and/or b_{13} are not equal to zero.

Using matrix algebra, we can write the system in the compact form:

$$\begin{pmatrix} 1 & b_{12} & b_{13} \\ b_{21} & 1 & b_{23} \\ b_{31} & b_{32} & 1 \end{pmatrix}\begin{pmatrix} x_t \\ y_t \\ z_t \end{pmatrix} = \begin{pmatrix} b_{10} \\ b_{20} \\ b_{30} \end{pmatrix} + \begin{pmatrix} \gamma_{11} & \gamma_{12} & \gamma_{13} \\ \gamma_{21} & \gamma_{22} & \gamma_{23} \\ \gamma_{31} & \gamma_{32} & \gamma_{33} \end{pmatrix}\begin{pmatrix} x_{t-1} \\ y_{t-1} \\ z_{t-1} \end{pmatrix} + \begin{pmatrix} \varepsilon_{xt} \\ \varepsilon_{yt} \\ \varepsilon_{zt} \end{pmatrix}$$

or $\mathbf{Bv_t} = \mathbf{\Gamma_0} + \mathbf{\Gamma_1 v_{t\text{-}1}} + \boldsymbol{\varepsilon}_\mathbf{t}$

where $\mathbf{B} = \begin{pmatrix} 1 & b_{12} & b_{13} \\ b_{21} & 1 & b_{23} \\ b_{31} & b_{32} & 1 \end{pmatrix}$, $\mathbf{v_t} = \begin{pmatrix} x_t \\ y_t \\ z_t \end{pmatrix}$, $\mathbf{\Gamma_0} = \begin{pmatrix} b_{10} \\ b_{20} \\ b_{30} \end{pmatrix}$,

$$\mathbf{\Gamma_1} = \begin{pmatrix} \gamma_{11} & \gamma_{12} & \gamma_{13} \\ \gamma_{21} & \gamma_{22} & \gamma_{23} \\ \gamma_{31} & \gamma_{32} & \gamma_{33} \end{pmatrix}, \quad \boldsymbol{\varepsilon}_\mathbf{t} = \begin{pmatrix} \varepsilon_{xt} \\ \varepsilon_{yt} \\ \varepsilon_{zt} \end{pmatrix}$$

Pre-multiplication by $\mathbf{B^{-1}}$ allows us to obtain the VAR model in standard form

$$\mathbf{v_t} = \mathbf{A_0} + \mathbf{A_1 v_{t\text{-}1}} + \mathbf{e_t} \tag{4}$$

In this paper, we estimate

$$\mathbf{v_t} = \mathbf{A_0} + \mathbf{A_1 v_{t\text{-}1}} + \mathbf{A_2 v_{t\text{-}2}} + \mathbf{\ldots} + \mathbf{A_T v_{t\text{-}T}} + \mathbf{e_t} \tag{5}$$

where $\mathbf{v_t}$ is defined as the vector of variables with first difference of natural logarithms, and T is the total number of lags used in the model.

We define a_i^0 as element i of the vector $\mathbf{A_0}$, a_{ij}^1 as the element in row i and column j of the matrix $\mathbf{A_1}$. Using the same pattern of notation, a_{ij}^T is the element in row i and column j of the matrix $\mathbf{A_T}$. We also define e_{it} as the element i of the vector $\mathbf{e_T}$. FP denotes forest products. With the new notation, Equation (5) can be rewritten in the equivalent form:

$$DEXP_{FPt} = a_1^0 + a_{11}^1 DEXP_{FPt-1} + a_{12}^1 DIMP_{FPt-1} + a_{13}^1 DPRI_{FPt-1} + a_{14}^1 DEXCH_{t-1} + \ldots + a_{11}^T DEXP_{FPt-T} + a_{12}^T DIMP_{FPt-T} + a_{13}^T DPRI_{FPt-T} + a_{14}^T DEXCH_{t-T} + \varepsilon_{1t} \quad (6)$$

$$DIMP_{FPt} = a_2^0 + a_{21}^1 DEXP_{FPt-1} + a_{22}^1 DIMP_{FPt-1} + a_{23}^1 DPRI_{FPt-1} + a_{24}^1 DEXCH_{t-1} + \ldots + a_{21}^T DEXP_{FPt-T} + a_{22}^T DIMP_{FPt-T} + a_{23}^T DPRI_{FPt-T} + a_{24}^T DEXCH_{t-T} + \varepsilon_{2t} \quad (7)$$

$$DPRI_{FPt} = a_3^0 + a_{31}^1 DEXP_{FPt-1} + a_{32}^1 DIMP_{FPt-1} + a_{33}^1 DPRI_{FPt-1} + a_{34}^1 DEXCH_{t-1} + \ldots + a_{31}^T DEXP_{FPt-T} + a_{32}^T DIMP_{FPt-T} + a_{33}^T DPRI_{FPt-T} + a_{34}^T DEXCH_{t-T} + \varepsilon_{3t} \quad (8)$$

$$DEXCH_t = a_1^0 + a_{41}^1 DEXP_{FPt-1} + a_{42}^1 DIMP_{FPt-1} + a_{43}^1 DPRI_{FPt-1} + a_{44}^1 DEXCH_{t-1} + \ldots + a_{41}^T DEXP_{FPt-T} + a_{42}^T DIMP_{FPt-T} + a_{43}^T DPRI_{FPt-T} + a_{44}^T DEXCH_{t-T} + \varepsilon_{4t} \quad (9)$$

The proper number of lags to use is not known *a priori*. There are three methods for determining the appropriate number. The first is to include enough lags to satisfy the assumption that $\mathbf{e_t}$ has zero means, constant variances, and is individually serially uncorrelated; If this is not met, then the innovations will be autocorrelated over time. The second is to include enough so that the additional lag, if included in the regression, is insignificant; that is, not to omit relevant variables from the regression. The third approach is not to include unnecessary lags that would reduce the precision of the estimates. We test for the number of lags using Akaike's Information Criterion (AIC) and Schwarz's Information Criterion (SIC). The estimated optimum lag length was determined to be 12 lags, which are necessary and sufficient to satisfy the requirement of independent and identical distribution in regression. In addition, a 12 month lag is enough to account for seasonal variations in trade. Therefore, we lost 13 observations for each data series by using 12 lags, so the final regressions are based on 225 observations.

With the assumption of $\mathbf{e_t}$ and unrestricted VAR, we estimated the system of equations by ordinary least squares (OLS) equation by equation, which yields the same estimates as the maximum likelihood method (Hamilton, 1994). Briefly, three unrestricted VAR models (hardwood lumber, softwood lumber, and panels and plywood) were estimated with twelve lags of each variable and a constant term. Each

VAR consists of four equations; import, export, price, and exchange rate (Equation (6)-(9)).

After estimating three VARs, we utilized impulse response analysis to quantify and graphically depict the time path of the effects of typical shocks on imports and exports. In equation (5), a VAR can be written in the vector of Moving Average ($\boldsymbol{MA}(\infty)$) form as

$$\begin{bmatrix} x_t \\ y_t \\ z_t \end{bmatrix} = \begin{bmatrix} \bar{x} \\ \bar{y} \\ \bar{z} \end{bmatrix} + \sum_{i=0}^{\infty} \begin{pmatrix} \psi_{11}(i) & \psi_{12}(i) & \psi_{13}(i) \\ \psi_{21}(i) & \psi_{22}(i) & \psi_{23}(i) \\ \psi_{31}(i) & \psi_{32}(i) & \psi_{33}(i) \end{pmatrix} \begin{bmatrix} e_{x_{t-i}} \\ e_{y_{t-i}} \\ e_{z_{t-i}} \end{bmatrix}$$

or in the compact form,

$$\mathbf{v_t} = \boldsymbol{\mu} + \boldsymbol{\Psi}_0\mathbf{e_t} + \boldsymbol{\Psi}_1\mathbf{e_{t-1}} + \boldsymbol{\Psi}_2\mathbf{e_{t-2}} + \dots . \tag{6}$$

with $\boldsymbol{\Psi}_0$ as the impact multiplier[4]. Each element in $\boldsymbol{\Psi}_0$ is the contemporaneous impact of a one-unit change in the error term on a variable. For example, $\psi_{13}(0)$ is the simultaneous impact of a one-unit change in e_{z_t} on x_t. Each element in $\sum_{i=0}^{\infty}\boldsymbol{\Psi}_\mathbf{i}$ is the long-run multiplier which is the accumulated effects of unit impulses in the error term. As stated in Enders (2004), because the variables are assumed to be stationary, each long-run multiplier must be finite. In addition, the long-run multiplier in this method is equal to the long-run effect on the variables of a permanent change in an error term (Hamilton, 1994).

A plot of the coefficient $\psi_{jk}(i)$ against *i* is called the impulse response function (IRF). The IRF describes the system's response to a shock in specific variables (i.e., exchange rate and price) that represents the dynamics in the data given all other variables dated *t* or earlier held constant. It also visually represents the behavior of each series, whether the response converges back to its long run trend, and if so, whether it converges smoothly or with oscillation (Enders, 2004; Hamilton, 1994).

[4] Hamilton (1994) calls this the dynamic multiplier.

1.D.2 Methodology

One objective of this study was to observe the behavior of forest products trade in each category in response to the exchange rate and price shocks due to efforts aimed at sustainable forest management. Before estimating the VARs, however, we performed the Granger causality test. This test determines if the past information of other variables can predict the future of the dependent variables. The results (Table 2) reveal that all other lagged endogenous variables can explain each dependent variable, except for the exchange rate. This information is consistent with our hypothesis that the exchange rate does not depend on other lagged variables except its own lags. In the real world, the exchange rate depends on total domestic and foreign currencies in both current capital accounts. Although forest products trade seems to be large in value, it is not large enough to affect the exchange rate.

Based on Equation (6)-(9), we then estimated 3 unrestricted VARs with 12 lags for each variable and a constant term[5]. Impulse response functions were calculated using a Choleski decomposition. IRF traces the effect of a one standard deviation shock to one of the innovations on current and future values of the endogenous variables. In addition, each VAR yields impact multipliers (short-run effect) and long-run multipliers (long-run effect). Because the variables in the VAR are stationary, a shock in the system would cause variables to differentiate (if at all) from the initial level. The response of the exchange rate, exports, imports, and price to its own positive shock theoretically must be positive in the short-run. This study presents only the response of the variables to an exchange rate innovation and a price innovation. We hypothesize that a shock in exchange rate would discourage exports and encourage imports at least in the short-run, unless there have been some factors suppressing the short-run impacts of exchange rate, such as a contract. A shock in the exchange rate could affect price in both directions, depending on several constraints.

[5] The estimated coefficients of the VARs are not shown in the study, however, they are available upon requested.

A shock in price has no short-run and long-run effect on the exchange rate, as the results of the Granger causality test indicate. We hypothesize that the long-run effects of all variables are finite with either positive or negative values. The long-run effects were calculated and are discussed below.

Because of the stationary characteristics of variables in the VARs, the impulse responses should converge to zero, meaning the variables return to their steady state. The accumulated responses should move to some non-zero constant, implying the long-run multiplier (Quantitative Micro Software, 2005).

1.E EMPIRICAL RESULTS AND DISCUSSION

After imposing positive shocks, the impulse responses of each variable in each market returned to the variable's steady state. Figures 4 - 6 present the dynamic patterns in the disaggregated forest product trade response to a positive innovation in exchange rate and price with the solid line. The dashed line depicts plus and minus two standard errors. The accumulated responses of each variable in each market are shown in Appendix 2 with the same format of the solid and dashed lines. Price variables returned to steady state approximately 15 months faster than other variables. Thus, domestic prices of wood products exhibited less fluctuation (or are less sensitive) than the amount of imports and exports. It is possible that the U.S. forest industries can adjust their wood production to serve the demand by delaying harvests and/or reducing production levels when the domestic price is low, or importing more products when the domestic price is high. Such practices could maintain stability in price. In contrast, if there were a positive shock either in exchange rate or price, import and export variables would have fluctuated before returning to their steady state for approximately 30 months.

1.E.1 Short-run effect

We found a negative instantaneous effect of exports for all three markets in response to the positive shocks. Appreciation in exchange rate and increasing domestic price discouraged exports. Unlike exports, import variables in all observed markets did not respond contemporaneously to the shocks. The results are consistent with Boungiorno et al. (1988) and Koonnathamdee (2008), who reported no statistically significant difference from zero between the short-run effect for the same product imports in response to the exchange rate. Although we hypothesized that the U.S. would have imported more when the exchange rate increased or high domestic price policies were implemented, the result of no response might be due to the U.S. characteristic of the major importer of Canadian forest products. A positive shock in the exchange rate simultaneously reduced the domestic price of hardwood lumber and panel/plywood products. This result substantiates the work of Uusivuori and Buongiorno (1991) and Hanninen and Toppinen (1999). However, the exchange rate shock increased the domestic price of softwood lumber. Price in each market also responded positively to its own price in the short-run, which follows our hypothesis. Furthermore, increasing domestic price reduced exports for all markets. The details of each short-run effect or impact multiplier are presented in Table 3, and Table 4 reports standard errors of impact multipliers. The computed multipliers demonstrate that the magnitude of each multiplier in response to positive or negative shock is the same, but in a different direction.

1.E.2 Long-run effect

The long-run effect or the total effect of each variable in response to a shock can be easily observed, either by the long-run multipliers in Table 3 or by the accumulated response presented in Appendix 2. We found positive long-run multipliers for all import variables in response to a positive shock in exchange rate, while the opposite was true for the export variables - other than hardwood lumber. These results are similar to the findings of Bolkesjø and Boungiorno (2006) confirming international trade theory. The positive long-run multiplier of hardwood lumber exports in response to positive exchange rate shock demonstrates the unique characteristics of the market, especially for the high demand for hardwood from

Canada. To the price variables, negative long-run multipliers in hardwood and softwood lumber are the results of a response to an appreciation shock while panel/plywood products exhibited positive long-run multiplier. Generally, price and import variables responded positively to a positive price shock except for panel/plywood product imports. In contrast, exports would decline after a positive shock in price.

1.E.3 Sensitivity Analyses

This section aims to answer two questions; the sensitivity of the shock and the stability in forecasting. The first question arises because of the typical practice of imposing a one-unit shock, which raises a concern as to what would happen if the shock was more or less than one-unit. Because of the assumptions of linearity of residuals and the unrestricted VAR, each system of equations is estimated by the OLS method, equation by equation. The effects of more or less shock could be obtained by multiplying the proportion to a one-unit case. For example, Figure 4-6 depicts the dynamic patterns in response to a one standard deviation shock using the solid line. The dashed lines represent a plus and minus of two standard deviation shock which are similar to the solid line.

The stability of forecasting comes from the nature of the data, especially for the exchange rates because the exchange rate data reveals an upward trend from the initial period of study to 2002, and a downward trend afterward. To examine the stability of forecasting, this study estimated three additional unrestricted VARs using only data from 1989-2002. With the same procedure, the dynamic patterns of each variable in the observed markets are shown in Figures 7-9. We then calculated the impact and long-run multipliers of each variable as in the Table 5, and Table 6 reports standard errors of the impact multipliers.

Comparing the dynamic patterns from Figures 4-6 to Figures 7-9 reveals that the patterns were very similar, particularly for the time length to the steady state. In addition, the short-run effect of each variable in response to various shocks possessed the same sign. The long-run multipliers also have the same sign except for hardwood lumber exports in response to an exchange rate shock. The consistency of time length to the steady state and the direction of predicted variable is due to the stationary process of the variables.

The magnitude of each impact and long-run multipliers is not the same, because of differences in the estimated coefficients and level of the shocks, especially for the exchange rate. Because of the slight difference in the standard deviation of residuals in the price equations, the magnitudes of each impact and long-run multiplier in response to a price shock are quite close. It is common for every econometric model to have different coefficients when employing different observations, but the consistencies of direction and theory are preferred. Therefore, this study could benefit policy makers in estimating impact direction of the shocks on trade components.

1.E.4 Implications for Sustainable Forest Management

This study is an attempt to link trade in forest products and sustainable forest management and to clarify the controversy of the negative impacts to trade due to increased emphasis on SFM. As discussed before, any SFM instrument in the U.S. is likely to increase the cost of wood products. We imposed a one standard deviation of the price residual as an innovation from SFM, and found that all trade components were influenced by forest conservation. This result is consistent with Barbier et al. (1995), Linden and Uusivuori (2002), Leppänen et al. (2005) and Bolkesjø et al. (2005). All trade components responded to the shock in both the short-run and long-run, except that import variables exhibited only a long-run effect. Our results reveal that a new SFM measure reduced exports in both the short-run and long-run. Increasing forest conservation does not affect imports in the short-run, but it results in higher imports in hardwood and softwood lumber and lower imports in panel/plywood products in the long-run.

According to a review of transnational leakage of forest conservation, forest conservation in the U.S. can influence the degree of conservation or deforestation in

Canada (Gan and McCarl, 2007). Our results indicate that the U.S. will export less of all products in both the short-run and long-run, but import more hardwood and softwood lumber from the Canada in the long-run. The reduction in the U.S. export of all products may imply that the products are used higher in the country. Increase in Canadian hardwood imports may imply about transnational leakage because this may increase harvesting level in Canadian hardwood forests. However, softwood lumber in Canada is produced from both natural and plantation forests. Thus, the issue of transnational leakage of forest conservation is less clear in the U.S. and Canada experience.

A new or more stringent SFM instrument (e.g., forest certification) influenced the higher price contemporaneously and over time for all observed markets. This result probably represents a concern for forest industries; however the higher price does not always mean lower producer income. Because the demand for wood products in general is price inelastic and the market structure of wood products is oligopolistic, forest industries would gain the net higher income from increasing SFM efforts or adopting more stringent forest certification schemes. In this case, consumers receive the burden.

The results differ substantially from the policy perspective toward SFM in Europe. Leppänen et al. (2005) and Bolkesjø et al. (2005) noted that there are compensations to forest industries in order to encourage SFM practice including forest certification and other tax and emission trading systems. Unlike Europe, the policies toward SFM in the U.S. are voluntary. Some forest owners could sell their uncertified timbers at a slightly higher price but lower than that for certified products because the market for uncertified products is still available. Furthermore, the emerging markets for non-timber forest products and ecosystem services, whose production could be enhanced by SFM, could lessen the negative impact for landowners through these new revenue streams. Signaling may lower the magnitude of price shocks, however, and also the impacts on trade variables of increasing forest conservation. That is, SFM efforts in the U.S. have been aimed at ensuring that managing for timber markets maintains ecological, economic, and social sustainability, and have resulted in significant lags in implementation. As a result of the long time period for implementation, rational producers and consumers may adjust their behaviors prior to policy implementation. Therefore, a lower magnitude of the price shock could be possible. The expected burdens, benefits, and costs, and all trade components in response to the shock would be lower than the study estimates.

1.F CONCLUDING REMARKS

This study assessed the effects of changes in the exchange rate and sustainable forest management on trade in three forest product markets, not only contemporaneously but also over time. This essay examined three forest product groups, hardwood lumber, panel/plywood products, and softwood lumber, under the unrestricted Vector Autoregression (VAR) using monthly data of the U.S.-Canada bilateral trade. This study presents impulse response functions (IRFs) that describe the response of imports, exports, and domestic prices to exogenous shocks in exchange rate and SFM instruments. The IRFs revealed significant dynamic responses to a shock in exchange rate and a shock in price as the proxy of increasing forest conservation. These dynamic responses suggest that models of forest products trade and/or related policies may be incomplete if they cannot explain the dependence of current trade components on the history of all other related variables.

Major findings of the study are that a shock in the exchange rate did not affect U.S. imports in the short run; a shock in exchange rate reduced U.S. exports in the short run; and exchange rate played an essential role in determining the long-run behavior of the U.S. trade in forest products. These findings confirm that depreciation policies should be rejected, because the policy would not improve significant competitiveness of the industries. The U.S. forest products trade still exhibits a large deficit in both short-run and long-run, particularly for hardwood and softwood lumber. This study substantiates the results of Daigneault et al. (2008).

The essay offers empirical evidence of the impact of U.S. sustainable forest management. Increasing forest conservation discouraged exports and encouraged the social price of wood products in both the short-run and long-run. The U.S. will import more hardwood and softwood lumber from Canada in the long-run to offset excess demand. However, the impacts on forest products of increasing forest conservation may be overestimated because the U.S. currently has implemented SFM voluntarily and with no legislation or enforcement.

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APPENDICES

APPENDIX 1– TABLES AND FIGURES

Table 1. Descriptive statistics for U.S.-Canada trade variables

Variable	Mean	Maximum	Minimum	Std. Dev.	Unit	Abbreviation as dependent variable
Exchange Rate	1.313	1.600	0.967	0.159	N/A	DEXCH
Hardwood Lumber Imports	59,692	116,597	15,685	28,975	M^3	$DIMP_{HDWD}$
Panel/Plywood Imports	595,902	1,156,692	94,612	323,749	M^3	$DIMP_{PPLY}$
Softwood Lumber Imports	3,295,039	4,924,065	1,736,685	671,600	M^3	$DIMP_{SFTWD}$
Hardwood Lumber Exports	67,901	105,648	26,024	16,857	M^3	$DEXP_{HDWD}$
Panel/Plywood Exports	65,687	114,485	15,520	20,250	M^3	$DEXP_{PPLY}$
Softwood Lumber Exports	55,146	118,515	23,354	17,819	M^3	$DEXP_{SFTWD}$
Hardwood Lumber Price	372.487	472.874	210.013	46.296	$US/$M^3$	$DPRI_{HDWD}$
Panel/Plywood Price	392.013	549.716	276.507	72.231	$US/$M^3$	$DPRI_{PPLY}$
Softwood Lumber Price	210.291	263.760	126.357	28.881	$US/$M^3$	$DPRI_{SFTWD}$

Table 2. Granger causality tests for U.S.-Canada trade variables

Dependent variable	All other lagged endogenous variables	Chi-square	Degree of freedom	Probability
$DIMP_{HDWD}$	DEXCH $DPRI_{HDWD}$ $DEXP_{HDWD}$	52.094	36	0.040
DEXCH	$DIMP_{HDWD}$ $DPRI_{HDWD}$ $DEXP_{HDWD}$	23.627	36	0.944
$DPRI_{HDWD}$	$DIMP_{HDWD}$ DEXCH $DEXP_{HDWD}$	58.590	36	0.010
$DEXP_{HDWD}$	$DIMP_{HDWD}$ DEXCH $DPRI_{HDWD}$	69.867	36	0.001
$DIMP_{PPLY}$	DEXCH $DPRI_{PPLY}$ $DEXP_{PPLY}$	70.167	36	0.001
DEXCH	$DIMP_{PPLY}$ $DPRI_{PPLY}$ $DEXP_{PPLY}$	19.986	36	0.986
$DPRI_{PPLY}$	$DIMP_{PPLY}$ DEXCH $DEXP_{PPLY}$	77.717	36	0.000
$DEXP_{PPLY}$	$DIMP_{PPLY}$ DEXCH $DPRI_{PPLY}$	93.929	36	0.000
$DIMP_{SFTWD}$	DEXCH $DPRI_{SFTWD}$ $DEXP_{SFTWD}$	57.633	36	0.013
DEXCH	$DIMP_{SFTWD}$ $DPRI_{SFTWD}$ $DEXP_{SFTWD}$	22.378	36	0.963
$DPRI_{SFTWD}$	$DIMP_{SFTWD}$ DEXCH $DEXP_{SFTWD}$	50.423	36	0.056
$DEXP_{SFTWD}$	$DIMP_{SFTWD}$ DEXCH $DPRI_{SFTWD}$	56.454	36	0.016

Table 3. Impact and long-run multipliers for U.S.-Canada trade variables

Variable	Appreciation exchange rate innovation (Depreciation)		SFM regulation innovation pass-through price shock	
	Impact multiplier	Long-run multiplier	Impact multiplier	Long-run multiplier
$DIMP_{HDWD}$	0.0000 (0.0000)	0.0597 (-0.0597)	0.0000	0.0042
$DPRI_{HDWD}$	-0.0043 (0.0043)	-0.0078 (0.0078)	0.0323	0.0170
$DEXP_{HDWD}$	-0.0126 (0.0126)	0.0189 (-0.0189)	-0.0168	-0.0043
$DIMP_{PPLY}$	0.0000 (0.0000)	0.0506 (-0.0506)	0.0000	-0.0036
$DPRI_{PPLY}$	-0.0064 (0.0064)	0.0027 (-0.0027)	0.0523	0.0240
$DEXP_{PPLY}$	-0.0111 (-0.0111)	-0.0162 (0.0162)	-0.0437	-0.0390
$DIMP_{SFTWD}$	0.0000 (0.0000)	0.0287 (-0.0287)	0.0000	0.0017
$DPRI_{SFTWD}$	0.0024 (-0.0024)	-0.0023 (0.0023)	0.0460	0.0255
$DEXP_{SFTWD}$	-0.0261 (0.0261)	-0.0470 (0.0470)	-0.0410	-0.0190

Table 4. Impact multipliers and standard errors for U.S.-Canada trade variables

Variable	Impact multiplier and standard errors (Positive exchange rate shock)	Impact multiplier and standard errors (Positive price shock)
$DIMP_{HDWD}$	0.0000 [0.00000]	0.0000 [0.00000]
$DPRI_{HDWD}$	-0.0043 [0.00216]	0.0323 [0.00152]
$DEXP_{HDWD}$	-0.0126 [0.00496]	-0.0168 [0.00486]
$DIMP_{PPLY}$	0.0000 [0.00000]	0.0000 [0.00000]
$DPRI_{PPLY}$	-0.0064 [0.00350]	0.0523 [0.00246]
$DEXP_{PPLY}$	-0.0111 [0.00652]	-0.0437 [0.00616]
$DIMP_{SFTWD}$	0.0000 [0.00000]	0.0000 [0.00000]
$DPRI_{SFTWD}$	0.0024 [0.00307]	0.0460 [0.00217]
$DEXP_{SFTWD}$	-0.0261 [0.00914]	-0.0410 [0.00885]

Table 5. Impact and Long-run Multipliers for U.S.-Canada trade variables: 1989-2002

Variable	Appreciation exchange rate innovation (Depreciation)		SFM regulation innovation pass-through price shock	
	Impact multiplier	Long-run multiplier	Impact multiplier	Long-run multiplier
$DIMP_{HDWD}$	0.0000 (0.0000)	0.0110 (-0.0110)	0.0000	0.0092
$DPRI_{HDWD}$	-0.0027 (0.0027)	-0.0054 (0.0054)	0.0339	0.0165
$DEXP_{HDWD}$	-0.0031 (0.0031)	-0.0029 (0.0029)	-0.0220	-0.0114
$DIMP_{PPLY}$	0.0000 (0.0000)	0.0236 (-0.0236)	0.0000	-0.0090
$DPRI_{PPLY}$	-0.0048 (0.0048)	0.0004 (-0.0004)	0.0548	0.0264
$DEXP_{PPLY}$	-0.0167 (0.0167)	-0.0089 (0.0089)	-0.0485	-0.0394
$DIMP_{SFTWD}$	0.0000 (0.0000)	0.0139 (-0.0139)	0.0000	0.0065
$DPRI_{SFTWD}$	0.0001 (-0.0001)	-0.0133 (0.0133)	0.0471	0.0241
$DEXP_{SFTWD}$	-0.0318 (0.0318)	-0.0215 (0.0215)	-0.0431	-0.0270

Table 6. Impact multipliers and standard errors for U.S.-Canada trade variables: 1989-2002

Variable	Impact multiplier and standard errors (Positive exchange rate shock)	Impact multiplier and standard errors (Positive price shock)
$DIMP_{HDWD}$	0.00000 [0.00000]	0.00000 [0.00000]
$DPRI_{HDWD}$	-0.00274 [0.00273]	0.03394 [0.00193]
$DEXP_{HDWD}$	-0.00312 [0.00633]	-0.02196 [0.00621]
$DIMP_{PPLY}$	0.00000 [0.00000]	0.00000 [0.00000]
$DPRI_{PPLY}$	-0.00482 [0.00441]	0.05484 [0.00311]
$DEXP_{PPLY}$	-0.01670 [0.00851]	-0.04849 [0.00800]
$DIMP_{SFTWD}$	0.00000 [0.00000]	0.00000 [0.00000]
$DPRI_{SFTWD}$	0.00006 [0.00379]	0.04714 [0.00268]
$DEXP_{SFTWD}$	-0.03178 [0.01180]	-0.04305 [0.01140]

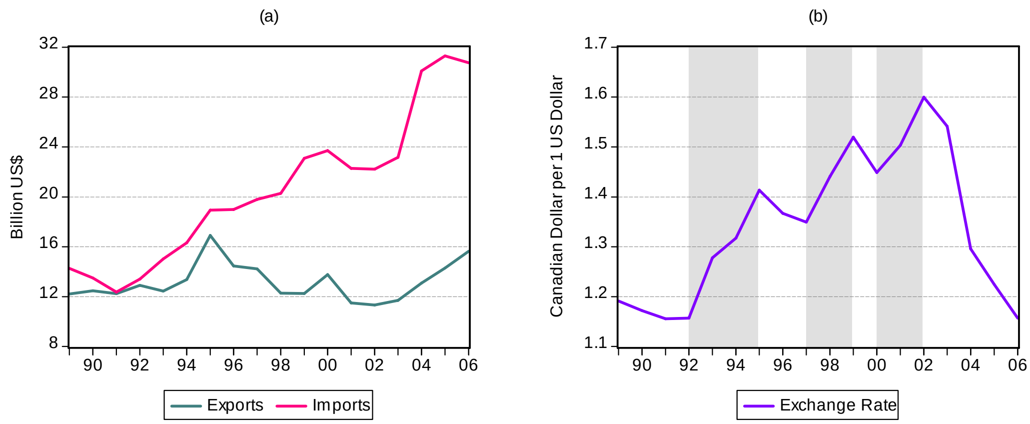

Figure 1. U.S. forest products trade (a) and exchange rate (b) trends

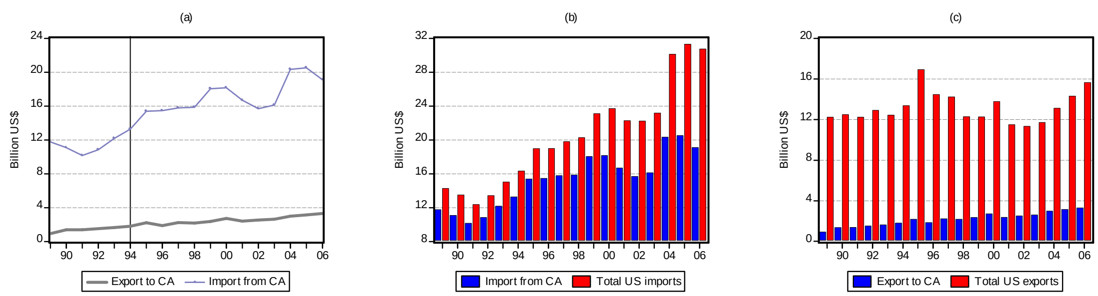

Figure 2. U.S.- Canada trade in forest products (a), the share of imports from Canada to the total U.S. imports (b) and the share of exports to Canada to the total U.S. exports (c)

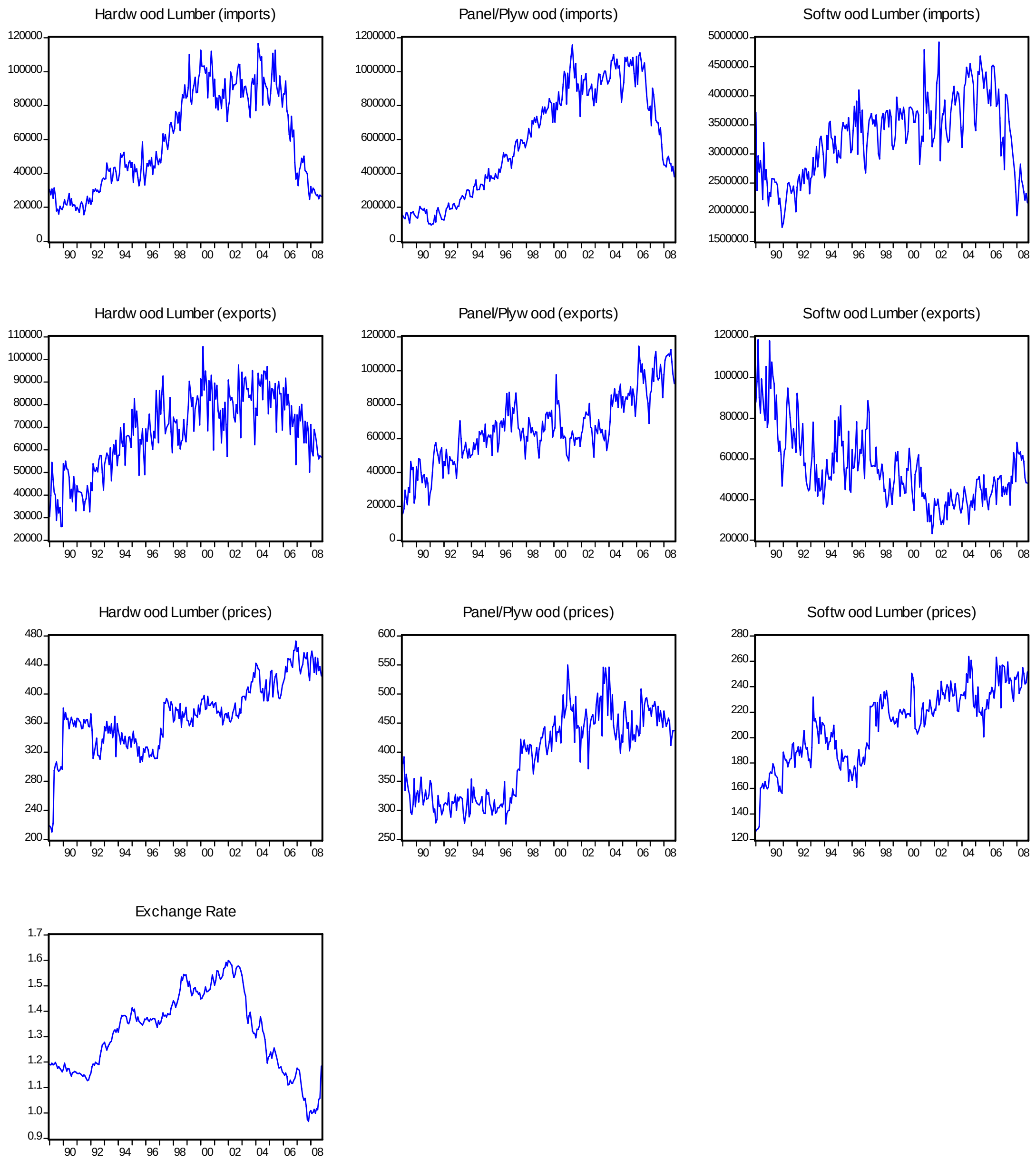

Figure 3. Monthly U.S.-Canada exchange rate and forest products trade: 1989-2008

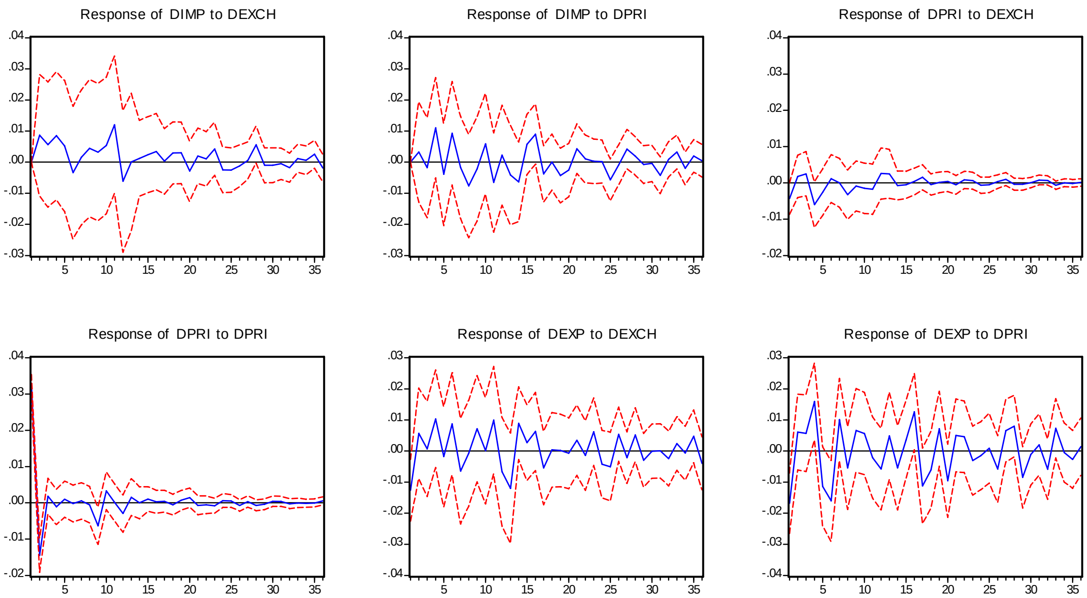

Figure 4. Dynamic patterns in hardwood lumber market

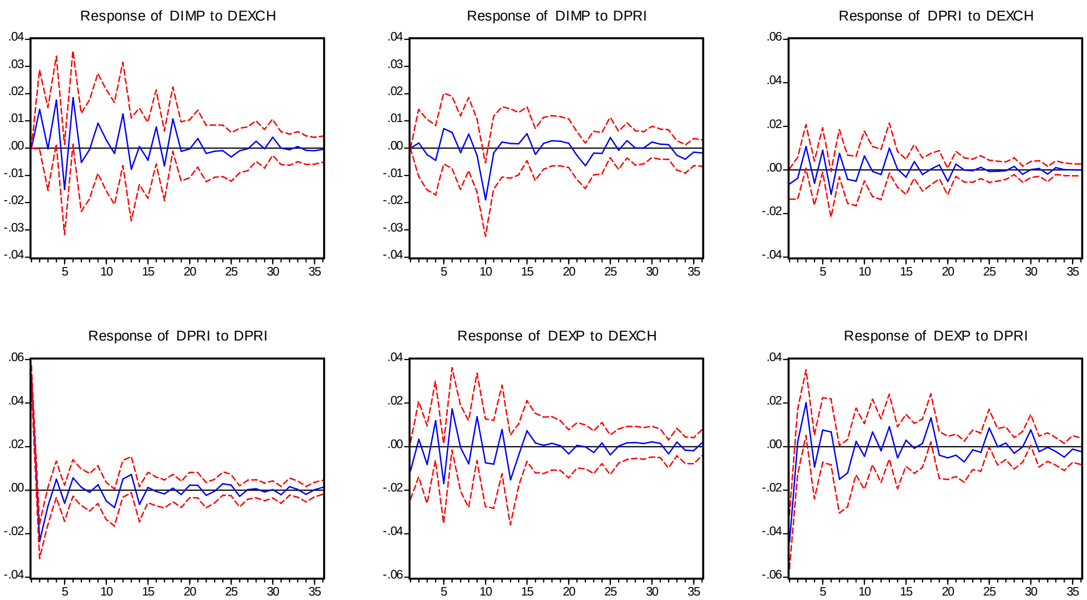

Figure 5. Dynamic patterns in panel/plywood product market

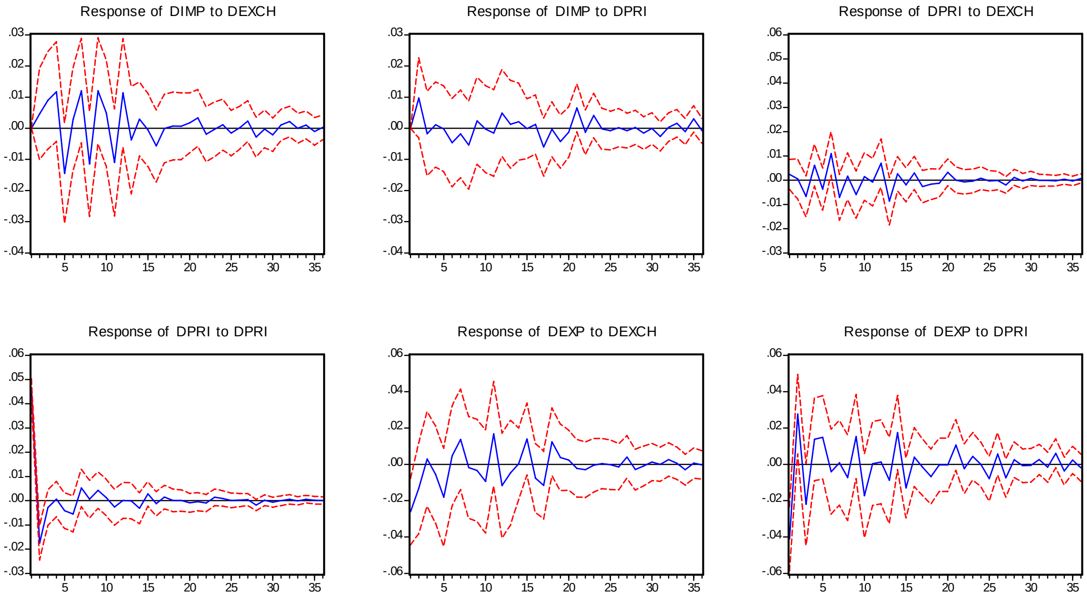

Figure 6. Dynamic patterns in softwood lumber market

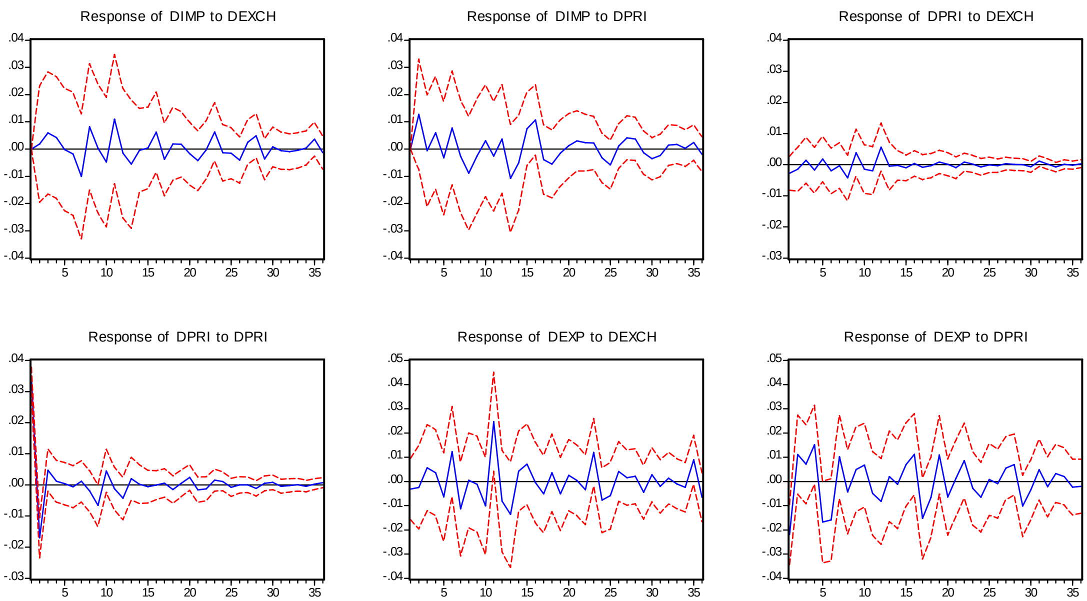

Figure 7. Dynamic patterns in hardwood lumber market: 1989-2002

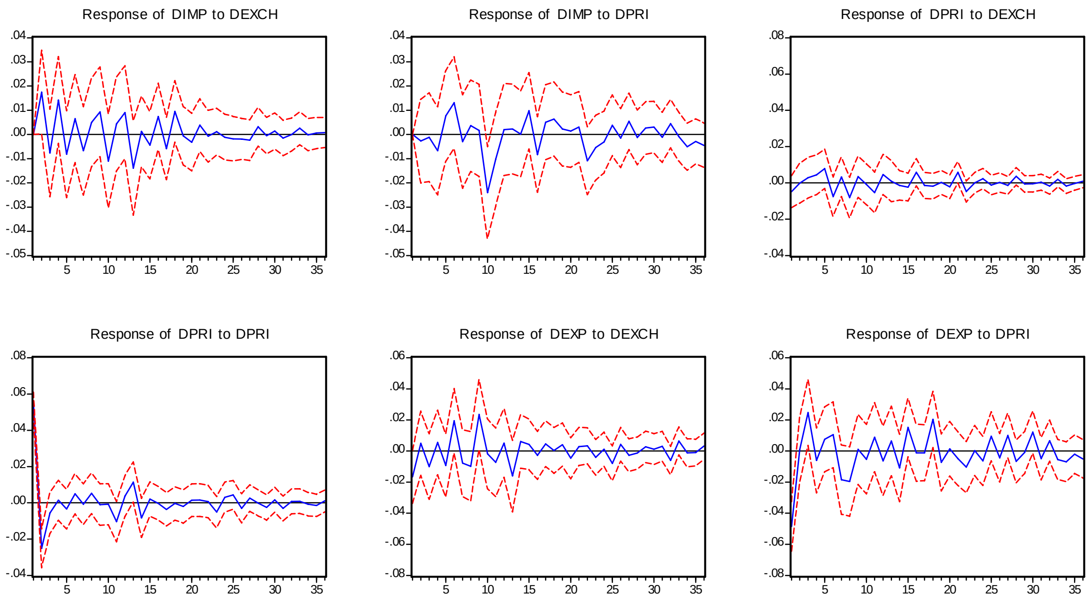

Figure 8. Dynamic patterns in panel/plywood product market: 1989-2002

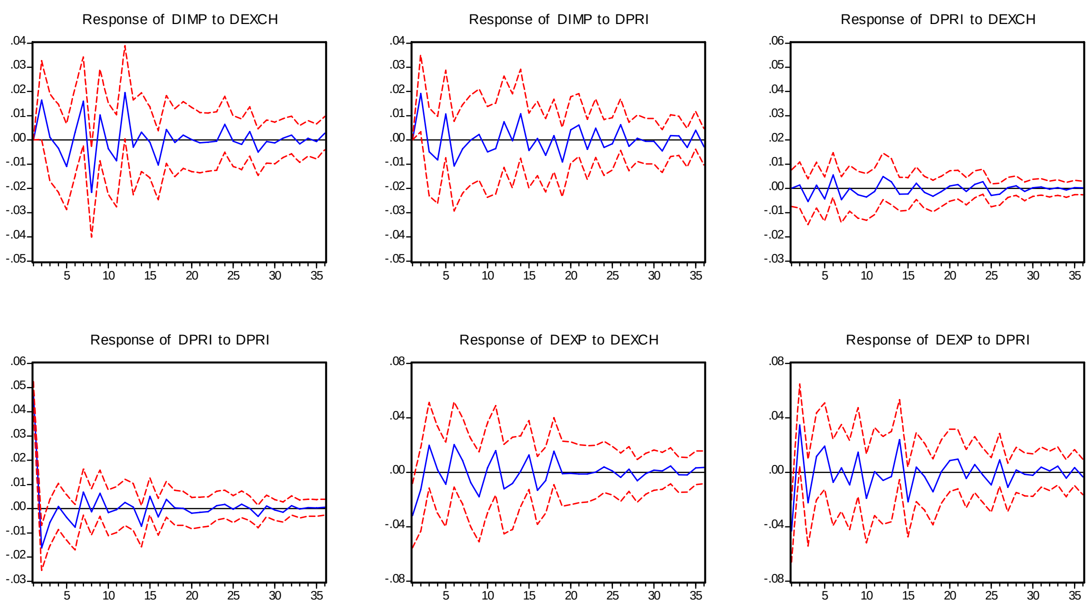

Figure 9. Dynamic patterns in softwood lumber market: 1989-2002

APPENDIX 2 –FIGURES OF ACCUMULATED RESPONSE

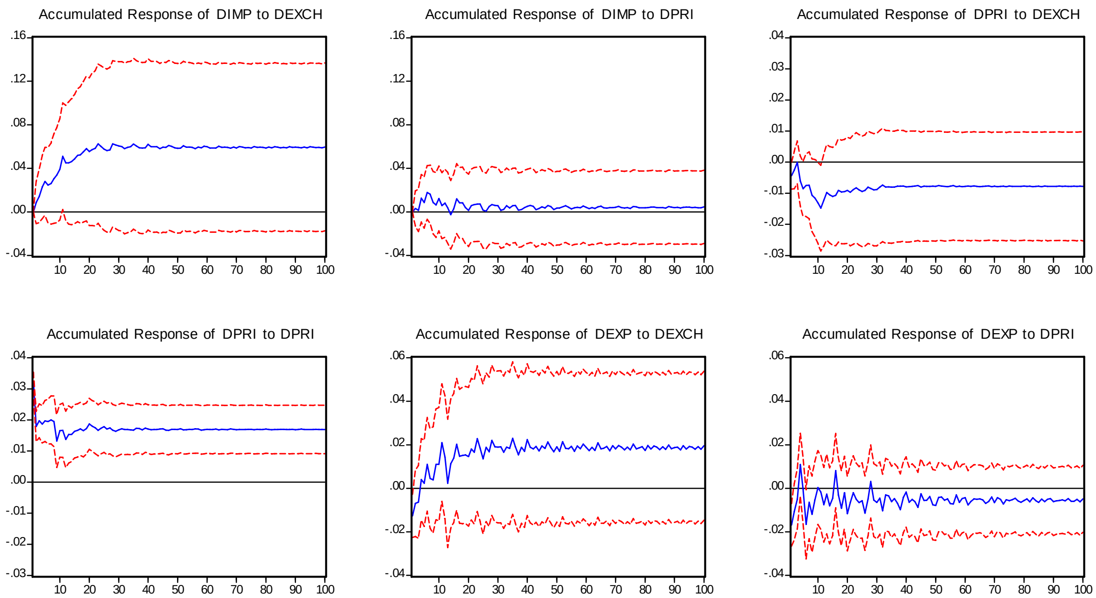

Figure 10. Accumulated response of variables in hardwood lumber market

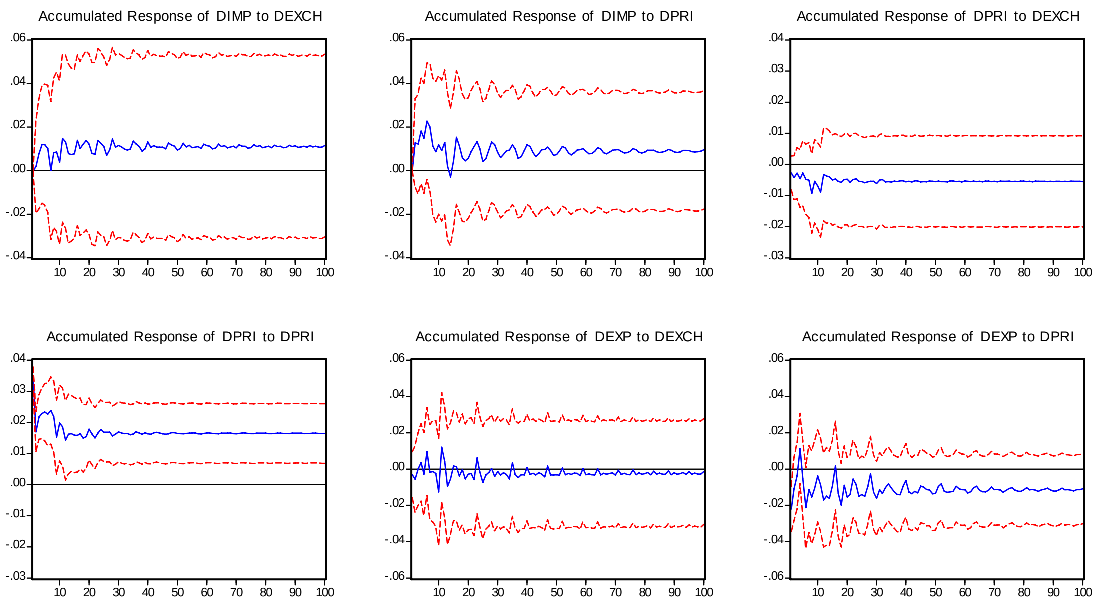

Figure 11. Accumulated response of variables in hardwood lumber market: 1989-2002

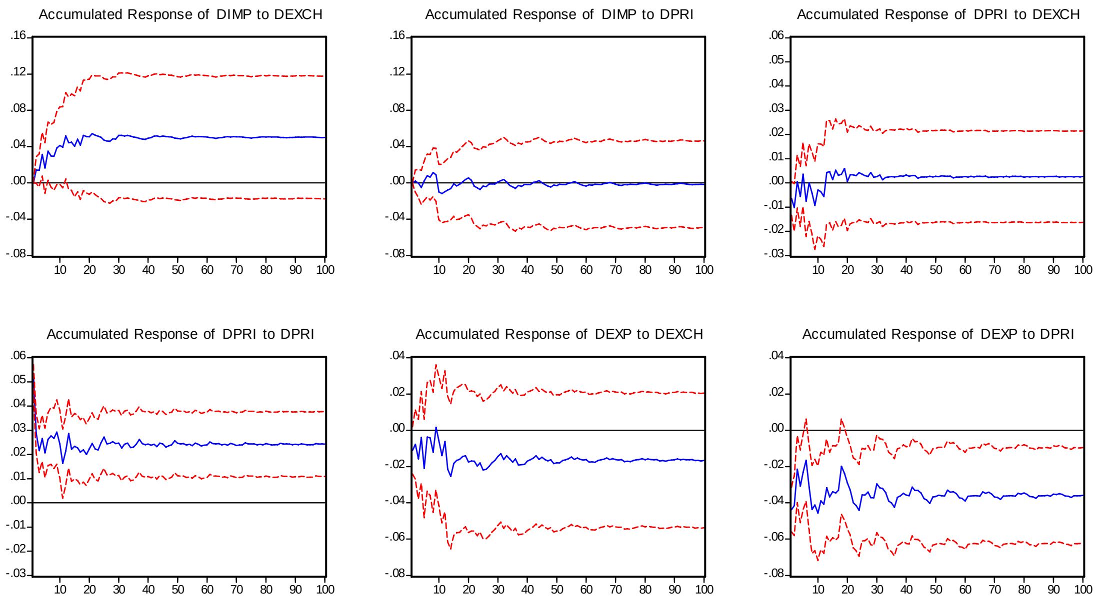

Figure 12. Accumulated response of variables in panel/plywood products market

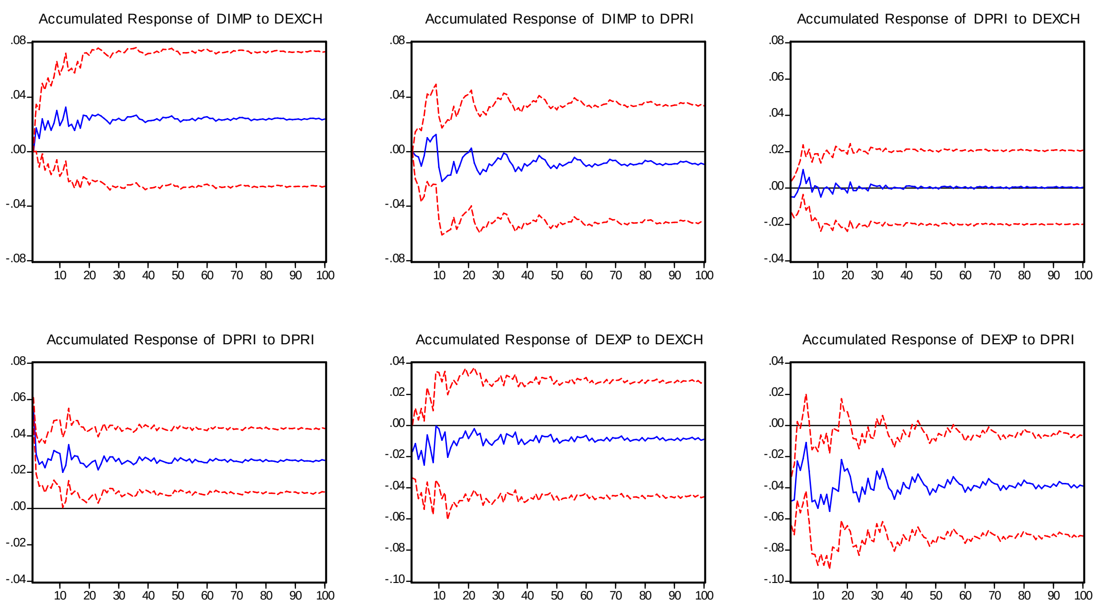

Figure 13. Accumulated response of variables in panel/plywood products market: 1989-2002

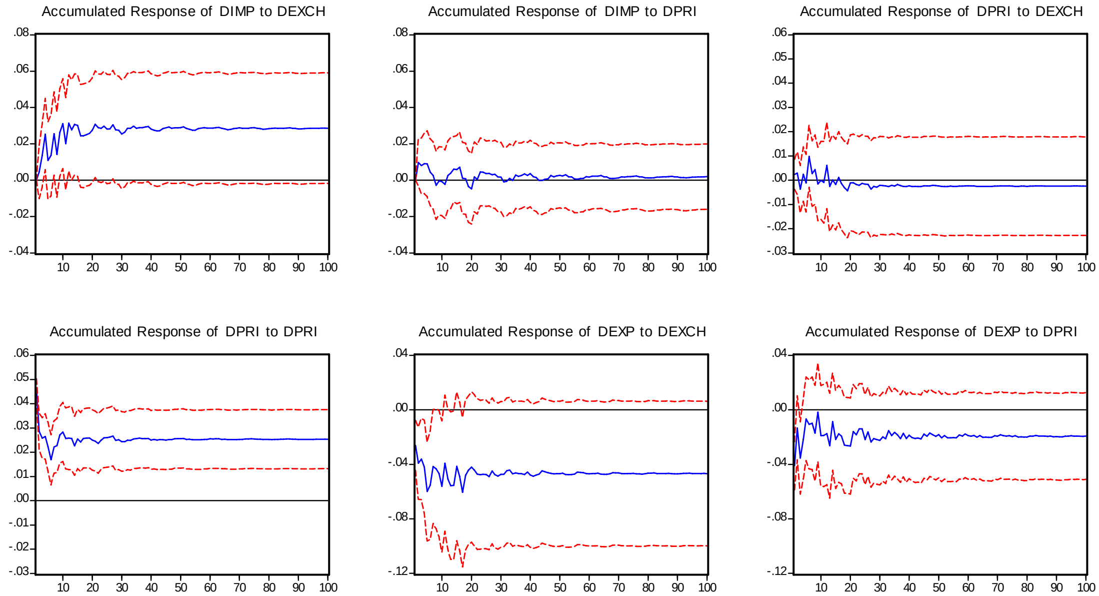

Figure 14. Accumulated response of variables in softwood lumber market

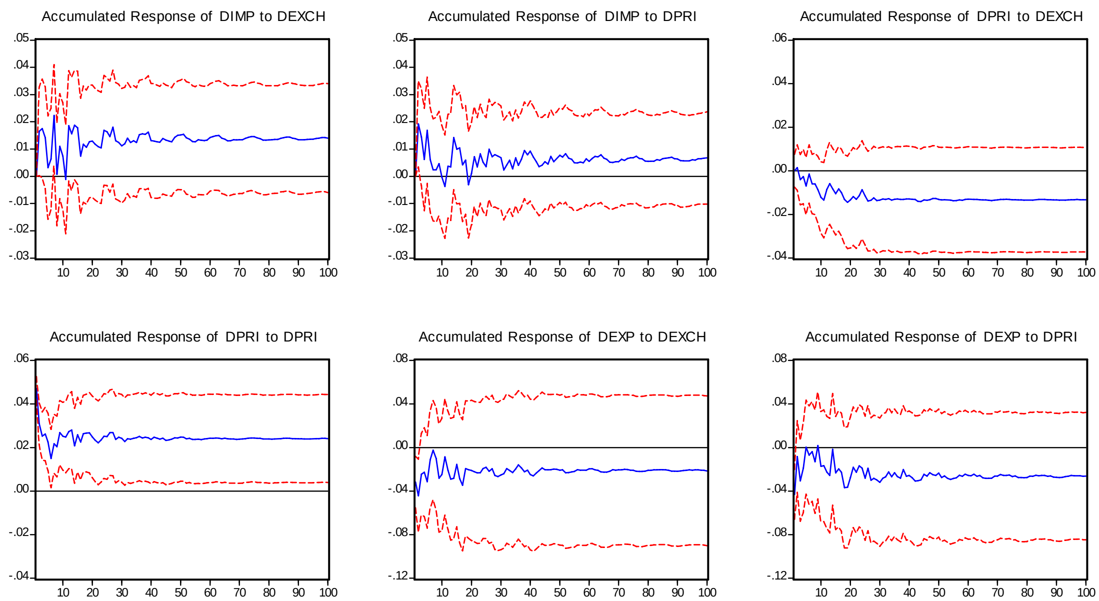

Figure 15. Accumulated response of variables in softwood lumber market: 1989-2002

PART 2 EXPLORING NONINDUSTRIAL PRIVATE FOREST OWNERSHIP OBJECTIVE CATEGORIES, WILLINGNESS TO HARVEST TIMBER, AND INTEREST IN NON-TIMBER USES

ABSTRACT

Fragmentation and parcelization of forestland represent two of the more significant issues for Sustainable Forest Management (SFM) in the United States. Resolving the problems resulting from these issues requires information about forest owners. This study illustrates a simultaneous-equation model to estimate interactions among ownership objective categories and planned behavior. This study categorized multiple ownership objectives including dimensions of non-timber benefits, monetary, farm or home site values, and bequest. Factors influencing those categories then were estimated and discussed. The study also estimates factors influencing willingness to harvest in the future and interest in managing for non-timber uses. The empirical results reveal that forest landowners are not homogenous and possess multiple ownership objectives. The interaction among ownership objective categories and planned behavior reveal that implementing incentives and revising U.S. forest policy with SFM objectives should be considered in order to remedy the current forest problems.

2.A INTRODUCTION

Fragmentation and parcelization of forestland represent two the more significant issues for Sustainable Forest Management (SFM) in the United States. According to DeCoster (2000), "about 3 million acres are being split into pieces smaller than 100 acres every two years… around 2.4 million acres of forestland are also being converted to developed land every two years." While fragmentation results from both natural disturbances and human activity (DeCoster, 2000), parcelization is due primarily to forest landowner decisions (McEvoy, 2004). In addition, recreation use, residential development, and other objectives have become increasingly important to nonindustrial private forest (NIPF) owners. Because the external environment for forestry and forest landowners' behavior are continuously changing, existing forest policies must be adjusted constantly. SFM policies that balance the economic, social, and environmental dimensions of management can be one solution to address these problems. In order to implement the appropriate policies and to effectively deliver essential information regarding forest management to NIPF owners, we must better understand their reasons for owning forests, attitudes, and behavior.

Few studies had been focused on landowner attitudes, beliefs, and motivations prior to 1990 (Bliss and Martin, 1989). Conversely, NIPF landowner behavior has been studied extensively since 1990, particularly with regard to how they make decisions (Newman, 2002; Amacher et al., 2003; Conway et al., 2003). Without incorporating existing knowledge of landowner behavior and objectives, harvesting and reforestation policies are incomplete, because landowners might be interested in factors such as recreation and bequests (Conway et al., 2003). In addition, "behavior is driven by a much richer set of values and preferences" (Becker, 1993); self-interest or material gain may not be the only objective. In fact, landowners do not possess a single objective. Therefore, understanding landowner objectives and behavior requires a multiple objective framework. However, much of the existing NIPF literature either assumes that all landowners behave similarly, uses a representative agent model[1], or does not differentiate decisions by ownership types. Kuuluvainen et al. (1996), Kurttila et al. (2001), Janota and Broussard (2008) and Majumdar et al. (2008) are some of the exceptions.

The objectives of this paper are to explore NIPF landowner reasons for owning forests and to test for the existence of differing NIPF ownership categories. The study estimated models that address all of the important, and related, NIPF landowner objectives and future decisions. In other words, the study provides information on heterogeneous forest landowner objective categories and the link between each ownership type and behavior. The second objective is to estimate how forest owner objectives influence actual behavior. This objective provides some insight into the current problems of fragmentation and parcelization, which are projected to reduce

[1] A representative agent model is employed generally in economics assuming all agents' preference and behavior are similar.

future timber supplies. Specifically, examining the effects of different categories of ownership objectives on making decision may offer opportunities to mitigate the extent of fragmentation and parcelization.

The remaining sections of the paper introduce the empirical model which is comprised of three equations explaining NIPF ownership categories, decisions, and interest in managing for non-timber values; describe the data and variables used; discuss the econometric model containing a set of equations; and present the empirical results and their implications.

2.B EMPIRICAL MODEL

This analysis follows conventional economic assumptions including the assumptions of Becker (1993) that individuals (NIPF owners) maximize welfare as they envision it. Their behavior is forward-looking that is grounded in the past, and assumed to be consistent over time. In addition, forest owners try to anticipate the uncertain consequences of their actions. With these assumptions, ownership objective categories, which may be seen as beliefs, values, or preferences, not only directly affect decisions, but also affect other attitudes. Decisions and attitudes also influence forest owner objectives as feedback or rational expectation. We also apply Ajzen (1991), the theory of planned behavior, to our analysis. Because the willingness to harvest timber in the future and interest in managing for non- timber uses in fact are intention, they affect actual behavior directly. Based on these assumptions, we hypothesize interaction among ownership objective categories, intention, and behavior.

Ownership objective categories as used in this study were derived from 16 reasons for owning forests stated in question 6 of the questionnaire (Appendix 2). Each objective category was based on the forest owner utility maximization, including benefits from tangible and intangible values[2]. Each category contained different

[2] Considering each reason for owning forests as goods and services from the forest, the owner receives many dimensions of benefits and utility from it. Although each NIPF owner has several bundles containing goods and services from his forest, with theory of consumer behavior he can compare and

weights of 16 ownership reasons therefore it follows the multiple objectives scheme. This concept differs from those in previous studies that assumed only one objective for holding a forest, mostly timber production. Details of each category derivation are discussed in the data and variables section.

Based on the discussed assumptions, our empirical model was comprised of three related models. First, a multinomial logit or polytomous logistic regression model was used to estimate the probability of differences in forest ownership categories or types. Second, a probit model was utilized to estimate the probability of landowners planning future timber harvests. Finally, a linear regression model estimated by ordinary least squares (OLS) is employed to estimate landowner interest in managing for non-timber objectives. The models are discussed below.

2.B.1 NIPF ownership objective categories

Previous studies of NIPF owner ownership objectives suggest that landowners should not be treated as one homogenous group (Kurttila et al., 2001; Majumdar et al., 2008; Kaetzel, 2008). Landowners may differ with regard to ownership motivations, views on stewardship, and forest management behavior. These differences can be logically related to various landowner groups. Majumdar et al. (2008) characterized NIPF owners in Alabama, Georgia, and South Carolina. Based on multivariate cluster analysis, forest owners are described as belonging to one of three groups; those with timber, non-timber, or multiple objectives. Using the concept of strategic management, Kurttila et al. (2001) categorized NIPF owners' forestry business units into four business groups: Stars, Cash Cows, Wildcats, and Dogs[3]. The authors estimated these strategic choices using multinomial logit model with forest owner and forest holding characteristics as explanatory variables. Kaetzel (2008) employed

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pick the best bundle with highest utility. Therefore, a forest owner can compare and rank all possible reasons for holding a forest.

[3] These groups are related to forest strategies matrix; strengths, weaknesses, opportunities, and threats. Based on strengths, Stars are the forest businesses containing opportunities while Cash cows are the businesses containing threats. Based on weaknesses, Wildcats are the businesses with opportunities while Dogs are the businesses with threats.

principal component analysis to group NIPF owners of the Tennessee Northern Cumberland Plateau. The author categorized forest owners into four groups, heritage, privacy, utility, and undecided[4]. Based on these results, the multinomial logit model was employed to estimate the probability of the type of motivation for owning woodland, using selected independent variables of owners' information, attitudes, and behavior.

The model was based on the principle that a rational forest owner makes decisions to hold forest to maximize the utility gained from that choice. The forest landowner type equation was specified as a predicted probability:

$$\Pr(y_i = m \mid x_i) = \frac{\exp(\mathbf{x}_i \boldsymbol{\beta}_m)}{\sum_{j=1}^{J} \exp(\mathbf{x}_i \boldsymbol{\beta}_j)} \text{ where } \boldsymbol{\beta}_1 = \mathbf{0}. \tag{1}$$

Since $\exp(\mathbf{x}_i \boldsymbol{\beta}_1 = \mathbf{0}) = \exp(\mathbf{x}_i \mathbf{0}) = 1$, the model is commonly written as

$$\Pr(y_i = 1 \mid x_i) = \frac{1}{1 + \sum_{j=2}^{J} \exp(\mathbf{x}_i \boldsymbol{\beta}_j)}$$

or in the general form

$$\Pr(y_i = m \mid x_i) = \frac{\exp(\mathbf{x}_i \boldsymbol{\beta}_m)}{1 + \sum_{j=2}^{J} \exp(\mathbf{x}_i \boldsymbol{\beta}_j)}.$$

(2)

$\Pr(y_i = m \mid x_i)$ represents the probability of observing outcome *m* given **x**, where *y* is the dependent variable with *J* nominal outcomes, $\mathbf{x}$ represents a vector of independent variables influencing landowner objective categories, and $\boldsymbol{\beta}$ is a vector of parameters. The maximum likelihood method was used to estimate the model requiring asymptotic properties in order to produce efficient estimators (Long, 1997). The

[4] In Kaetzel (2008), 9 landowner motivations are used as criteria to group landowner. Landowner with privacy motivation has factor loadings in the following motivations: for privacy, to have trees surrounding primary or vacation home, and to learn more from nature. Landowner with utility motivation has factor loadings in: long-term financial investment, to collect firewood, for timber production, and for hunting and fishing. For heritage motivation, landowner has factor loadings in: to pass woodland to children or other heirs and woodland as part of family heritage. Undecided category represents all missing data.

dependent variable represents the forest landowner objective categories, which are discussed in detail in Section 2.C.2 below. The independent variables in the model were chosen based on economic theory, assuming that a NIPF owner chooses an objective category bundle to maximize his/her utility, subject to a budget constraint. The probability of landowner objective types can be derived as a function of land characteristics, and landowner information including demographic characteristics, perception, and behavior.

2.B.2 Willingness to harvest timber in the future

Using the NIPF Ownership Objectives model discussed above, we obtained information on each landowner's ownership objective type. The willingness to harvest model was developed to estimate the importance of the objective types to expected behavior. The major research question for this model, then, is how ownership objective categories affect the willingness to harvest timber in the future.

Several relevant studies have been conducted on harvesting decisions and behavior, which are reviewed by Beach et al. (2005) and Cubbage et al. (2003). Many of the estimated models are discrete choice models of previous harvesting decisions or harvested acreage models with linear regression. The willingness to harvest timber in the future is another NIPF owner decision now requiring increased attention due to increasing forest fragmentation and parcelization. Hoyt (2008) estimated a future harvest model using logistic regression and concluded that NIPF owners are more likely to harvest timber if they (1) had harvested timber in the past, (2) had timber production as primary ownership objective, (3) had received forest management advice, (4) and were interested in improving forest health.

This study utilized a probit model of future harvest planning using maximum likelihood method. The estimated model results in the probability of willingness to harvest timber in the future and factors influencing it. The dependent variable was the respondents reported intention to harvest or not harvest timber in the future, while the independent variables were forest ownership categories; land characteristics;

demographic characteristics; and owner's perception, attitudes, and previous harvesting[5].

2.B.3 Level of landowner's interest in managing for non-timber uses

This model was constructed with the hypothesis that ownership objective categories affect landowner interest in managing for non-timber uses. Previous studies of landowner management interest in non-timber activities include Conway et al. (2003), Arbuckle et al. (2009) and Poudyal and Hodges (2009). These studies employed linear regression using OLS to observe factors influencing landowner interest in non-timber activities such wildlife management (Poudyal and Hodges, 2009), recreation, and agroforestry (Arbuckle et al., 2009). Conway et al. (2003) reported that size of tract and absenteeism are very important predictors of non-timber activities, while Arbuckle et al. (2009) found that environmental or recreational motivations for land ownership and contacts with natural resource professionals are positively associated with interest in agroforestry. Poudyal and Hodges (2009) substantiated the latter work. They found that receiving professional forest management advice increases the chance of forest landowners considering wildlife and avian habitat in their management decisions.

This study employed OLS, the most frequently used regression method, to assess the importance of the factors influencing landowner interest in non-timber uses. This model differs from the landowner objectives with non-timber benefits in the first model because this model examined forest owner behavior, rather than simply objectives. The dependent variable was the expressed level of landowner interest in various forms of non-timber management. Details of their derivation are discussed in Section 2.C.2. The independent variables examined were forest ownership categories; land characteristics; demographic characteristics; use of government incentives; and owner's perception and attitudes.

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[5] Hoyt (2008) found that "NIPF landowners who actually have sold timber in the past were 2.7 times more likely to harvest timber in the future."

2.C DATA AND VARIABLES

2.C.1 Data collection and survey

Data were obtained using a 2007 mail survey of approximately 2,000 NIPF landowners. The survey covered the 16-county Cumberland Plateau region of Tennessee[6]. This region, a part of the world's longest hardwood forested plateau, has been pressured by the increased demand for recreational use and residential development. Landowner names were randomly selected from county property tax records. A pretest was conducted on a random sample of Cumberland Plateau NIPF landowners prior to finalizing the questionnaire. The revised survey included two follow-up contacts with non-respondents, following Dillman (2000) Tailored Design Method. Approximately 250 names were eliminated from the sample population because the individual no longer owned forestland in the region, had died, or the tax records contained an incorrect address. The total number of respondents to the survey was 689, with a final response rate of 39%. Details of the questionnaire are in Appendix 2, and survey process is discussed in Hoyt (2008).

Variables used in this study were comprised of choice, binary, and continuous variables. The descriptive statistics are presented in Table 7.

2.C.2 Dependent variables

Three dependent variables were used in this study. The first was a choice variable derived from the question in the survey that stated "How important is each of the following reasons for why you own *forest land* on the Cumberland Plateau?". Based on the 16 ownership objectives collected from the landowner survey, we constructed an index to categorize NIPF ownership objectives. We employed factor analysis, using the principal-components factor method[7] with orthogonal varimax

[6] The study area can be separated into the North Plateau containing, Campbell, Cumberland, Fentress, Morgan Overton, Pickett, Putnam, and Scott Counties and the South Plateau containing Bledsoe, Franklin, Grundy, Marion, Sequatchie, Van Buren, Warren and White Counties.

[7] This method assumes the communalities equal to 1 meaning that there are no unique factors.

rotation (Hamilton, 2006; Stata Corporation., 2005), after determining that the Kaiser-Meyer-Olkin measure of sampling adequacy (KMO) was acceptable[8]. Based on the ownership objective categories upon which a landowner possessed the highest factor loading, we classified landowners into four categories: those most interested in either non-timber benefits, monetary returns, farm or home site values, or bequest. Regression factor scores[9] for the four categories were computed and defined as sub-category variables. We used those sub-category variables to create the dependent variable, *type*, in the multinomial logit equation. Depending on which categories that each landowner scored highest, they were assigned a corresponding value of 1-4 for the *type*. For example, if an individual scored highest on non-timber benefits (*f1*), a value of 1 was assigned. Landowners whose highest score was for monetary values (*f2*), farm and home site values (*f3*), and bequest values (*f4*) were assigned numbers 2-4 respectively. Based on objective ranking and factor scores, the highest factor scores of each component are reasonable representations of ownership type for each landowner.

The second dependent variables used in the second model is the binary variable of the planning decision to harvest timber in the future (*harf*; 1 if planning to harvest timber and 0 otherwise). The data was drawn from the question 17 of the survey; "Are you planning to harvest timber from your forest land in the future?" From the survey, 62.52% of total respondents stated that they were not planning to harvest timber in the future.

Similar to the *type* variable, the level of interest in managing for non-timber uses (*int_ntu*) covering six categories was created by factor scores derived from question 24 in the survey. The question is the following; "Please indicate your level of interest in managing for the following non-timber uses." Those categories were (a) enhancing wildlife habitat for hunting, (b) protecting water quality, (c) storing carbon

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[8] The value of KMO less than 0.49 is unacceptable. Our KMO value for each component was in the range of meritorious (0.80 to 0.89) to marvelous (0.90 to 1.00).

[9] Hamilton (2006) explains factor scores which are "linear composites, formed by standardizing each variable to zero mean and unit variance, and then weighting with factor score coefficients and summing for each factor".

to reduce global warming by maintaining forest cover, (d) maintaining forest cover for aesthetics, (e) protecting rare species, and (f) enhancing habitat for birds. Forest landowner revealed their preferences in response to a question of indicating the level of interest in managing each non-timber use categories on a scale ranging from 1 (no interest) to 4 (high interest). This third dependent variable is a continuous variable, and was estimated from the only one component of factor loading.

2.C.3 Independent variables

The independent variables were the individual characteristics of both NIPF landowners and their forests. Such characteristics consisted of ownership characteristics, timber harvesting decisions, forest management characteristics, and demographic variables. This study created eight variables using information from the survey representing landowners' attitudes, motivations, and interests. The descriptive statistics of these variables are presented in Table 7. Details of extracted variables are discussed below.

Based on information from the survey, we created independent variables using factor analysis with the principal component factor method. After factor loadings of each question were calculated, regression factor scores were used to estimate the variables. The created variables are continuous variables with zero means and unity variance. From the process of creating *type* variable, we created four attitudinal variables corresponding to each sub-category in *type*. Specifically, *f1*, *f2*, *f3*, and *f4* are continuous variables representing forest landowners' objective categories for holding forestland. We created a variable called landowner perception of the current level of land clearing and timber harvesting on the Plateau (*perc*)[10]. A high value for *perc* indicates that landowners perceive a high level of land clearing and timber harvesting. The other two independent variables were constructed using nine attitudes for selling

[10] The question was "What is your perception of the current level of land clearing and timber harvesting on the Plateau?"

timber in the future[11]. Based on the same routine factor analysis discussed above and the attitudes, we created two attitude variables; forest landowner attitudes for selling timber in the future: forest enhancement attitude (*enh*) and monetary attitude (*mny*). The last created variable was financial incentives for managing non-timber uses (*finnt*). This variable was derived by factor analysis from three financial incentives; (a) property tax incentives, (b) payments from private individuals or companies, and (c) payments from government.

2.D ESTIMATION METHOD

This study required a set of reduced form equations or the simultaneous equation model:

$$pref \quad = f\begin{pmatrix} small, medium, pur, inh, tenure, tenures, \\ perc, male, married, highed, highinc, \\ harf, int\_ntu \end{pmatrix} \tag{3}$$

$$harf \quad = f\begin{pmatrix} harp, f1, f2, f3, f4, small, medium, tenure, sellf, \\ res, conv, perc, advise, parti, loss, enh, mny, age, \\ married, college, highed, lowinc, highinc \end{pmatrix} \tag{4}$$

$$int\_ntu \quad = f\begin{pmatrix} finnt, nti, small, medium, pur, inh, tenure, tenures, \\ res, perc, advise, enh, mny, age, college, highed, \\ lowinc, highinc, f1, f2, f3, f4 \end{pmatrix} \tag{5}$$

Equation (3) included two endogenous variables, *harf,* and *int_ntu,* that can be explained by other sets of independent variables. Unlike the single equation model, in the simultaneous equation models we could not estimate the parameters of Equation (3) without taking into account information provided by other equations[12] (Cameron

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[11] The question 16 in the survey asked forest owner to rank the importance of each reason from not important to extremely important. We imply those reasons to be forest owner attitudes for selling timber in the future. Those are (a) motivated by selling price, (b) to improve forest health, (c) to convert from hardwood to pine, (d) the reputation of the logger, (e) an urgent financial need, (f) for timber stand improvement, (g) for wildlife habitat improvement, (h) to clear land for farming, and (i) for real estate development.

[12] An endogenous regressor is usually correlated with the error term of the equation in which it appears as an explanatory variable resulting in inconsistent estimators. This problem, which is also called

and Trivedi, 2005; Maddala, 1983). Maddala (1983) suggests a technique for estimating a simultaneous equation system with discrete dependent variables, while Cameron and Trivedi (2005) offer a technique for estimating a simultaneous equation system with an endogeniety problem with a system containing a continuous dependent variable.

The estimation procedure in this study entailed first, estimating Equation (3) using the multinomial logit model. The estimated results were the base case. We next estimated Equation (4) via the probit model and obtain predicted probability, *h1*. Third, we estimated Equation (5) using OLS. We then calculated the residual from the estimated Equation (5). Finally, we re-estimated Equation (3) by using the multinomial logit model, replacing predicted probability from Equation (4) *h1* to *harf* variables, and adding a variable called *eint*, representing the residual of estimating Equation (5) as an endogeniety correction variable. Therefore, Equation (6) is the efficient equation without endogenous regressor problem. Based on the correction method stated in Maddala (1983) and Cameron and Trivedi (2005), the estimates from this equation were consistent. The specification of the new equation was,

$$pref \quad = f\begin{pmatrix} small, medium, pur, inh, tenure, tenures, \\ perc, male, married, highed, highinc, \\ h1, int\_ntu, eint \end{pmatrix}. \tag{6}$$

The study estimated Equations (3)-(6) separately by the methods described. Figure 15 provides a chart of how the equations are related and how ownership objective categories are related to willingness to harvest timber in the future and landowner interest in managing for non-timber uses.

2.E EMPIRICAL RESULTS AND DISCUSSION

The overall KMO for ownership categories was 0.895. These factors explained 64.62% of the total variance. The results of the factor loadings are shown in Table 8. A total of 181 landowners scored highest on non-timber and bequest objectives (26.5%

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endogeniety, violates the law of large numbers and the estimated parameters do not converge to their true population values.

of total observations for each group). Landowners scoring highest on monetary and farm and home site values totaled 159 (23.82%) and 162 (23.72%), respectively (Table 9). Based on information in the level of interest in managing for non-timber uses, the overall KMO test was acceptable (0.904). The variable explained 68.29% of the total variance of their factor analysis. For the attitudes for selling timber in the future, the overall KMO test for sampling adequacy for creating the two variables was 0.862. Factor loadings were shown in Table 10.

2.E.1 Factors affecting NIPF ownership objective categories

Parameter estimates for the multinomial logit models of landowner objective types are presented in Table 11 (base case model)) and Table 12 (efficient model). Both models were estimated using non-timber benefits as the base category. We then performed likelihood ratio tests and Wald tests for independent variables and for combining alternatives[13]. The tests rejected the null hypothesis that one independent variable could be dropped from the model for all independent variables, except *inh*, *male,* and *highinc*. With the significance of *eint*, the tests confirmed that the expected endogeniety problem from *int_ntu* was corrected. The tests for combining alternatives confirmed that any categories could not be dropped from the model. Therefore, the typical hypothesis of similarity of ownership objectives categories for all NIPF owners can be rejected. The base case model correctly predicted different types of preferences for 56.2% while the efficient model correctly predicted those for 64.9%. Comparing information such as log pseudolikelihood, pseudo R^2, Akaike's Information Criteria (AIC), and Bayesian Information Criteria (BIC), indicated that the efficient model is preferred to the base case model.

Based on the category of non-timber benefits, most independent variables (i.e., landowner characteristics, decision to harvest in the future, and forest owner interest factors) were related to NIPF ownership objective categories except for *inh* and *highinc*

[13] Results of the tests are available upon request.

(Table 12). This confirms our hypothesis regarding the interaction among ownership objective categories, intention, and behavior that was not discussed in previous studies. This implies that forest landowners have different objective categories. The predicted probabilities for forest landowner type groupings were 0.142 for non-timber benefits, 0.255 for monetary, 0.327 for farm or home site, and 0.276 for bequest. The partial change or marginal effect[14] of the multinomial logit models are presented in Table 13. For binary variables, the marginal effect is the discrete change from 0 to 1. These marginal effects represent the change in the predicted probability of each choice arising from a one unit change in an independent variable. For example, if a forest landowner owns less than 50 acres, the probability of favoring non-timber benefits is 0.127 lower than a landowner with more than 50 acres. This is consistent with Conway et al. (2003) that "landowners with larger tracts engage in more non-market activities, perhaps because there are greater resource activities." In contrast, if an individual owns less than 50 acres, the probability of favoring bequest is 0.125 greater than those owning more than 50 acres. For continuous variables, for example, each additional 10 years of holding the land in the family increased the probability of being a bequest category landowner by 0.004, while it decreased the probability of being a non-timber benefits category landowner by 0.004. However, the marginal effects of the continuous variables do not need to have the same sign as its corresponding coefficient due to the estimation method of marginal effect (Long, 1997; Long and Freese, 2006).

Measures of discrete change in probabilities were constructed to provide a clearer picture for both continuous and binary independent variables in the multinomial logit model, because the marginal effects for continuous variables representing non-linear relationships may have an interpretation problem. We plotted those discrete changes, based on a change from 0 to 1 for binary variables and one standard deviation change for continuous variables (Figure 16). The results illustrate

[14] The partial change in probability is computed by taking the partial derivative of Equation 2 with respect to each continuous independent variable when variables are held at their means and 0 or 1 for binary variables.

that small and medium tract sizes increased the probability of being forest landowners with bequest objectives, for example, while they decreased the probability for the non-timber benefits and monetary returns objectives. If forest landowners purchased the land, they were more likely to possess all objective categories, but not bequest. Landowners with a history of holding forestland in the family were less likely to favor non-timber benefits, but more likely to inherit. Landowner perception of the current level of land clearing and timber harvesting decreased the probability of favoring bequest values. Married forest landowners were more likely to favor non-timber benefits and monetary objectives. Forest landowners with high education were more likely to favor non-timber benefits and bequest. Interest in managing for non-timber uses naturally is highly correlated with the non-timber benefits objective, and less likely to favor farm or home site values. Forest landowners who had expressed a willingness to harvest in the future were more likely to favor monetary objectives, but less likely to favor non-timber benefits.

2.E.2 Willingness to harvest timber in the future

The estimators of the willingness to harvest timber in the future are presented in Table 14 and the marginal effects are presented in Table 15, with a predicted probability of 0.338. The results reveal that objective categories, particularly non-timber benefits and monetary returns, were significant factors related to future timber harvest plans. If the owner has non-timber objectives, they were less likely to harvest timber, and the opposite was true for monetary returns. A standard deviation change in non-timber benefits category centered around the mean decreased the probability of willingness to harvest timber in the future by 0.123, while a standard deviation change in monetary returns increased the probability by 0.166, holding all other variables constant. Prior timber harvesting decisions were positively related to the willingness to harvest timber in the future. Therefore, if a forest owner had previous harvesting experience, his/her willingness to harvest timber in the future was 0.168 greater than a forest owner who had no experience, ceteris paribus.

The significant factors with increasing probability of willingness to harvest timber in the future were forest owners who had received professional forest management advice (0.155), wanted to sell timber with forest enhancement motivation (0.106), and were highly educated (0.139). Significant factors with decreasing probability of willingness to harvest timber in the future were forest owners who planned to sell their forest in the future (0.110), lost pine trees in the recent Southern Pine Beetle epidemic in Tennessee (0.123), and were elderly (0.004).

Ownership objective categories for holding forest were related to the willingness for future harvests in different ways, especially for landowners who favor non-timber benefits. Forest landowners with non-timber benefits were less likely to harvest timber in the future, while forest landowners with forest enhancement motivation were more likely to harvest. Forest owners will not harvest timber in the future because they obtain non-timber benefits with the forested land, however they will sell timber with forest enhancement motivation, but not for monetary motivation[15].

2.E.3 Level of landowner interest for managing non-timber uses

The final landowner decision evaluated was the level of interest in managing for non-timber uses. We hypothesized that ownership objective categories for owning forest are related to landowner interest. The results confirm this hypothesis (Table 16). Ten variables were statistically significant either at the 0.01, 0.05, or 0.1 levels of significance. The financial incentive factor and non-timber objective were the most two important factors for landowner interest in managing non-timber uses with coefficients of 0.392 and 0.357. Education variables, *college* and *highed*, were significantly and positively related to landowner interest (0.120 and 0.185 respectively). Perception of the current level of land clearing and timber harvesting, forest

[15] This point is totally different in the developing countries where forests belong to the public entities. In addition, non-government organizations and governmental bodies are more likely to define forests as the collection of trees. Logging banned is an example of forest protection however this is a failure policy in many countries due to increasing illegal logging and lack of enforcement.

enhancement motivation for selling timber, and age of landowner variables were positively related to landowner interest (0.1, 0.157, and 0.006 respectively). Only two statistically significant variables were negatively related to landowner interest: landowners who had received forest management advice and landowner who derived non-timber income.

2.E.4 Discussion

NIPF landowners on the Cumberland Plateau could be grouped into four categories based on their interest in non-timber benefits, monetary returns, farm or home site values, and bequest values. Some of the ownership objective variables, particularly in the non-timber benefit category, were statistically significant and related to the willingness to harvest timer in the future and managing for non-timber uses. Therefore, our hypothesis of the interaction among ownership objectives and intention, or planned behavior, was not rejected.

Based on the results of the ownership objective category model, larger tract sizes were more likely to increase the probability of favoring non-timber benefits and monetary returns. Therefore, if the trend of fragmentation and parcelization of the forests does not diminish, ownership objective categories are likely to shift to more farm or home sites and bequest values types. Decreasing the number of forest owners interested in monetary returns could reduce future timber supply, while decreasing the number forest owners with non-timber benefits would pose a significant barrier to attempts to focus more efforts on sustainable forest management.

The results could be a starting point for rethinking U.S. forest policy as it relates to fragmentation and parcelization and to promoting SFM. Because of the divergence of objectives for holding forests, policy makers face a wide range of alternative policies to affect all types of NIPF owners. Clearly, developing policies specific to the range of objectives is unwarranted as well as infeasible, but the information can provide insights into how government incentives can affect some ownership objective types. If the objectives of the new policy are to resolve fragmentation and parcelization and support SFM policy, a mix of financial incentives, education, and regulations may be needed. Regardless of the appropriate balance of incentives and restrictions, the results provide some evidence of how different landowner types may respond.

Our results reveal that receiving forest management advice (*advice*) was not only related to an increased willingness to harvest timber in the future, but also to a decreased landowner interest in managing for non-timber uses. This suggests that existing advice and information has been heavily focused on timber production. Therefore, more emphasis is needed on non-timber assistance if the changing landowner population, as well as the general public, is to be served.

Government supported education programs could be a good non-regulatory instrument for these revised objectives. Due to the positive relationship of education parameter(s) in the willingness to future harvest model and interest in managing for non-timber uses model, increasing education programs for forest enhancement, wildlife management,, and recreation could increase timber supply and non-timber uses. Financial incentives such as property tax incentives and government payments, can increase the level of interest in managing for non-timber uses, and indirectly increase probability of being non-timber benefits type.

2.F CONCLUDING REMARKS

The growing pressures of forest fragmentation and parcelization have increased the rate of forestland conversion to other uses, including residential development. Although sustainable forest management is a challenging solution that balances all demands, appropriate policies are needed to guarantee and enforce the results. We explored NIPF ownership objective categories, intention, and behavior that will influence the success of SFM. In addition, the study observed interactions among ownership objective categories and intentions, and the factors influencing them. This study differs from previous work by explicitly linking ownership objective categories and planned behavior.

We substantiated that forest landowners are not homogeneous. In addition, SFM requires combining social, economics, and environmental dimensions. Employing independent decisions (e.g. the harvesting decision model without incorporating other dimensions) will not reflect full picture of SFM, where heterogeneous forest landowners and interdependent decision and practices are required (Kant, 2003; Wang 2004). In our case, we categorized forest landowners into four groups including two major groupings for non-timber and monetary returns, without discarding the other groups. In addition, forest owner behavior is included in the estimating system in order to serve as SFM estimating model.

Because forestland contains factors of market failures, implementing incentives and policies would provide better solutions than a laissez-faire approach. We suggest that government supported education programs be provided to NIPF owners, with a focus on SFM and non-timber products. Because the current direction of SFM in the U.S. emphasizes the emerging market for non-timber products and activities, this dimension still requires much knowledge and information. Therefore, agencies can disseminate forest management information, expand programs and their rate of participation, promote compatible land use practices, and offer new, more directed policies.

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APPENDICES

APPENDIX 1 – TABLES AND FIGURES

Table 7. Descriptive statistics

Name	Mean	Standard deviation	Min	Max	Description
Dependent variable					
pref	2.502	1.145	1	4	Preference: 1 = non-timber benefits; 2 = monetary values; 3 = farm and home site values; 4 = bequest benefits
harp	0.463	0.499	0	1	Past timber harvesting: 1 = harvest; 0 = no harvest
harf	0.375	0.484	0	1	Planning to harvest in the future: 1 = plan to harvest; 0 = plan to no harvest
int_ntu	0	1	-2.612	1.135	Level of landowner interest for managing non-timber uses (obtained by regression factor scores)
Independent variable					
small	0.526	0.500	0	1	Small ownership: 1 = landowner has 50 acres or less; 0 = otherwise
medium	0.231	0.422	0	1	Medium ownership: 1= landowner has 51-100 acres; 0 = otherwise
large	0.243	0.429	0	1	Large ownership: 1 = landowner has more than 100 acres; 0 = otherwise
pur	0.714	0.452	0	1	Acquisition of the majority of forest land: 1 = purchased it; 0 = otherwise
inh	0.211	0.408	0	1	Acquisition of the majority of forest land: 1 = inherited it; 0 = otherwise
tenure	40.484	38.532	1	215	Number of years the landowner's family owned the land
tenures	3121.464	6023.779	1	46225	Square of tenure
multiple	0.256	0.437	0	1	Multiple tracts: 1 = if landowner owns more than one tract in the area; 0 = otherwise
f1	0	1	-3.031	2.038	Forest owner preference toward non-timber benefits (obtained by regression factor score)
f2	0	1	-2.836	3.013	Forest owner preference toward monetary values (obtained by regression factor score)
f3	0	1	-2.309	2.957	Forest owner preference toward farm and home site values (obtained by regression factor score)
f4	0	1	-2.325	2.770	Forest owner preference toward bequest benefits (obtained by regression factor score)
inhf	0.761	0.427	0	1	Plan to do with forestland: 1 = inheritance for heirs; 0 = otherwise
devf	0.063	0.243	0	1	Plan to do with forestland: 1 = develop it; 0 = otherwise
sellf	0.193	0.395	0	1	Plan to do with forestland: 1 = sell it for profit; 0 = otherwise
res	0.523	0.500	0	1	Residency: 1 = primary residence on

					forestland; 0 = absentee
conv	0.101	0.302	0	1	Forestland conversion: 1 = converted forestland; 0 = no conversion
perc	0	1	-2.304	1.344	Perception of the current level of land clearing and timber harvesting on the Plateau (obtained by regression factor score)

Table 7 cont.

Name	Mean	Standard deviation	Min	Max	Description
Independent variable					
advice	0.233	0.423	0	1	Forest management advice: 1 = yes 0 = no
parti	0.075	0.263	0	1	Participation in government cost-share assistance programs: 1 = yes; 0 = no
loss	0.477	0.500	0	1	Pine tree loss during Southern Pine Beetle epidemic: 1 = yes; 0 = no
enh	0	1	-2.850	2.165	Forest enhancement attitude for selling timber (obtained by regression factor score)
mny	0	1	-2.925	3.556	Monetary attitude for selling timber (obtained by regression factor score)
nti	0.214	0.410	0	1	Derivation non-timber income: 1 = derived non-timber income; 0 = no non-timber income from the forestland
finnt	0	1	-1.679	1.457	Financial incentives in managing for non-timber uses (obtained by regression factor score)
retired	0.327	0.469	0	1	Working status: 1 = retired; 0 = otherwise
age	61.910	12.335	24	96	Age of landowner
ages	3984.734	1530.248	576	9216	Square of age
male	0.751	0.433	0	1	Gender: 1 = male; 0 = female
married	0.770	0.421	0	1	Marital status: 1 = married; 0 = otherwise
college	0.435	0.496	0	1	Education: 1 = college graduate or some college or Vo-tech training; 0 = otherwise
highed	0.211	0.408	0	1	Education: 1 = some graduate school and graduate degree; 0 = otherwise
lowinc	0.163	0.369	0	1	Level of income: 1 = landowner gross annual income less than 25 K; 0 = otherwise
highinc	0.299	0.458	0	1	Level of income: 1 = landowner gross annual income greater than 75 K; 0 = otherwise

Note: Number of observations = 683

Table 8. Rotated factor loadings ownership objectives

	Non-timber benefits	Monetary returns	Farm or home sites	Bequest
a. To pass on to heirs	0.2854	0.1653	0.2158	***0.5040***
b. For privacy	***0.7369***	0.0673	0.3036	0.0148
c. To preserve nature	***0.7539***	0.1318	0.0653	0.1686
d. For financial investment	0.1327	***0.7201***	0.1029	-0.0437
e. For hunting and fishing	0.4995	***0.5239***	-0.0618	0.0250
f. For other recreation	***0.6958***	0.3857	-0.0038	0.0510
g. For wildlife management	***0.7442***	0.3337	-0.0371	0.0983
h. For timber production	-0.0186	***0.7455***	0.2388	0.2423
i. For grazing and livestock	0.0727	0.3105	***0.7707***	0.0820
j. Part of farm or home site	0.3549	-0.0564	***0.7296***	0.1637
k. To enjoy scenery	***0.7783***	-0.0156	0.2850	0.1231
l. Inherited the land	0.0210	0.0813	0.0480	***0.8753***
m. It connects me to nature	***0.8232***	0.0110	0.1046	0.1897
n. For peacefulness & tranquility	***0.8338***	-0.0434	0.2474	0.0825
o. It connects me to the past	0.4633	0.0311	0.1580	***0.6561***
p. Enjoy working on the land	***0.5641***	0.1539	0.4903	0.0045

Table 9. Types of forest owners

Category	Frequency	% of landowners	Cumulative
Non-timber benefits	181	26.50	26.50
Monetary	159	23.28	49.78
Farm and home site values	162	23.72	73.50
Bequest	181	26.50	100
Total	683	100	

Table 10. Rotated factor loadings motivation for selling timber in the future

Motivation	Forest enhancement	Monetary
a. Motivated by selling price	0.3009	***0.6907***
b. To improve forest health	***0.8746***	0.1857
c. To convert from hardwood to pine	0.4176	***0.5360***
d. The reputation of the logger	***0.4845***	0.4800
e. An urgent financial need	0.2129	***0.6702***
f. For timber stand improvement	***0.8814***	0.1465
g. For wildlife habitat improvement	***0.8476***	0.1312
h. To clear land for farming	0.2102	***0.6490***
i. For real estate development	0.0593	***0.7404***

Table 11. Multinomial logit model—A base case model

type	Monetary		Farm or home site value		Bequests	
	Coefficient	Robust Standard Error	Coefficient	Robust Standard Error	Coefficient	Robust Standard Error
small	-0.605**	0.293	0.474	0.348	0.787**	0.382
medium	-0.426	0.355	0.488	0.395	1.304***	0.418
pur	-0.403	0.556	-0.307	0.554	-2.167***	0.532
inh	-0.309	0.651	-0.482	0.667	0.488	0.590
tenure	0.026***	0.010	0.047***	0.010	0.051***	0.011
tenures	0.000*	0.000	0.000***	0.000	0.000***	0.000
perc	-0.292*	0.160	-0.368**	0.157	-0.725***	0.172
male	0.517*	0.294	0.722**	0.311	0.283	0.327
married	-0.283	0.327	-0.581*	0.323	-1.020***	0.335
highed	-0.030	0.296	-1.110***	0.412	-0.120	0.359
highinc	-0.090	0.271	-0.374	0.301	0.219	0.320
harf	1.272***	0.255	0.746***	0.278	0.533*	0.293
int_ntu	-0.631***	0.172	-0.914***	0.171	-0.764***	0.180
constant	-0.275	0.704	-1.134*	0.683	-0.408	0.671
Number of observation	683			Wald chi2(39)		328.06
Log pseudolikelihood	-704.439			Prob > chi2		0.0000
AIC	1492.878			BIC		1682.991
Pseudo R2	0.2550			Correct predictions		56.2%

Note: ***Significant at 1%, **5%, and **10% level of significance

Table 12. Multinomial logit model—An efficient model

pref	Monetary		Farm or home site value		Bequests	
	Coefficient	Robust Standard Error	Coefficient	Robust Standard Error	Coefficient	Robust Standard Error
small	0.526	0.408	1.147**	0.447	1.338***	0.446
medium	-0.243	0.455	0.545	0.472	1.397***	0.470
pur	-0.695	0.805	-0.707	0.682	-2.682***	0.652
inh	-1.031	0.879	-1.118	0.788	-0.116	0.702
tenure	0.017	0.011	0.043***	0.011	0.048***	0.011
tenures	0.000	0.000	0.000***	0.000	0.000***	0.000
perc	0.264	0.187	0.224	0.179	-0.305*	0.184
male	0.339	0.317	0.695**	0.336	0.294	0.338
married	-0.093	0.351	-0.621*	0.356	-1.101***	0.345
highed	-0.786*	0.417	-1.441***	0.471	-0.347	0.386
highinc	-0.515	0.348	-0.490	0.329	0.013	0.328
int_ntu	-2.178***	0.313	-2.599***	0.303	-2.020***	0.319
h1	10.048***	0.942	6.110***	0.929	4.873***	0.907
eint	2.233***	0.363	2.671***	0.358	1.893***	0.395
constant	-2.895***	0.990	-2.145**	0.828	-0.846	0.751
Number of observation	683		Wald chi2(42)		396.40	
Log pseudolikelihood	-590.9237		Prob > chi2		0.0000	
AIC	1267.186		BIC		1470.878	
Pseudo R2	0.3775		Correct predictions		64.9%	

Note: ***Significant at 1%, **5%, and **10% level of significance

Table 13. Marginal effects of the multinomial logit model

Variable	Non-timber benefits		Monetary		Farm or home site		Bequest	
	dy/dx	S. E.	dy/dx	S. E.	dy/dx	S. E.	dy/dx	S. E.
small^{D}	-0.127***	0.048	-0.087	0.056	0.088	0.065	0.125*	0.064
medium^{D}	-0.072*	0.037	-0.172***	0.046	-0.020	0.075	0.265***	0.082
pur^{D}	0.143***	0.049	0.139*	0.082	0.176**	0.070	-0.458***	0.085
inh^{D}	0.098	0.111	-0.098	0.096	-0.147*	0.088	0.147	0.093
tenure	-0.004***	0.001	-0.004**	0.002	0.004**	0.002	0.004***	0.002
tenures	0.000***	0.000	0.000	0.000	0.000*	0.000	0.000*	0.000
perc	-0.008	0.020	0.053**	0.025	0.055**	0.026	-0.100***	0.025
male^{D}	-0.060	0.038	-0.011	0.051	0.095*	0.055	-0.024	0.057
married^{D}	0.070**	0.030	0.108**	0.043	-0.013	0.059	-0.165***	0.059
highed^{D}	0.119*	0.059	-0.024	0.060	-0.198***	0.060	0.102	0.071
highinc^{D}	0.041	0.035	-0.058	0.053	-0.067	0.056	0.084	0.059
int_ntu	0.279***	0.035	-0.055	0.037	-0.208***	0.038	-0.016	0.039
h1	-0.839***	0.103	1.057***	0.098	0.067	0.118	-0.285**	0.111
eint	-0.279***	0.044	0.068	0.052	0.231***	0.056	-0.020	0.059
Predicted Probability		0.142		0.255		0.327		0.276

(^{D}) dy/dx is for discrete change of dummy variable from 0 to 1

Note: ***Significant at 1%, **5%, and **10% level of significance

Table 14. Estimated results of willingness to future harvest model—A probit model

	Coefficient	Robust Standard error
harp	0.458***	0.121
f1	-0.337***	0.080
f2	0.455***	0.068
f3	0.013	0.068
f4	0.031	0.066
small	-0.166	0.147
medium	-0.015	0.163
tenure	0.002	0.002
sellf	-0.314**	0.153
res	0.137	0.138
conv	0.192	0.191
perc	-0.086	0.062
advice	0.411***	0.145
parti	0.046	0.225
loss	-0.339***	0.115
enh	0.289***	0.072
mny	0.018	0.063
age	-0.011**	0.005
married	-0.172	0.133
college	-0.002	0.135
highed	0.368**	0.175
lowinc	0.110	0.165
highinc	0.078	0.137
_cons	0.117	0.390

Number of observation	683	Wald chi2(23)	165.68
		Prob > chi2	0.0000
Pseudo R2	0.2261	Log likelihood	-349.6413

Note: ***Significant at 1%, **5%, and **10% level of significance

Table 15 Marginal effects of the probit model

	dy/dx	Standard error
harp^{D}	0.168***	0.043
f1	-0.123***	0.027
f2	0.166***	0.025
f3	0.005	0.023
f4	0.011	0.024
small^{D}	-0.061	0.053
medium^{D}	-0.006	0.059
tenure	0.001	0.001
sellf^{D}	-0.110**	0.052
res^{D}	0.050	0.048
conv^{D}	0.072	0.074
perc^{D}	-0.031	0.023
advice^{D}	0.155***	0.054
parti^{D}	0.017	0.084
loss^{D}	-0.123***	0.042
enh	0.106***	0.026
mny	0.007	0.022
age	-0.004*	0.002
married^{D}	-0.064	0.050
college^{D}	-0.001	0.051
highed^{D}	0.139**	0.068
lowinc^{D}	0.041	0.063
highinc^{D}	0.029	0.051
Predicted Probability	0.338	

(^{D}) dy/dx is for discrete change of dummy variable from 0 to 1
Note: ***Significant at 1%, **5%, and **10% level of significance

Table 16. Estimated results of factor influencing level of interest in managing for non-timber uses

int_ntu	Coefficient	Robust standard error	t-statistics
finnt	0.392***	0.035	11.320
nti	-0.113*	0.066	-1.730
small	0.012	0.067	0.180
medium	-0.072	0.076	-0.960
pur	0.192	0.134	1.430
inh	0.119	0.128	0.930
tenure	0.003	0.002	1.360
tenures	0.000	0.000	-1.350
res	-0.037	0.058	-0.640
perc	0.100***	0.029	3.500
advice	-0.103*	0.064	-1.670
enh	0.157***	0.041	3.870
mny	-0.002	0.030	-0.060
age	0.006**	0.002	2.370
college	0.120*	0.068	1.770
highed	0.185**	0.079	2.330
lowinc	0.015	0.087	0.170
highinc	-0.006	0.056	-0.110
f1	0.357***	0.040	9.000
f2	0.038	0.034	1.130
f3	-0.033	0.031	-1.090
f4	0.051	0.037	1.390
_cons	-0.604***	0.201	-3.000
Number of observation	683	F(22, 660)	38.50
R-squared	0.588	Prob > F	0.0000
Adj R-squared	0.574	Root MSE	0.6528

Note: ***Significant at 1%, **5%, and **10% level of significance

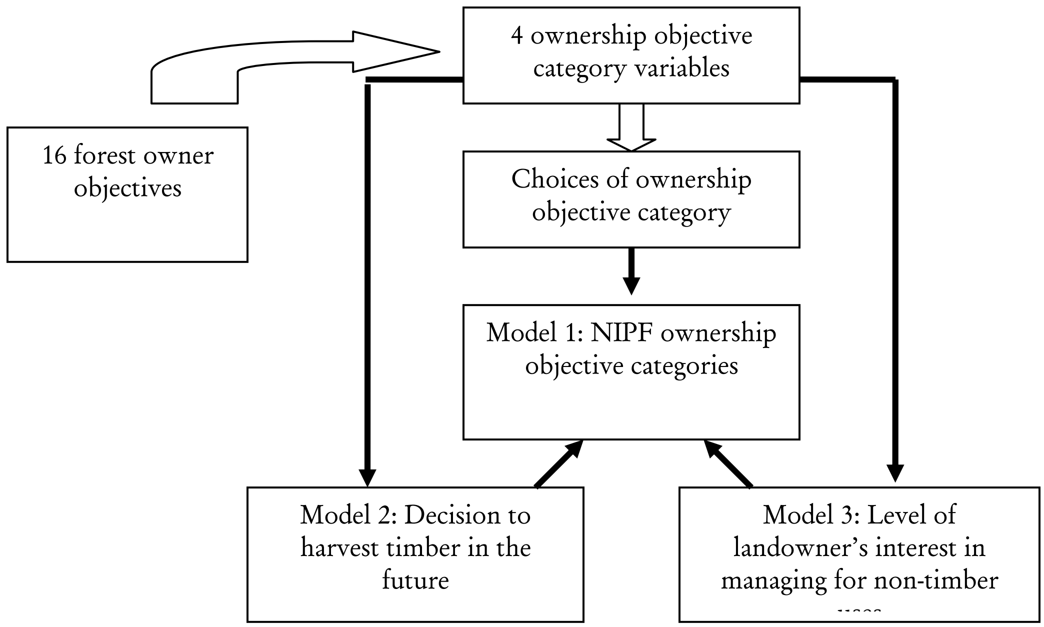

Figure 16. The relationship of ownership objective categories and estimated models

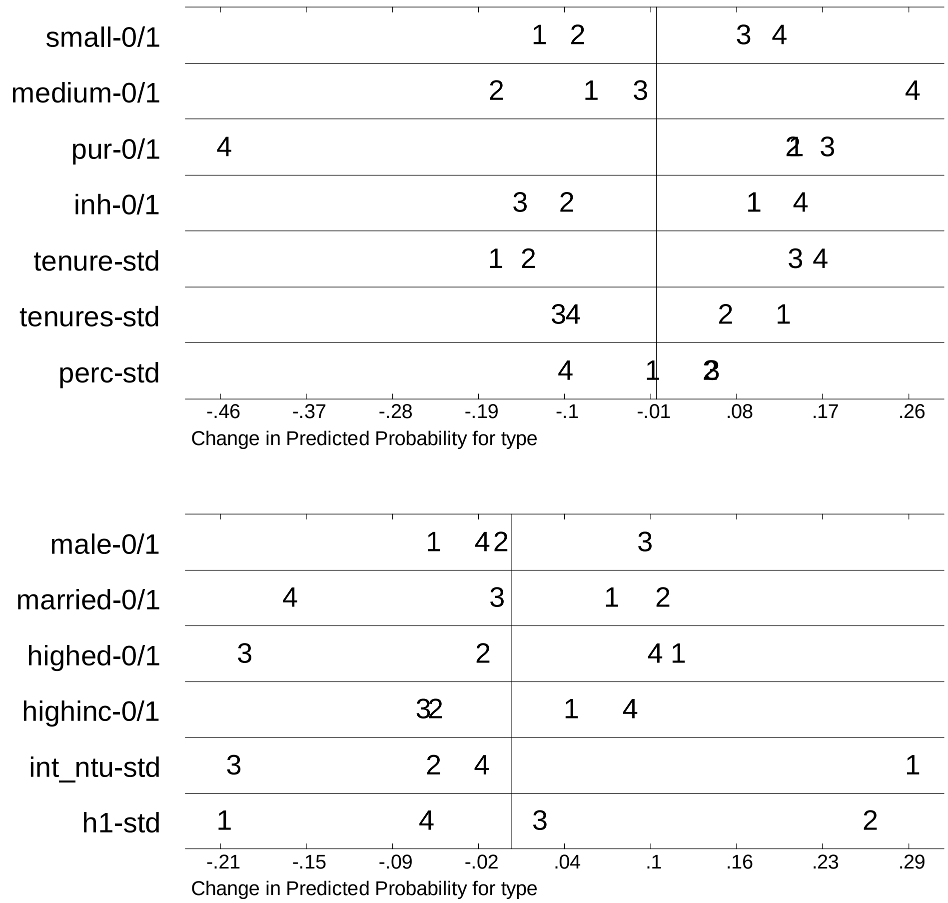

Figure 17. Plot of predicted probability with discrete change in the multinomial logit model

APPENDIX 2 –THE SURVEY INSTRUMENT

Cumberland Plateau Landowner Survey

2007

Department of Forestry, Wildlife and Fisheries
The University of Tennessee

*The University of Tennessee Department of Forestry, Wildlife and Fisheries is surveying private landowner opinions concerning the future of forest land on the Cumberland Plateau. For this study **forest land** is defined as a **minimum of ten (10) acres of tree cover**. Please be assured your answers will be **KEPT STRICTLY CONFIDENTIAL** and will be used only for group comparison for statistical purposes. Thanks in advance for taking the time to fill out and complete the survey.*

1. Do you own *forest land* in Tennessee with at least 10 acres of tree cover? ***(Please check one.)***

☐ No (If you do not own *forest land*, there is no need to continue, but please mail the survey back in the enclosed envelope.)

☐ Yes

2. How many acres of *forest land* do you own on the Cumberland Plateau? ***(Please check one.)***

☐ less than 10 acres
☐ 10 – 50 acres
☐ 51 – 100 acres
☐ 101 – 150 acres
☐ 151 – 200 acres
☐ 201 – 250 acres
☐ 251 – 300 acres
☐ more than 300 acres

3. How did you acquire the majority of your *forest land*? *(Please check one.)*

☐ Purchased it
☐ Inherited it
☐ Traded (land swap)
☐ Gift
☐ Foreclosure
☐ Tax Assessor sale
☐ Other *(please specify)*:

____

4. How many *years AND generations* has your *forest land* been owned by you and your family?

1. _________# of years 2. _________# of generations

5. Do you own more than one tract of *forest land* on the Cumberland Plateau?

☐ No

☐ Yes

6. **How important is each of the following reasons for why you own *forest land* on the Cumberland Plateau?**

	Not Important	Slightly Important	Moderately Important	Very Important	Extremely Important
a. To pass on to heirs	☐	☐	☐	☐	☐
b. For privacy	☐	☐	☐	☐	☐
c. To preserve nature	☐	☐	☐	☐	☐
d. For financial investment	☐	☐	☐	☐	☐
e. For hunting and fishing	☐	☐	☐	☐	☐
f. For other recreation	☐	☐	☐	☐	☐
g. For wildlife management	☐	☐	☐	☐	☐
h. For timber production	☐	☐	☐	☐	☐
i. For grazing and livestock	☐	☐	☐	☐	☐
j. Part of farm or home site	☐	☐	☐	☐	☐
k. To enjoy scenery	☐	☐	☐	☐	☐
l. Inherited the land	☐	☐	☐	☐	☐
m. It connects me to nature	☐	☐	☐	☐	☐
n. For peacefulness & tranquility	☐	☐	☐	☐	☐
o. It connects me to the past	☐	☐	☐	☐	☐
p. Enjoy working on the land	☐	☐	☐	☐	☐
q. Other (please specify): ____________________	☐	☐	☐	☐	☐

7. **What do you plan to do with your *forest land* in the future?** ***(Check all that apply.)***

- ☐ Inheritance for heirs
- ☐ Develop it
- ☐ Sell it for profit
- ☐ Donate it to an endowment fund
- ☐ Other *(please specify):* ____________________

8. **Is your primary residence on your *forest land* on the Cumberland Plateau?**

- ☐ No → I live approximately ________miles from the property.
- ☐ Yes

9. **Within the past five (5) years, have you converted any of your *forest land* to other uses or forest types?**

- ☐ No conversion.
- ☐ Converted hardwood to pine.
- ☐ Converted pine to hardwood.
- ☐ Converted to other land uses *(please specify):* ____________________

10. **In your opinion, how much of the Cumberland Plateau is currently covered by forests?**

- ☐ Less than 25%
- ☐ 25 – 50 %
- ☐ 51 – 75 %
- ☐ More than 75%

11. **What is your perception of the current level of land clearing and timber harvesting on the Plateau?**

	Very Low	Low	Appropriate	High	Very High
a. Timber Harvesting	☐	☐	☐	☐	☐
b. Land Clearing	☐	☐	☐	☐	☐

12. **Have you ever sold or harvested timber from your *forest land*?**

- ☐ No → **Please skip to Q13 on the next page**
- ☐ Yes

12a. For the most recent timber sale, did you use a professional forester to administer the timber sale operations?

- ☐ No
- ☐ Yes

12b. Approximately how many acres were involved in the sale area?

- ☐ 1 – 25 acres
- ☐ 26 – 50 acres
- ☐ 51 – 75 acres
- ☐ 76 – 100 acres
- ☐ More than 100 acres

12c. What forest products were harvested from the sale area?

(Check all that apply.)

- ☐ Pine Pulpwood
- ☐ Hardwood Pulpwood
- ☐ Tielogs
- ☐ Pine Sawtimber
- ☐ Hardwood Sawtimber
- ☐ Veneer/Specialty Logs

12d. What was your opinion of the "visual quality" of the timber harvest area immediately after the logging operations were completed?

- ☐ Poor
- ☐ Fair
- ☐ Good
- ☐ Excellent

13. **Have you ever received forest management advice or information concerning your *forest land*?**

- ☐ No → **Skip to Q14**
- ☐ Yes

13a. From where or whom did you get the forest management information or advice? ***(Check all that apply.)***

☐ State Division of Forestry
☐ University Forestry Professor
☐ Forest Industry
☐ Logger or Timber Buyer
☐ Consulting Forester
☐ Family or Friends
☐ Extension Service
☐ Other *(please specify):* ____________________

13b. Do you have a written forest management plan with clearly defined goals and objectives for your *forest land*?

☐ No → Do you have an unwritten management plan? ☐ No ☐ Yes
☐ Yes

14. Have you ever participated in government cost-share assistance programs for forestry or wildlife management practices?

☐ No
☐ Yes → What program(s)? ____________________

15. Did you lose any pine trees during the recent Southern Pine Beetle epidemic in Tennessee?

☐ No → **Skip to Q16**
☐ Yes → Approximately how many acres were lost? ________ (acres)

15a. Did you have a salvage timber sale during or after the most recent Southern Pine Beetle epidemic?

☐ No → Please explain: ____________________
→ **Skip to Q16**
☐ Yes

15b. **Did you plant pine trees in any of the Pine Beetle affected area(s) at the completion of the salvage timber sale?**

☐ No → **Skip to Q16**
☐ Yes

15c. How many acres were planted?________(acres planted)

16. There are many reasons why landowners <u>might</u> want to sell timber from their *<u>forest land</u>* in the future. Please indicate how important each of the following reasons for selling timber might be to you.

	Not Important	Slightly Important	Moderately Important	Very Important	Extremely Important
a. Motivated by selling price	☐	☐	☐	☐	☐

b. To improve forest health	☐	☐	☐	☐	☐
c. To convert from hardwood to pine	☐	☐	☐	☐	☐
d. The reputation of the logger	☐	☐	☐	☐	☐
e. An urgent financial need	☐	☐	☐	☐	☐
f. For timber stand improvement	☐	☐	☐	☐	☐
g. For wildlife habitat improvement	☐	☐	☐	☐	☐
h. To clear land for farming	☐	☐	☐	☐	☐
i. For real estate development	☐	☐	☐	☐	☐
j. Other (please specify): ______________________	☐	☐	☐	☐	☐

17. Are you planning to harvest timber from your *forest land* in the future?

☐ No

☐ Yes

18. Please check the box indicating how important each of the following events would be to you for a successful sale, if you were to ever consider selling some timber.

	Not Important	Slightly Important	Moderately Important	Very Important	Extremely Important
a. Getting a timber appraisal	☐	☐	☐	☐	☐
b. Using a sealed bid process	☐	☐	☐	☐	☐
c. Negotiating directly with a buyer	☐	☐	☐	☐	☐
d. Selling the timber on a lump sum basis	☐	☐	☐	☐	☐
e. Past experience with timber sales	☐	☐	☐	☐	☐
f. Tennessee Master logger harvests timber	☐	☐	☐	☐	☐
g. Following Best Management practices	☐	☐	☐	☐	☐
h. Using "partial cut" harvesting methods	☐	☐	☐	☐	☐
i. Using "clear cut" harvesting methods	☐	☐	☐	☐	☐
j. Professional forester administers sale	☐	☐	☐	☐	☐

19. In your opinion, how much do you think your timber is worth on a dollar per/acre amount? $______________/acre

20. What dollar per/acre amount would you be "willing to accept" to sell your timber? $______________/acre

21. Do you derive any non-timber income from your *forest land*?
I derive . . . . . .

☐ income from a hunting lease. → Annual Value = $____________________
☐ income from other non-timber activities. → Annual Value = $______________
(*please specify other non-timber activities):* __________________________

____

☐ no non-timber income from my forest land.

22. Please check the box indicating how useful each of the following ways of learning about timber sale/harvesting operations would be for you.

	Not Useful	Slightly Useful	Moderately Useful	Very Useful	Extremely Useful
a. Extension publications	☐	☐	☐	☐	☐
b. Web Link Workshops	☐	☐	☐	☐	☐
c. Forest Landowner Associations	☐	☐	☐	☐	☐
d. Landowner workshops/field days	☐	☐	☐	☐	☐
e. Talking with a professional forester	☐	☐	☐	☐	☐
f. Other (please specify): ____________	☐	☐	☐	☐	☐

23. Harvesting *forest land* has certain risks and liabilities associated with it. How much risk, if any, do you feel is associated with each item below?

	No Risk	Slight Risk	Some Risk	High Risk	Very High Risk
a. Timber being stolen	☐	☐	☐	☐	☐
b. Property damage	☐	☐	☐	☐	☐
c. Water quality impacts	☐	☐	☐	☐	☐
d. Damage to residual trees	☐	☐	☐	☐	☐
e. Landowner liability	☐	☐	☐	☐	☐
f. Poor wood utilization and waste	☐	☐	☐	☐	☐
g. Beauty of the area affected	☐	☐	☐	☐	☐
h. Other (please specify): ____________	☐	☐	☐	☐	☐

24. Please indicate your level of interest in managing for the following non-timber uses.

	No Interest	Slight Interest	Some Interest	High Interest
a. Enhancing wildlife habitat for hunting	☐	☐	☐	☐
b. Protecting water quality	☐	☐	☐	☐
c. Storing carbon to reduce global warming by maintaining forest cover	☐	☐	☐	☐
d. Maintaining forest cover for aesthetics	☐	☐	☐	☐
e. Protecting rare species	☐	☐	☐	☐
f. Enhancing habitat for birds	☐	☐	☐	☐
g. Other (please specify):	☐	☐	☐	☐

NOTE: If you checked "No Interest" for all items in Q24, Skip to Q28. Otherwise continue with Q25.

25. How useful would you find the following financial incentives in managing for non-timber uses?

	Not Useful	Slightly Useful	Moderately Useful	Very Useful	Extremely Useful
a. Property tax incentives	☐	☐	☐	☐	☐
b. Payments from private individuals or companies	☐	☐	☐	☐	☐
c. Payments from government	☐	☐	☐	☐	☐
d. Other (please specify): ______________________	☐	☐	☐	☐	☐

26. Many of the incentive-based programs listed in Q25 place restrictions on the land. How would each of the following restrictions affect your decision to accept financial incentives to manage for non-timber uses?

	Would prevent me from accepting financial incentives to manage for non-timber uses	Would encourage me to accept financial incentives to manage for non-timber uses	Unsure
a. Allow public access to my property.	☐	☐	☐
b. Limit development of my property.	☐	☐	☐
c. Limit my timber harvesting.	☐	☐	☐
d. Prohibit new buildings on my property.	☐	☐	☐
e. Other *(please specify):* ______________________	☐	☐	☐

27. How useful would you find the following information sources for managing for
non-timber uses?

	Not Useful	Slightly Useful	Moderately Useful	Very Useful	Extremely Useful
a. Extension publications	☐	☐	☐	☐	☐
b. Web Link Workshops	☐	☐	☐	☐	☐
c. Talking with a professional resource manager	☐	☐	☐	☐	☐
d. Workshops or field days	☐	☐	☐	☐	☐
e. Professional assistance	☐	☐	☐	☐	☐
f. Demonstration areas	☐	☐	☐	☐	☐
g. Other *(please specify):* ______________________	☐	☐	☐	☐	☐

Finally, we would like to learn more about your background. Please be assured your answers are **CONFIDENTIAL** and will **ONLY** be used for group comparisons. No question you answer on this survey will be linked to you personally in any analysis or report.

28. What is your current occupation? ***(Please check one.)***

☐ Owner of business
☐ Professional/Management
☐ Clerical or office worker
☐ Craftsman/blue collar
☐ Farmer
☐ Forestry/Logging/Mining
☐ Homemaker
☐ Government employee
☐ Retired
☐ Other ________________________

28a. If you checked FARMER, what percentage of your total income comes from farming? ***(Please check one.)***

☐ None
☐ Less than 25 percent
☐ 25 – 49 percent
☐ 50 – 75 percent
☐ More than 75 percent

29. In what year were you born? _________

30. What is your gender?

☐ Male
☐ Female

31. What is your marital status?

☐ Not married
☐ Married
☐ Divorced
☐ Widowed

32. What is the highest grade of school you completed?

☐ Less than High School
☐ High school graduate/GED
☐ College graduate
☐ Some graduate school

☐ Some college or Vo-tech training ☐ Graduate degree

33. What was your approximate 2006 gross annual income?

☐ Less than $25,000
☐ $25,001 – 50,000
☐ $50,001 – 75,000
☐ $75,001 – 100,000
☐ More than $100,000

Thank you so much for helping with this important study. If you have comments or opinions you were not able to express in the survey, please share them with us in the space below.

If you would like a summary of the survey results, please place an X here_____.

If you have any questions about the survey, please contact Dr. Don Hodges at dhodges2@utk.edu. Please return the questionnaire using the stamped, pre-addressed envelope provided or mail to:

Cumberland Plateau Forest Landowner Survey
Department of Forestry, Wildlife and Fisheries
2021 Stephenson Dr., Ste. 131
Knoxville, Tennessee 37996

CONCLUSION

To ensure that the services and values provided by forests are maintained for current and future users, a global effort was initiated in the late 1980s to encourage the sustainable management of the world's forests. The Food and Agricultural Organization (2006) of the United Nations states that sustainable forest management (SFM) "…aims to ensure that the goods and services derived from the forest meet present-day needs while at the same time securing their continued availability and contribution to long-term development….". Thus, forest management decisions made at every level must be based on both short- and long-term consequences of proposed actions. This dissertation is an attempt to provide additional information about the economics of SFM, which is a global concept, comprised of economic, social, and environmental goals. The study responds to several inquiries in economics regarding SFM, and is comprised of two essays addressing issues related to SFM. Essay one discusses the macro-level problem of trade in forest products and controversial issues regarding the impacts of SFM on trade. Essay two discusses the micro-level problem of forest landowner preferences and decisions.

Implementing SFM is not easy. There are several design and default problems of implementation. At the individual level, forest ownership plays a major role in supporting or hindering SFM, particularly in the U.S. where the majority of forests belongs to private owners. At the global perspective, particularly in trade, exporting forest products countries prefer no trade protection regardless of how good the protection policy may be for society. Sustainable forests are another case of the commons, requiring SFM as a process of cooperation from horizontal and vertical stakeholders ranging from individuals to global levels.

The major findings from the micro to macro level of this study can assist policy makers in understanding the multiple dimensions of SFM. From the micro level with a case of Cumberland Plateau of Tennessee in the United States, the study found that forest owners possessed different ownership objective categories for holding forests.

All forest owners as stakeholders could support SFM implementation by reaching their optimum levels of timber and non-timber uses. SFM does not maintain only one dimension of environmental aspect, but incorporates economic and social uses of the forest. Therefore, with SFM as a goal, forest owner decisions related to their preferences could enhance forest sustainability. However, because of the market failure characteristics of forests, public policy may be an important option for providing incentives for reaching the established goals.

SFM and its policies have been perceived primarily as barriers to international trade in forest products. In fact, the perceptions are derived from the beliefs of an unfair world or simple self-interest perspectives. However, clarification from academic research is needed to provide information and estimate the impacts of SFM policies on trade components. Our study was an attempt to provide additional information regarding trade in forest products and sustainable forest management practices. With the experience from the bilateral trade from U.S.-Canada, we found that increasing forest conservation discouraged exports and encouraged the social price as internalized externalities of wood products in both the short-run and long-run. This is a mechanism of internalized externalities of forest products. The U.S. will import more hardwood and softwood lumber from Canada in the long-run to offset excess demand. However, the impacts on forest products of increasing forest conservation may be overestimated because the U.S. currently has implemented SFM voluntarily and with no legislation or enforcement.

The final conclusion for this study is a call for extending empirical research related to SFM. Because the U.S. is unique, due to the extent of private ownership and the means of implementing SFM policies, the results from this study are a good reference for countries having either the same forest owner characteristics or the voluntary scheme of policy implementation.

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VITA

Pracha Koonnathamdee was born in Bangkok, Thailand on March 16, 1974. Pracha earned B.A. in Economics awarded with second class honor from Thammasat University, Bangkok, Thailand in March 1996. Pracha also graduated in M.A. in Economics from Thammasat University in December 1998 awarded with the best economic thesis. After graduation, he worked at Thailand Development Research Institute (TDRI) before appointed as a lecturer at Faculty of Economics, Thammasat University in May 1999. In August 2002, Pracha took a sabbatical leave to attend Andrew Young School of Policy Studies for his M.A. in Economics with specializes in Public Finance and Public Policy. After graduation, he entered the Graduate School at the University of Tennessee in 2005 in Ph.D. program in Economics. He later transferred to Ph.D. program in Natural Resources concentration in Forest Economics and Policy. Pracha specializes in applied economics including natural resource and environmental economics, public finance, econometrics, and agricultural economics and policy. Pracha is now served as a faculty member at Faculty of Economics, Thammasat University.