J. Forest Economics **9**, 181–203 (2003)

http://www.urbanfischer.de/journals/jfe

Journal of **FOREST ECONOMICS**

Decisions nonindustrial forest landowners make: an empirical examination

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Abstract

Our purpose is to estimate a model of non-industrial forest landowner behavior that considers certain types of behavior that have escaped discussion and rigorous investigation in the literature, yet which are critical to future policy making. Our focus on the many different but related decisions landowners make broadens the typical understanding of landowner behavior to show how bequest motives, debt and participation in non-timber activities, and harvesting decisions are interrelated and dependent on landowner preferences, market, and land characteristics.

Key words: nonindustrial forest landowners, bequests, debt, nontimber activities, absenteeism, forest fragmentation.

JEL Classification: Q23, N50

Introduction

Previous work in nonindustrial private forest (NIPF) landowner behavior is extensive, focusing primarily on how harvesting decisions of forest landowners are related to market, landowner preferences and type, and timber characteristics (e. g., Greene and Blatner 1986, Royer 1987, Romm et al. 1987, and Dennis 1989, 1990, Birch 1992, Hyde and Newman 1991, and Kuuluvainen et al. 1996 provide recent surveys). The primary focus on harvesting and reforestation forms a somewhat incomplete picture of forest landowners from a policy standpoint, because landowners might be less interested in purely market-based activities and more interested in participating in nontimber activities on their land, such as hunting, hiking and wildlife observation. Others have noted that NIPF landowners may also plan to make bequests of their forests to future generations or their immediate heirs (e. g., Hultkrantz 1992). Both bequest motives and nontimber activities could be important in determining whether a landowner will ever harvest.

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1104-6899/03/09/03–181 $ 15.00/0

Another understudied decision facing landowners, at least empirically, is their propensity to save, or if savings is negative, the size of their debt burdens. Debt limits options for land-use and perhaps dictates how landowners manage timber, i. e., Fina et al. (2001) show that those with higher debts may be more likely to accept lower prices for harvesting in order to meet financial obligations.[1] Debt may also be important to a landowner's nontimber activities or their bequests. Those landowners with high debt to income ratios may be less likely to bequeath timber and instead harvest it, and they may have less leisure time to devote to nontimber activities.

We set forth in this paper to estimate a model which addresses all of these important, and related, decisions. The estimation is based on the common utility-based two period nonindustrial forest landowner model, where a landowner is assumed to value amenities from his/her forest and may leave forest stocks at the end of their lives for future generations.[2] The definition of a general reduced form to estimate follows from this model and is estimated for a recent survey of landowners in the Southeastern U. S., where timber production from nonindustrial forest land is highest. A reduced form has not been constructed to estimate a full set of decisions for landowners, and thus one purpose of our empirical analysis will be experimental in the sense that we will implicitly test the conditions behind the reduced form, such as separability of decisions (for a definition of separability, see Kuuluvainen 1989).

This focus on a more complete set of landowner decisions also leads us to a second objective. This is to study how current landowner preferences, which are known to be shifting in the U. S., might influence their behavior. In areas such as the Eastern and Southern U. S., rapid urban expansion is resulting in forest land being sold in increasingly smaller pieces.[3] Landowners are also choosing to live far away from their landholdings. These "absentee" landowners have not been considered extensively, and certainly have not been examined with regard to most

[1] Recently policy makers have argued that landowner tax burdens are a contributing factor of forest fragmentation, or the trend toward parceling land into smaller pieces over time (Decoster 1998).

[2] Pattanayak et al. (2002) estimate a model which considers timber harvesting and land set aside for nontimber reasons. Our paper differs in that we consider other decisions, and we specifically examine the level of activities chosen by landowners for nontimber purposes. The impact of landowner absenteeism and the importance of debt burdens are also considered here.

[3] Forest fragmentation is one of the most frequently discussed trends associated with nonindustrial private forest ownership (NIPF) throughout the U. S. Policy makers constantly face the tradeoff between development, provision of contiguous forests, and the preservation of open spaces. This tradeoff is especially evident where population growth is occurring in historically rural areas (Society of American Foresters 1997, Decoster 1998). A byproduct of growth is the parcelization of forest land holdings into increasingly smaller pieces. As forest land becomes parcelized, the availability of future timber is thought to decrease as harvest access suffers. The breaking up of contiguous forest land may also reduce forest amenities, such as wildlife, that require large forest tracts.

of the decisions we consider, but one can imagine they behave differently with regards to their land compared to resident landowners.

The empirical results establish the importance of landowner preferences and landowner type to the decisions we examine. Our results show that there are significant differences between landowners holding large versus small landholdings, those who are absentee versus resident owners, those with high versus low debt loads, and those that do and do not have bequest intentions. These differences suggest that aggregate models of timber supply may be missing some important features of landowner decisions. That is, while we know a considerable amount about harvesting, we do not know much about the other decisions that might be useful in characterizing nonindustrial landowner behavior.

The remainder of the paper is organized as follows. First, we introduce a simple and standard model of nonindustrial forest landowner behavior that has appeared frequently in the literature. Second, we present the econometric model that follows from the conditions for each decision. Third, we present estimation results using data from Virginia that is typical of the forest sector in many high growth rural areas throughout the U. S. Finally, we offer concluding remarks.

Simple model of landowner decisions

The most frequently used model to explain any nonindustrial landowner decision other than harvesting has been the two period utility maximization problem or its dynamic equivalent, the overlapping generations model (Johannson and Lofgren 1986, pp. 173–175, Max and Lehman 1988, Koskela 1989, Amacher and Brazee 1997, Amacher et al. 1999, Ollikainen 1998).[4] Our purpose is not so much to examine the utility based two period model analytically, as the others have done. Rather, we make use of it to identify in reduced form the decisions that we should estimate using our data. No other model of landowner behavior accommodates all of these decisions that are known to be or are conjectured as important.

In this model, a representative landowner is assumed to have the following utility function,

$$U(C_1, C_2, Q_1, Q_2, \Omega) = U(C_1, \Omega) + \rho U(C_2, \Omega) + N(Q_1, \Omega) + \rho\alpha N(Q_2, \Omega) \quad [1]$$

and the following budget equations:

$$C_1 = PX_1 - S + M, \text{ and} \quad [2]$$

$$C_2 = \{[(K_0 - X_1) + F(K_0 - X_1) - Q_2]\, P + (1 + r)\, S\}, \quad [3]$$

[4] Given that our data (discussed later) is a cross section of landowners, it is not possible to study the timing of decisions. Of course, more dynamic models that illustrate rotation ages do not make bequests or savings explicit.

where N(.) represents nontimber amenities the landowner receives from unharvested forests on their land (i. e., it represents utility derived from nontimber activities on their land), and utility is separable in timber and nontimber components, a common assumption (see Koskela and Ollikainen 1997, Amacher and Brazee 1997). ρ is the rate of time preference, which we set equal to $1/(1+r)$, for simplicity in notation, where r is the market interest rate. Q_1 and Q_2 represent unharvested forest stock left in the first and second period (note $Q_1 = K_0 - X_1$); Ollikainen (1998) and Amacher and Brazee (1997) show how Q_2 equates to the forest stock bequeathed to the next generation at the end of the landowner's life, so that α is the weight the landowner attaches to this bequest. C_1 and C_2 are consumption in periods 1 and 2, respectively, P is the constant stumpage price (thus, this is a price net of harvesting costs), X_1 is timber volume harvested in period 1, S is savings, M is other income unrelated to forest harvesting, and K_0 is an endowment representing standing forest timber stock that the landowner begins with in period 1. Finally, Ω represents a vector of elements important to utility, including landowner type and demographics (its precise makeup in our data is discussed later).

As is the case in these models, the choice of harvesting in the first period (X_1) and the initial timber stock (K_0) determines Q_1, the unharvested stock in the first period. Similarly, we can examine the choice of forest stock left unharvested in the second period Q_2 (i. e., corresponding directly to harvesting in that period). Another standard assumption in defining budget equations is that the landowner works in the first period only (obtaining income of M), while harvesting for income generation can occur in either the first or second periods. The concave forest growth function F(.) describes total volume of timber stock available in the second period – this stock depends on unharvested timber from the first period ($K_0 - X_1$). We assume as is usual that there is declining marginal utility of forest stock and consumption, and that $\partial U(.)/\partial Q$, $\partial U(.)/\partial C_1$ and $\partial U(.)/\partial C_2$ are nonnegative.

A word about interpretation of Q_1 and Q_2 is needed before continuing. These variables represent *unharvested* forest stocks in both periods; they are therefore important to nontimber amenities and, using Amacher and Brazee (1997) and Ollikainen (1998) interpretations, to bequests. For example, the landowner values using Q_2 as a bequest at the end of the second period (see [3]), but this stock also provides nontimber amenities during the life of the owner. As a result, the decision to harvest in the first period, and the decision of how much timber to set aside and **not** harvest in the second period, completely specify the landowner's decisions regarding bequests, harvesting, and nontimber amenities provided by their forests.

The representative landowner maximizes [1] subject to [2] and [3]. Substituting [2] and [3] into [1] and taking derivatives, the first order conditions corresponding to S, X_1, and Q_2 are,[5]

[5] In what follows, subscripts for functions denote the derivative of the function with respect to the argument indicated in the subscript. This is a partial derivative for functions of more than one argument.

$$-U_{C_1}(.) + \rho U_{C_2}(.) = 0 \quad [4a]$$

$$U_{C_1}(.)P + \rho U_{C_2}(.)P(-1 - F_x) - N_{Q_1}(.) = 0 \quad [4b]$$

$$\alpha\rho N_{Q_2}(.) - \rho U_{C_2}(.)\rho = 0 \quad [4c]$$

The first order condition for savings [4a] (or equivalently debt), shows that the landowner saves (or accumulates debt) so that discounted marginal utility of consumption remains constant between time periods, a standard result. The landowner harvests timber (condition [4b]) to equate the marginal benefit of not harvesting, in terms of nontimber amenities, to the marginal benefits of harvesting.

In the literature regarding these models, one important property of harvesting depends on the presence of nontimber amenities. If nontimber amenities are absent, then $N(.) = 0$ in [1], and the necessary condition [4b] for harvesting X_1 reduces to: $U_{C_1}(.)P + \rho U_{C_2}(.)(-1 - F_x) - P = 0$, which using condition [4a] then implies that harvesting in the first period is a function of (nonconstant) prices, harvesting costs, and forest stocks. This is a special case of Jevon's rule in a two period model (e.g., see Amacher and Brazee 1997). It implies X_1 would **not** depend on utility or any of the arguments of utility (i.e., Ω, M), i.e., we say that harvesting "separates" from utility and consumption. Moreover, when there are zero nontimber amenities, there is no value of leaving forest stocks unharvested at the end of the second period, so that we have the simple solution $Q_2 = 0$.

If harvesting separates from utility and consumption, then the landowner's decisions are also said to be 'recursive', in that one can solve harvesting in the first period, which then through forest growth determines harvesting in the second period (using $Q_2 = 0$). This harvesting solution determines harvest income. Harvest and nonharvest incomes are then used in the budget constraints [2] and [3] to solve for consumption that maximizes utility.

Harvesting does not separate and decisions are not recursive if the landowner receives nontimber amenities, i.e., if $N(.) > 0$. In this case, harvesting in the first period is determined by equation [4b]; harvesting depends on elements that are part of utility. Q_2, the stock of forest bequeathed in the second period, is also no longer zero and now depends on elements of utility (see eqn. [4c]). For example, by substituting [2] and [3] into [4b], we see that harvesting and bequests depend on income, debt, and other characteristics that determine utility.[6]

In the econometric section, we will provide a weak test for this separation. One simply tests the null hypothesis that elements of consumption and other aspects of utility (like landowner characteristics) are important explanatory variables in pre-

[6] Of course, this language is somewhat confusing, because harvesting does not separate when $N(.) > 0$ even though utility is separable in [1].

dicting the probability that the landowner harvests or leaves timber and land as a bequest. The case of nonseparation in harvesting is almost always assumed for nonindustrial landowners (see for example, Kuuluvainen 1989 and Ovaskainen 1992).

Data and estimable reduced form

We first discuss the particulars of our data, as this dictates the specifics of the reduced form we later estimate.

Data collection

Data were obtained using a 1998 mail survey of 1550 landowners within five counties in the northern piedmont region of central Virginia: Albemarle, Fluvanna, Greene, Louisa, and Nelson counties.[7] This area has undergone an 8 % overall increase in population between 1990 and 1995, and nonindustrial land ownership comprises over 75 % of total forest ownership. Landowner names were randomly sampled using tax records obtained from county courthouses. Corporately-owned properties and properties less than five acres in size were not included in the sample (the latter are found predominately in developed residential areas for our sampling area). Focus group meetings were held with landowners and county foresters, who work closely with private landowners in the sampling area to refine the questionnaire. A pretest was conducted on a random sample of 80 NIPF landowners in Culpeper County, Virginia, which has population and forest characteristics that are similar to the counties included in the full-sample survey. The revised full-sample survey included the recommended postcard follow-up sent to all landowners, following Dillman (1978). A total of 1490 surveys were delivered, and the final response rate was 38 %. A non-respondent telephone follow-up survey revealed no statistically significant differences between respondents and non-respondents based on paired t-tests of important variables, including income, length of ownership, age, and parcel size.

Selected descriptive statistics are presented in Table 1. About 22 % of the landowners in our sample were absentee, as it is defined in the literature (i. e., their residences are located at least 50 miles from their properties), which is consistent with other work (Hodge 1991, Birch 1992). About 62 % of landowners permanently resided on their property. The average age of landowners sampled was 60 years old, although absentee owners and owners of smaller tracts tended to be slightly younger. Average gross income per household for 1997 was $ 91,142.19. The average absentee landowner carried three times the debt load of the typical resident owner and had a debt to income ratio that was twice as large. Owners of large properties, by our definition, had a debt to income ratio that was over 50 %

[7] A copy of the survey and detail of tests are available from the authors upon request.

Table 1. Selected descriptive statistics.

Variable	Units	All Land-owners	Absentee Landowners	Resident Landowners	Tracts > 15 acres	Tracts ≤ 15 acres
Absentee	0,1	0.22	1.00	0.00	0.24	0.11
Tract Size	Acres	185.32	210.24	178.66	211.89	9.36
Bequest Intention	0,1	0.67	0.72	0.65	0.65	0.74
Debt to income ratio	Ratio	1.13	2.02	0.84	1.17	0.79
Days spent hunting	Days in last year	6.96	4.60	7.60	7.50	3.45
Harvested in past	0,1	0.62	0.60	0.63	0.67	0.34
Hardwood sawtimber present	0,1	0.45	0.41	0.46	0.44	0.48
Income	US dollars	91,142.19	108,510.64	86,268.66	92,904.11	81,093.75
Days in non-hunting nontimber activities	Days in last year	205.16	76.28	239.89	207.43	190.34
Miles of roads	Miles on property sampled	1.86	3.13	1.52	1.97	1.10
Reforestation after	0,1	0.20	0.31	0.17	0.20	0.21

higher than owners of small properties.[8] About 65 % of landowners had previously harvested, 80 % planned on leaving a timber and land bequest, 20 % of those harvesting also reforested, and all participated in nontimber activities on their land (the average number of hunting and non-hunting days were about 7 and 205 respectively per year). Resident landowners appeared to use their land more for nontimber activities than absentee owners. Finally, access within a tract was quite high (owing to the broken-up nature of the landscape), with an average length of private roads being 1.86 miles. Absentee landowners had twice as many miles of roads as resident landowners.

Reduced form and hypotheses

The theory section established that, to understand landowner behavior, we must treat harvesting *(H)*, bequest *(B)*, amenities derived from participation in non-

[8] In this study, a tract is considered "large" if it is greater than 15 acres in size. This threshold level was initially chosen because it is where logging costs are typically greatly reduced, enough to make capital-intensive logging operations financially feasible (personal communication, John Scrivani, Virginia Department of Forestry, 1998). Other thresholds were tried, but the estimation yielded no new insights.

timber activities *(N)*, and debt to income ratio *(D)* as important decisions when estimating a model of non-industrial forest landowner behavior. Given our data, we will use as a measure of N the level of participation in nontimber related activities by each landowner. Also, we will a priori assume that harvesting does not separate from utility (and test it later).

The first order conditions [4a]–[4b] suggest the following reduced forms for nontimber amenities *(N)*, harvesting *(X)*, debt *(D)*, and bequests *(B)*:

$$N = N\,(\underset{+/-}{\beta}, \underset{+}{\alpha}, \underset{-}{p}, \underset{+/-}{\rho}, \underset{+/-}{M}, \underset{+/-}{\Omega}; \varepsilon_N), \tag{5}$$

$$X = H\,(\underset{+}{\beta}, \underset{-}{\alpha}, \underset{+}{p}, \underset{+/-}{\rho}, \underset{+/-}{M}, \underset{+/-}{\Omega}; \varepsilon_X), \tag{6}$$

$$D = D\,(\underset{+/-}{\beta}, \underset{+}{\alpha}, \underset{+}{p}, \underset{+/-}{\rho}, \underset{+}{M}, \underset{+/-}{\Omega}; \varepsilon_S), \text{ and} \tag{7}$$

$$B = B\,(\underset{+/-}{\beta}, \underset{+}{\alpha}, \underset{-}{p}, \underset{+/-}{\rho}, \underset{+/-}{M}, \underset{+/-}{\Omega}; \varepsilon_B), \tag{8}$$

where the signs are expectations derived from comparative statics, and β is a composite variable representing site parameters such as size classes of forest stocks that increase forest yield at harvest, i. e., by writing $F(.) = \beta F(.)$ where $\beta > 0$ (see appendix). The presence of utility attributes Ω in these equations is indicative of the assumed non-separability of decisions discussed earlier. Debt is equivalent to negative net savings, and so the effects of parameters on debt would be the negative of their effect on savings, as long as landowners hold positive debt in our sample (they all do in fact).[9] Applying the idea of the two period model to our data, previous harvesting by the landowner, which we have data on, is similar to X_1, while intentions to bequest now are similar to Q_2. The terms ε_j represents the stochastic error present in estimating each decision j. These equations show that the decisions should include, as explanatory variables, price *P*, elements of preferences for bequests *(α)*, elements of forest growth *(β)*, non-harvesting income, and other elements important to utility (Ω).

The comparative statics are well known for two period models and thus we provide only a sketch of the results specific to our model in the appendix. These results and the signs above in [5]–[8] show that the precise effect of any parameter on each decision is generally ambiguous and depends on the sign and magnitude of cross partial derivatives for utility and forest yield functions. Moreover, as others have argued or found with data, the impact of prices and income on har-

9 There is some support in the theoretical literature that debt payment obligations reduce reservation prices for a forest landowner, which would increase the probability of harvesting (Fina et al. 2001). The possibility of credit constraints, known to be important to landowner behavior, is difficult to verify in our data. However, we do not expect these to be very important given that landowners in our sample were relatively wealthy (average income over $ 90,000 per year) and generally in retirement or close to that age. Others have also found these statistics for samples of nonindustrial landowners in other regions of Virginia (Hodge 1991).

vesting might be ambiguous because of unknown magnitudes of income and substitution effects (e. g., De Stiegeur 1984, Brooks 1985, Alig 1986, Dennis 1989, Newman and Wear 1993, Klosowski et al. 2001).

It is always a problem to represent precisely the impacts of utility attributes on harvesting and other decisions. For example, no model has yet to show the precise comparative statics for landowner absenteeism to harvesting and other decisions. However, we know that these variables affect utility and therefore must affect decisions if harvesting does not separate (Koskela 1989, Kuuluvainen 1989, Ovaskainen 1992). We will proceed by including as elements of Ω in our data the following: demographics, risk and environmental preferences, and other indicators for landowner type.

There is existing literature, complementary to our comparative statics, that identifies the empirical effects of other variables on some of the decisions in [5]–[8]. For example, for harvesting behavior, prices and income may have an ambiguous effect, as discussed earlier (e. g., Hyberg and Holthausen 1989, Kuuluvainen et al. 1996). Forest access may or may not increase harvesting, depending on the nontimber amenities valued by the landowner. Landowner characteristics such as absenteeism should be important given prior discussion in the applied literature (i. e., Shaffer and Meade 1997), but we have no way of knowing a priori what the econometric effects are of these variables. Fina et al. (2001) show theoretically that debt should increase the probability of harvesting, and it is well known that preferences for nontimber activities may affect harvesting (Binkley 1981, Boyd 1984, Alig et al. 1990, Newman and Wear 1993, Pattanayak et al. 2002). Thus, it is quite possible that nontimber amenities could influence debt and vice versa. In fact, Alig et al. (1990) note that wealth is important to participation in nontimber activities when viewed as leisure goods, and so income or debt should be important in equation [5]. In many cases landowners of course also appear to have an interest in jointly producing both timber income and forest nontimber amenities (Egan 1997, Newman and Wear 1993, Pattanayak et al. 2002).

We will examine landowner participation in hunting and non-hunting activities – one might imagine that hunting preferences for some species could increase harvesting, while non-hunting preferences probably decreases harvesting, although this may depend on specific habitat needs and its relationship with harvesting. Research has not yet examined *levels* of participation in these activities by landowners, but Jenkins et al. (2002) does establish that forest condition matters in the value hunters attach to a forest site. In Table 1 it is clear that while hunting was important for some landowners, most of the landowners engaged in non-hunting activities with higher frequency. Thus, timber prices, income, and land and landowner characteristics should be expected to affect these activities. We expect that the effects of these variables would be opposite their effects in the harvesting decision. Finally, our estimation of a bequest equation is included for completeness, but this has been studied very recently by Amacher et al. (2002). They show that high harvest prices and debt should reduce bequests, but preferences for nontimber amenities may increase them.

Limitations with our data dictate the precise approach in estimating each of the above equations. For example, we have continuous data for participation in non-timber activities and for debt, and these are non-censored (i. e., every landowner reported positive values for these). For the other variables we have discrete observations, i. e., we know whether the landowner planned on leaving a bequest or not, and whether the landowner had harvested/reforested or not. Thus, we estimate equations [6] and [8] using a specification for the discrete dependent variable,

$$Z^* = \beta' G + e_Z; Z = 1 \text{ if } Z^* > 0; Z = 0; \text{ if } Z^* \leq 0; \qquad [9]$$

where Z (= 0,1) is a binary (dependent) variable representing the observed participation vector for the three choices, β represents parameters to estimate, G is a vector of explanatory variables present in the equations from above, and e_z is an error with an extreme value distribution (Madalla 1983).

The functional form chosen for each equation was either linear or log-log form, mainly because there is little guidance in the literature, and because these forms approximate a family of utility functions (Chung 1994). Misspecification tests were applied where appropriate to assess the linearity implied in the functional forms. There are no such tests for binary dependent variable models because these do not have continuous errors, however, we followed the econometric literature and considered the percent correct predictions as a reasonable equation performance indicator (see Kennedy 1992 for justification of this procedure). For the continuous dependent variable equations, a RESET test was used to evaluate whether the functional forms were correct. All equations were corrected for heteroskedasticity of unknown form following White's method (Greene 1997).

Some right hand side variables that represent choices, such as debt to income ratio and measures of nontimber activities, could be correlated with errors in equations where they appear as explanatory variables, i. e., they may be endogenous. This was handled using a standard two staged instrumental variable approach to obtain asymptotically consistent estimates. In this procedure, a first stage prediction of each suspected endogenous variable was recovered using a regression of the endogenous variable on exogenous variables in the system. As long as each equation was at least identified (see Greene 1997), this prediction was used in the second stage when the equations are individually estimated.[10]

We used debt to income ratio as an explanatory variable for the B, X, and N equations, as this worked better than using the (highly) correlated debt and in-

[10] This two staged least squares procedure is a single equation approach that accounts for structural linkages. We tried to use a system-wide 3SLS approach, used in Pattanayak et al. (2002), which would improve efficiency, though not consistency, of estimates. However we were limited by our lack of data for some key decisions, like reforestation where only landowners who harvested could be included.

come variables separately in these equations. This does not affect the efficacy of our instrumental variable approach. The sample is large enough to implicitly assume the errors take on an asymptotic Normal distribution. Hence, the treatment of the debt to income ratio in a two staged least squares regression proceeds using $\hat{D}/I$ as a regressor in place of debt to income ratio, where I is income and $\hat{D}$ is the first stage prediction.[11]

A word about price is needed before proceeding. Prices were assumed to be *exogenous* from the perspective of a landowner, as in all forestry landowner work, given that each landowner is a price-taker.[12] Harvest price has been a difficult variable to include for previous NIPF studies. In our survey, nearly all respondents harvesting in the past 5 years knew the price they received, and this was adjusted to 1998 dollars to be consistent with the rest of our data points. We used actual price per acre for landowners who harvested, and regional prices from Timber Mart South for an average site and hardwood sawtimber for landowners not harvesting within the last 5 years (thus prices were in general not constant over all landowners in the sample).

This approach improves slightly upon the existing treatment of prices in the literature on NIPF landowners. It is similar to Bolkesjø and Baardsen (2002), in that we have some landowner specific prices. Other work (i. e., Dennis 1989, 1990, Hyberg and Holthausen 1989) made use of regional price data as a proxy for actual returns, while others have used estimated prices. For panel data, Kuuluvainen et al. (1996) used annual prices from written contracts between landowners and buyers for years in which a landowner made a sale, and regional prices for the years in which the owner did not sell. If we were to have used only regional prices, then there would have been little variation given their aggregate nature (i. e., each price would be an average price which is equal for all counties in our sample region). Moreover, despite the variation problem, using regional prices for all landowners would simply have meant that price was constant in our data for all landowners who harvested at the same time. Similarly, given that our data is cross sectional, inclusion of a market interest rate for our sample area would also have resulted in a variable that was constant for all landowners.

Another limitation of our data is important to mention. For harvesting, landowners knew only the total revenues from harvesting and acres harvested, but they generally did not know either volume or species harvested (this was verified and also found in our focus group and pre-testing).[13] Focus groups and

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[11] Formally, the central limit theorem implies Plim $\hat{D}/I = (1/I)$Plim $\hat{D}$, where I is income, because income is non-stochastic. If the model is identified and errors are i. i. d., then estimating $\hat{D}$ from the first stage regression implies Plim $\hat{D} = D$, so that Plim $\hat{D}/I = D/I$, the debt to income ratio.

[12] For other examples of this assumption, see Binkley (1981), Royer (1987), Dennis (1989, 1990), and Kuuluvainen et al. (1996).

[13] We tried using land area as a measure of intensity for harvesting. However, lack of variation in acreage harvested across landowners led to regressions that did not perform well.

pre-testing also showed that landowners did not know precise volume or species types, or even specific ages of trees, that existed on their property at the time of our survey.[14] Landowners generally knew the relative size of trees as sawtimber or pulpwood, and a dummy variable reflecting this is used as an explanatory variable in the regressions. This is fairly common in rapidly urbanizing areas where landowners are absentee and do not live continually on their property. Another reason landowners did not have perfect information of their property or harvest volume was that most landowners in our survey were not registered tree farmers (i. e., over 90 %). In our pre-testing and focus group meetings with the survey instrument, landowners did not recall the species composition or forest stocking removed during the harvest, rather, they knew the acreage harvested and their total revenues they collected from the sale (this was common in our pre-testing and focus groups).

Finally, we estimated each equation with the sets of variables shown to be important in the theory. Due to data limitations, some highly insignificant variables (i. e., that did not have t statistics significant at even the 20 % level) were dropped either because the regression failed to converge with the variable present, or dropping the variable improved the F statistic. In dropping these insignificant variables, we followed the principle of backward elimination (Draper 1998), where variables were only dropped if the F statistic of the regression did not decrease. In no cases was a statistically significant variable at the 20 % level or less dropped, nor did dropping a variable affect the remaining estimates appreciably, or the variable was left in the model. The benefit of not including some purely exogenous variables in the system of equations is that the order condition of identification for the debt and nontimber activity estimates holds (see Green 1997).

Estimation results

Model parameters were estimated for harvesting, timber bequests, involvement in nontimber activities, and debt equations (Tables 2–3). Log-log specifications worked best for the bequest and nontimber activity equations, while linear specifications worked best for the harvesting equation (functional form tests discussed later also confirmed this). The number of variables differs in the equations, and the elements of preferences contained in Ω for each equation differ, because as we noted highly insignificant variables were dropped for parsimony and degree of freedom considerations.[15] Also, the specifications estimated in Tables 2–3 were guided

[14] A reviewer pointed out that Nordic landowners who have harvested generally know volume but do not know the area harvested or age of stands with certainty.

[15] For example, a dummy variable indicating stocking type (i. e., pulpwood and sawtimber sized trees) and some aspects of the site did not affect nontimber activities appreciably and were very insignificant.

by the reduced forms [5]–[8] and also by previous literature (see the discussion that proceeds the reduced forms). Finally, participation in nontimber activity levels and debt were treated as endogenous when appearing on the right hand side.

Misspecification testing

We conducted several misspecification tests ex post to the estimation. These were used to test the exogeneity of parameters assumed to be exogenous, as well as the stability and appropriateness of the functional forms estimated. Percent correct prediction estimates of the dependent variables for each binary dependent variable regression, and RESET test statistics for the continuous dependent variable regressions were also computed (Tables 2–3). RESET tests assume a null hypothesis that the functional form does not change when regressed over data sorted accord-

Table 2. Estimation results for harvesting equation. Standard errors are in parentheses.

Variable[2]	Harvesting (0,1) (n = 167)	
Constant	–3.29**	(1.88)
Harvest price per acre	0.37***	(0.13)
Debt to income ratio[3]	0.39**	(0.19)
Pine sawtimber (Y/N)	–1.11	(0.74)
Days spent hunting[3]	0.06***	(0.01)
Days spent in non-hunting activities[3] acres	–0.17**	(0.01)
Average slope	0.33	(0.26)
Miles roads	0.002	(0.017)
Intend to Bequeath Timber/land (Y/N)[3]	–0.58**	(0.33)
Risk Perception[1]	0.49**	(0.23)
Landowner Age	0.02**	(0.012)
Parcel Inherited (Y/N)	0.49	(0.39)
Absentee (Y/N)	–1.90*	(1.30)
Large parcel		
(Y/N)	3.58***	(1.00)
Chi-squared statistic for regression	78.78***	
Percent correct prediction	79%	

[1] Dummy variable for perception of high risk growing trees.
[2] A blank space means the variable was highly insignificant in the regression and was dropped.
[3] Independent variables treated as endogenous include debt, days spent hunting, and days spent in non-hunting activities.
* significance at 0.15; ** significance at 0.10; *** significance at 0.05.

Table 3. Estimation results for timber bequest, debt loads, and nontimber activity day regressions. Timber bequest and nontimber activity equations are of log-log form. Standard errors are in parentheses.

Variable[2]	Timber Bequests (0,1)	Debt (US$)	Nontimber Activity Days
Constant	–5.06 (0.84)	8.09E+05*** (3.89E+05)	294.28*** (93.84)
Harvest price per acre	–0.025 (0.022)		17.15*** (9.94)
Debt to income ratio[3]	–0.04*** (0.10)	N/A	1.21*** (0.008)
Income		0.69 (0.91)	N/A
Pine sawtimber (Y/N)	0.82*** (0.27)	76793 (2.86E+05)	
Hardwood sawtimber (Y/N)		–45362 (1.29E05)	
Mixed sawtimber (Y/N)		1.66E+05*** (80291)	
Days spent hunting[3]	0.026*** (0.003)	5970.1 (21979)	N/A
Days spent in non-hunting activities[3]	0.014*** (0.003)	–798.28 (1535)	N/A
acres			0.24 (0.35)
Average slope	–0.07 (0.08)	–36736 (84737)	
Miles roads	–0.003 (0.008)	1288 (5636.90)	
Risk[1]	0.63*** (0.09)		
Previous Harvest (Y/N)			–81.34*** (46.8)
	0.02***	–9952***	–3.10***
Age	(0.004)	(3126.10)	(1.29)
Married (Y/N)		63252 (91575)	48.92 (55.73)
Employed (Y/N)		–2.34E05*** (84132)	
Live on Property (Y/N)			30.25*** (4.97)

Table 3. Continued.

Variable[2]	Timber Bequests (0,1)	Debt (US$)	Nontimber Activity Days
Parcel Inherited (Y/N)	0.21* (0.14)		6.99 (46.38)
Absentee (Y/N)	1.91*** (0.44)	1.99E05*** (8.6E04)	–245.34*** (57.45)
Large parcel (Y/N)	–0.65*** (0.288)	1.8E04 (9.8E04)	109.41*** (57.45)
Log Likelihood		–4820.31	–1790.58
Chi-squared statistic	102.32***	N/A	N/A
F-statistic	N/A	2.39	5.73
RESET test statistic value	N/A	–4.4	–4.2
Percent correct prediction	78%		

[1] Dummy variable for perception of high risk growing trees.
[2] A blank space means the variable was highly insignificant in the regression and was dropped.
[3] Independent variables treated as endogenous include debt, days spent hunting, days spent in non-hunting activities.
* significance at 0.15; ** significance at 0.10; *** significance at 0.05.

ing to estimated residuals. The test statistic results clearly show that the functional forms estimated are sufficient for us to reject the null hypothesis. For the binary dependent variables, the percent correct prediction in all cases is nearly 80%, which is reasonably high for these types of models.

Finally, tests were employed to consider the null hypotheses that the set of instruments we used were exogenous, and that the resulting identifying restrictions were appropriate. Both are needed to show that our two staged least squares regressions produced asymptotically consistent estimates. We used two tests, one to establish that the instruments were exogenous (Bound et al. 1995), and the other to check the conditions for identification (Davidson and MacKinnon 1993). The sufficient order condition for identification holds for each estimated regression, as the number of excluded exogenous variables in each regression exceeds the number of endogenous variables in that regression minus one.

The instrument exogeneity test proceeded as follows. We regressed the estimated residuals from each continuous dependent variable regression against assumed exogenous variables, and then we tested the null hypothesis that the coefficients on the exogenous variables were all equal to zero. For debt and nontimber activity regressions (residuals are not defined for the binary dependent variable regressions), none of the exogenous variable coefficients in the residual regressions had p-values less than 15 %, indicating that variables assumed to be exogenous were not correlated with the error in the estimated equations.

Harvesting

The dependent variable for the binary decision equaled one if the landowner had harvested in the past 5 years and zero otherwise. The Chi-squared statistic was 78.78, indicating that the regression was highly significant.[16] There were nine significant variables at the $P \leq 0.05$ level and one at the 0.15 level: a dummy variable for risk perception concerning growing timber (+),[17] whether the landowner intended on bequeathing timber to heirs (–), whether the tract was greater than 15 acres (+), whether the landowner was absentee (–), harvest price (+), time spent in non-hunting nontimber activities (–), debt to income ratio (+), and age (+).

Interestingly, debt was a strong motivator for harvesting. Bequest preferences were also important. Some of the more interesting results concerned the substitution of nontimber amenities with harvesting, and the importance of tract size and absenteeism. There has only recently been work that seeks to explore the importance of nontimber amenities to harvesting behavior (Pattanayak et al. 2002), but in their results acres of land preserved for (presumably) nontimber activities are included in a harvesting regression based on FIA plot data for the Southern U. S. Our results are similar, in that harvesting indeed depends on nontimber amenities, but we show that the *type* of nontimber amenity is also important. In our sample, participation in non-hunting nontimber activities were not complementary with harvesting. However, days spent hunting increased the likelihood of harvesting, as many species hunted in the sample area, such as whitetail deer, require early-successional forests.

Recall a secondary objective was to assess the impact of tract size and landowner absenteeism to landowner decisions. The dummy variable for absenteeism was negative and significant at the 10 % level, indicating that absentee landowners were considerably less likely to harvest than resident landowners. Absentee owners may have less information regarding harvesting than resident landowners. This group of landowners may also view their land more as a place to visit and enjoy than as an opportunity for timber revenues. This finding supports the view that the current trend toward absenteeism will reduce the total amount of timber

[16] In some theory literature, which has only considered rotation age, it has been suggested that a price × volume interaction term is important to harvesting. However, we could not use such a term because, as we noted earlier, landowners did not know harvest volumes (thus they would not have responded to this variable anyway). An interaction term for (price) × (acres harvested) also did not perform well.

[17] The risk variable in our regressions is a dummy variable which represents the landowner's answer to an ordinal scale question regarding their assessment of risk associated with growing trees, such as ice or insect damage. The dummy variable equaled one if the landowner chose a scale of 4 or 5, and equaled zero of the landowner chose a scale of 1–3 in their answer.

available for commercial harvesting. Size of the tract was also significant, and landowners with larger tracts were more likely to harvest. In highly parcelized areas, access to any given forest stand is reduced, and harvesting may require additional costly contracts between the logger and other adjoining landowners. Moreover, the benefits to the logger, with fixed costs, to harvesting smaller areas may also reduce the likelihood of a landowner finding a bidder for the forest stand. Our tract size variable may be reflective of this situation, or it may simply be a scale effect – without future work it is difficult to tell what this affect, albeit statistically significant, will have on timber supplies in a region.

Timber and land bequests

In the estimated timber bequest equation (Table 3), the dependent variable equaled one if the respondent planned on bequeathing **any** (all or part) of his/her timber and land to heirs, and zero otherwise.[18] This equation is somewhat different from the one estimated in Amacher et al. (2002), who considered the choice of timber bequest only. Significant variables in this decision included: debt to income ratio (–), the presence of pine sawtimber on the site (+), days spent hunting (+), days spent in nontimber activities (+), risk the landowner associated with timber production for profit (+), age (+), whether the parcel was inherited (+), whether the landowner was absentee (+), and whether the parcel was large (–). These signs make intuitive sense. Landowners with high debt should be less inclined to leave a bequest and more inclined to harvest or sell their property. If the landowner had nontimber amenities, or if they also inherited the property, then their incentive to bequest was higher. The positive sign of pine sawtimber is an indication of the higher merchantable value this product has in our sample area.

Absenteeism and tract size again played roles in the bequest decision, like they did in the harvest decision. Absenteeism also had a strong positive relationship with likelihood of timber bequests (recall absentee owners were also less likely to harvest). Tract size was negative and significant, indicating that owners of large land parcels tended not to bequeath timber as often as owners of smaller parcels.

Debt Choice

The estimated debt equation (Table 3) had four significant variables including the presence of sawtimber-size mixed pine/hardwoods (+), age of landowner (+), employment status (–), and a dummy variable indicating the landowner is absentee (+).[19] Landowner absenteeism was the most important finding here for future for-

[18] A multinomial logit model, which separated the choice to bequeath all timber from the choice to make a partial bequest was also estimated (e. g., see Greene 1997). However, for our sample, very few people who planned to bequeath timber intended only to bequeath part of their holdings. Therefore, this approach was dropped in favor of the binomial logit approach described above.

[19] Landowner debt includes mortgages, car loans, education loans, credit cards, and other loans.

est markets. The positive relationship between debt and absenteeism we found is plausible considering the majority of absentee landowners own more than one property, from the descriptive statistics in Table 1. The descriptive statistics also suggested that absentee landowners hold more than three times the amount of debt carried by resident owners.

Participation in nontimber activity

The final landowner decision from our theoretical model is the propensity to engage in nontimber activities (Table 3). Here, the dependent variable is the number of days in one year the landowner spent in nontimber related activities. This is more meaningful than a qualitative variable specifying whether a landowner recreated on his/her property, which would include most of the sample.[20] Seven variables are significant either at the 0.05 or 0.10 level: harvest price (+), debt /income ratio (+), a dummy variable indicating whether the landowner has ever harvested within the past five years (–), landowner age (–), a dummy variable indicating whether the landowner lives on the property (+), and variables indicating whether the landowner is absentee (–) and has a large tract (+). These variables all have expected signs. As timber prices increase, landowners are more likely to engage in recreation on their property. Perhaps this could mean that high quality land offers more opportunity for non-market activities, given that wildlife habitat might be better developed. The debt to income ratio is also a positive predictor of recreation activity. Landowner age negatively affects non-market activities, which makes sense given the high average age of landowners in our sample (and across the South in general). Landowners who live on their property are also more likely to recreate on it, again making sense.

As with most of our previous regressions, two very important predictors are the size of the tract and whether the landowner is absentee. Absentee landowners spend less time using their land for recreation. Many absentee landowners visit their land only periodically compared to those that live on or reside close to their properties. Landowners with larger tracts engage in more non-market activities, perhaps because there are greater resource opportunities.[21] All of these results imply that forest parcelization combined with absenteeism may lead to less nontimber recreation undertaken by landowners, even though harvesting will also be reduced.

[20] More complicated discrete choice models were attempted using several activities. An example included a Tobit type II model for harvesting and nontimber activities. However, these models either did not converge properly, or the Chi square statistics were not significant at even the 15 % level.

[21] This does not mean that nontimber amenities increase in areas with larger tracts, as highly parcelized areas may imply a larger number of landowners visiting more sites for recreation.

Does separation hold?

We noted before that a simple test for separation of harvesting was to determine if there were variables significant in the harvesting regression that are not directly related to profits from harvesting. Indeed, we found that there were many of these types of variables, including in fact nontimber amenities. Moreover, bequests were clearly important to landowners, indicating that nontimber amenities must be present in the utility function of landowners. This establishes that the estimated reduced form is indeed not recursive and also confirms our a priori assumed model structure.

Conclusions

Our purpose has been to estimate a model of non-industrial forest landowners, and consider certain types of behavior that have escaped discussion and rigorous investigation in the literature, yet which are critical to future policy making. Our focus on many different but related landowner decisions broadens the current understanding of landowner behavior to show how bequest motives, debt and nonmarket activities, as well as the usual harvesting decisions are interrelated and dependent on landowner preferences, market, and land characteristics. Landowner absenteeism, forest parcel size, and nontimber preferences factor importantly in these decisions. The new empirical evidence here provides policy guidance for the emerging issues of land parcelization in rapidly urbanizing forested areas. While it is true that our results must be taken within the context of the area sampled, this area and the landowners involved have much in common with other areas of the U. S. and with North American nonindustrial landowners in general.

The most important findings suggest that as tracts are parcelized into smaller and smaller pieces, it does not necessarily mean that forest cover declines, according to our results. Rather, harvesting declines and the likelihood landowners will leave standing forests as a bequest increases. However, landowners are also becoming increasingly absentee in rapidly urbanizing areas. We find that absenteeism can result in many changes within the forest sector, at least as far as nonindustrial forest landowners are concerned. In our sample, absentee landowners are less likely to harvest and less likely to engage in non-timber uses on their land. This implies, curiously, that absenteeism could increase forest cover among landowners, but fewer nontimber activities will be pursued in the forest. This is especially true if forest fragmentation into smaller parcels is also occurring, because we show that larger tracts are more likely to be harvested and used for non-timber activities. Absentee landowners also hold higher debt relative to their income, but they are also more likely to bequeath standing timber to their heirs. Again, however, any landowner with a large tract is *less* likely to bequeath timber and more likely to harvest. All of these results suggest collectively that absenteeism and fragmentation of forest land cannot be considered or discussed independently if one wants to predict what future forest cover will look like in rapidly urbanizing areas.

Another contribution of the results is to show how debt, nontimber activities, and harvesting behavior are related. All can influence future forest availability, and all are driven by landowner preferences and characteristics. Indeed, we find there are interesting substitutions and complementarities between all decisions. Landowners with high debt to income ratios are more likely to engage in non-market activities on their land but also more likely to harvest. Debt reduces the incentive to bequest standing forests. Another strong connection we find in our data is between harvesting and the type of nontimber activity preferred by the landowner. If landowners hunt, then they are more likely to harvest and are more likely to leave a bequest. Those landowners that do not hunt but still have preferences for nontimber uses of their land are much less likely to harvest and are even more likely to leave a bequest. Harvesting probably contributes to habitat needs of species that are hunted in this area.

Appendix (selected comparative statics results)

Recall the first order conditions for the endogenous choice variables S, Q_2, and X_1 are,

$$\mathrm{V_S}: \quad -U_{C_1}(.) + \rho U_{C_2}(.) = 0 \qquad \text{[a1]}$$

$$\mathrm{V_{Q2}}: \quad \alpha\rho N_{Q_2}(.) - \rho U_{C_2}(.)P = 0 \qquad \text{[a2]}$$

$$\mathrm{V_{X1}}: \quad U_{C_1}(.)P + \rho U_{C_2}(.)P(-1 - F_x) - N_{Q_1}(.) = 0 \qquad \text{[a3]}$$

Where V is the value function. Recall also that $Q_1 = K_0 - X_1$, where K_0 is a given endowment, so that the comparative statics of X_1 give the comparative statics of Q_1. Using the implicit function theorem, we can write endogenous variables above as functions of exogenous variables in the system,

$$Q_2 = Q_2\,(\alpha, P, \rho, M, \Omega) \qquad \text{[a4]}$$

$$X_1 = X_1\,(\alpha, P, \rho, M, \Omega) \qquad \text{[a5]}$$

$$S = S\,(\alpha, P, \rho, M, \Omega) \qquad \text{[a6]}$$

using X for X_1, and Q for Q_2 to simplify notation, we can define the Jacobian matrix for the system as,

$$|J| = \begin{vmatrix} V_{QQ} & V_{QX} & V_{QS} \\ V_{XQ} & V_{XX} & V_{XS} \\ V_{SQ} & V_{SX} & V_{SS} \end{vmatrix} \leq 0 \qquad \text{[a7]}$$

where it can be shown that $V_{XX} < 0$, $V_{SS} < 0$, and $V_{QQ} < 0$. Suppose to identify how variables affecting forest yield impact choice variables, we write the growth function as $F(.) = \beta F(.)$, where $\beta > 0$ is an exogenous parameter and is larger for characteristics of the site that improve yield. We insert this assumption into the first order conditions in the text prior to deriving the comparative statics results.

To complete the comparative statics, we need to know several cross partial derivatives of choice variables and exogenous parameters. We present these for a subset of the parameters,

$$
\begin{aligned}
&V_{SP} = -U_{C_1C_1}X_1 - \rho U_{C_2C_2}[K_0 - X_1 + \beta F(K_0 - X_1) - Q_2] \geq 0 \\
&V_{QP} = -U_{C_2}\rho - U_{C_2C_2}\rho P[K_0 - X_1 + \beta F(K_0 - X_1) - Q_2] \leq, \geq 0 \\
&V_{SX} = -U_{C_2C_2}P + \rho U_{C_2C_2}[P(-1 - \beta F_X) \geq 0 \\
&V_{SQ} = \rho U_{C_2C_2}(-P) \geq 0 \\
&V_{QX} = \rho P^2 U_{C_2C_2}(1 + \beta F_X(.)) \leq 0 \\
&V_{XM} = U_{C_1C_1}P^2 \leq 0 \\
&V_{SM} = -U_{C_1C_1} \geq 0 \\
&V_{X\beta} = -\rho U_{C_2}PF_X(.) + P^2\rho U_{C_2C_2}(-1 - F_X)F(.) \geq, \leq 0 \\
&V_{S\beta} = \rho U_{C_2C_2}PF(.) \leq 0 \\
&V_{X\alpha} = 0 \\
&V_{Q\alpha} = \rho N_{Q_2} \geq 0 \\
&V_{S\alpha} = 0
\end{aligned}
\qquad [a8]
$$

The comparative statics results now follow by totally differentiating the system in [a4]–[a6], using [a8], and solving for the derivatives of each choice variable with respect to the endogenous parameter of interest. We can ignore the impact of the interest rate ρ for our data, because it exists at one point in time for a cross section of landowners in a relatively small area – there would be no variation in the variable. Also, note that we did not present the second derivates with respect to Ω, as this variable accumulates all variables that impact utility but are not captured in the other variables, such as other preferences of the landowner that impact decisions (i.e., being married, etc).

Applying Cramer's rule to the system of equations in [a1]–[a3], using [a7] and elements of [a8] where appropriate, the following results can be derived, where a '+'indicates that increases in the argument increase the LHS variable, and a '–' indicates that increases in the argument reduce the LHS variable:

$$Q_2 = Q_2(\underset{+/-}{\beta}, \underset{+}{\alpha}, \underset{-}{p}, \underset{+/-}{\rho}, \underset{+/-}{M}, \underset{+/-}{\Omega}) \qquad [a5]$$

$$X_1 = X_1(\underset{+}{\beta}, \underset{-}{\alpha}, \underset{+}{p}, \underset{+/-}{\rho}, \underset{+/-}{M}, \underset{+/-}{\Omega}) \qquad [a6]$$

$$S = S(\underset{+/-}{\beta}, \underset{+}{\alpha}, \underset{+}{p}, \underset{+/-}{\rho}, \underset{+}{M}, \underset{+/-}{\Omega}) \quad [a7]$$

under the assumption that the cross partial V_{XS} is small in absolute value. Also, recall that Q_2 qualitatively is similar to a bequest and to the timber stock set aside for nontimber activities.

Acknowledgements

We would like to thank John Scrivani and the Virginia Department of Forestry for help with our survey design and sampling schemes, and the Southern Forest Resource Assessment Consortium (SOFAC) for financial support. This paper is drawn from Conway's thesis written at Virginia Polytechnic Institute and State University.

received 10 February 2003, accepted 7 October 2003

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