Hedonic Analysis of Hunting Lease Revenue and Landowner Willingness to Provide Fee-Access Hunting

Anwar Hussain, Ian A. Munn, Stephen C. Grado, Ben C. West, W. Daryl Jones, Jeanne Jones

Abstract: Selling hunting access may supplement household income, yet only a small proportion of nonindustrial private (NIP) landowners in United States lease the right to hunt their land. Based on a survey of Mississippi landowners, the decision to lease hunting rights and factors influencing lease revenue per leased hectare were analyzed. The two issues were jointly modeled consistent with Heckman's sample selection model, and the lease revenue was specified in accordance with hedonic pricing theory. Empirical results showed that landowner concerns about loss of privacy, accident liability, and conflicts with personal use of land reduced the likelihood of leasing; total landownership and specific landowner characteristics increased it. With regards to factors explaining differences in lease revenue per leased hectare, bottomland hardwoods commanded a greater premium than many other land uses. In addition, lease revenue per hectare was distinctly higher where a landowner had expertise in managing a hunting lease enterprise. These findings have implications for landowners interested in managing wildlife-associated enterprises and public agencies engaged in the provision of natural resource-based recreation. FOR. SCI. 53(4):493–506.

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WITH INCREASING DEMAND for hunting access in the United States, policy interest in nonindustrial private (NIP) landowner willingness to provide fee-access is also increasing. Whereas NIP landowners own the majority of the land in the United States, the proportion providing fee-access is low in most states (Lynch and Robinson 1998, Cordell et al. 1999, p. 202) [1]. Facilitating fee-access and other wildlife-associated recreation on private lands is important to forest landowners who often have to wait years for timber sale revenues to materialize (Yarrow and Yarrow 1999). Fee hunting may also serve as an incentive-based mechanism to reverse trends of habitat loss and thus conserve wildlife (Benson 2001, Jones et al. 2001). There are beneficial regional economic impacts as well, because recreational activities contribute to local economies (Loomis et al. 1989, Wallace et al. 1991) with a lower environmental cost than traditional economic activities (English and Bergstrom 1994).

Despite its importance, fee-access by NIP landowners is a relatively underinvestigated issue (Mozumder et al. 2004). Guynn and Schmidt (1984) and Wright and Kaiser (1986) identified factors influencing landowner willingness to provide fee-access (e.g., personal liability lawsuits and property damage). Loomis and Fitzhugh (1989) and Messonier and Luzar (1990a) analyzed the determinants of hunting lease revenues (e.g., hunting site and lease characteristics and market segmentation). Shrestha and Janaki (2004) further refined our understanding by incorporating land use characteristics, albeit at a relatively crude scale, into a hedonic model whereas Zhang et al. (2006) contributed by recognizing the importance of jointly analyzing NIP willingness to provide fee-access and hunting lease revenues [2]. Several critical issues remain to be addressed. First, fee-access is predominantly confined to larger landowners, who are essentially a small proportion of the forest landowning community. Any analysis of hunting lease supply, thus, necessarily entails disproportionate sampling and taking care of estimation issues that follow consequently. Simple random sampling is not appropriate when interest is focused on subgroups that are a small proportion of the population (Levy and Lemeshow 1999, p. 75). Second, a much finer delineation of land uses on NIP lands is critical if estimated implicit prices are to guide NIP landowner land allocation decisions across land types (e.g., relative proportion of managed pines, natural pines, mixed pine-hardwood, bottomland hardwoods, row crops, and so on). Third, it is important to account for market segmentation while estimating implicit prices (Palmquist 1991, p. 89). Given that Messonier and Luzar (1990b) ascertained that distinct markets within states exist, providing for market segmentation in empirical models is needed.

Our objective in this article is to answer two interrelated questions regarding the hunting lease market served by NIP landowners while simultaneously addressing the issues identified above: What determines NIP landowner willingness to participate in the hunting lease market? What accounts for the observed variation in monetary returns earned

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by those who provide fee-access? Analyzing each issue individually is important because of their distinct policy implications and estimating them jointly is necessary given their interrelated character. An analysis of these issues and the approach taken in this study should complement earlier studies of the supply side of hunting lease markets in the southeastern United States [3]. Innovative aspects of this study include (1) a conceptual outline of the hunting lease market, (2) a hedonic price function that finely differentiates forest types, agricultural and other land uses, and other determinants, (3) provisions for market segmentation, (4) a stratified random sampling scheme that is attuned to the skewed distribution of landownership in the southeast United States, (5) a weighted maximum likelihood estimation (WMLE) that is necessitated by the use of stratified random survey data, and (6) use of the estimated model to simulate the significance of landowner constraints and concerns for expanded fee-access.

The US Hunting Lease Market

Although still evolving, the US hunting lease market may be characterized in terms of certain aspects (Taff 1991, Adams et al. 1992). In particular, hunting leases may vary with respect to duration, game permitted for harvest, and lease rate per unit. With regards to duration, a hunting lease may be short-term (1 day to 3 months), annual, or multiyear (2–5 years); available game may include deer, turkey, small game, waterfowl, or any combination thereof; and hunting privileges may be transferred on a per area, per gun, or per hunting club basis.

One way to analyze observed variations in hunting lease rates for a specific lease contract is to use hedonic pricing (Rosen 1974). Indeed, the hedonic hunting lease function has its basis in the interaction of demand for and supply of hunting site attributes. Systematic variation in lease rates per hectare may thus be used to impute implicit prices of (or willingness to pay for) hunting site attributes. Underlying assumptions are that the hunting lease market is a single integrated market that is in equilibrium and that hunting leases have any number of levels of available characteristics from which hunters can choose.

Of the two economic agents that interact in a hunting lease market, private landowners are the suppliers of hunting leases who attempt to maximize profits by equating lease revenue per unit to opportunity cost in equilibrium. In the short run, they have the potential to recoup average variable costs; in the long run they are assumed to supply hunting leases conditional on full recovery of relevant opportunity costs. To connect with interested hunters, often they rely on word of mouth, family, and friends and sometimes on newspaper or Internet websites.

The demand side of the hunting lease market involves hunters who purchase leases to maximize utility by using hunting tracts along with other market-purchased goods and personal time to produce "recreational experiences" in a household production framework (Bockstael and McConnell 1981). A hunter's decision may be conceptualized as a two-stage process: in stage one, the hunter minimizes the cost of producing a hunting trip; in stage two, the hunter maximizes utility from consuming both hunting trips (nonmarket goods) and market goods subject to budget and time constraints. Minimizing the cost of producing a hunting trip provides the economic basis for determining hunting site demand (Miranowski and Bender 1984).

Landowner Decision to Provide Hunting Access

According to Wright et al. (1990), a landowner's decision to provide hunting access is not a purely dichotomous choice but a matter of the degree to which access is provided or restricted. Accordingly, five types of access may be distinguished: prohibition (precluding recreation), exclusion (reserving hunting opportunities to personal enjoyment), restriction (expanding access to include friends and acquaintances), open access (allowing everyone), and fee-access (charging a fee for access). Depending on the type of hunting access, factors underlying the landowner decision to provide access vary. In particular, the decision to provide fee-access (z_i) depends on three broad sets of factors:

$$z_i = f[\text{Resource attributes, landowner attributes, user-related concerns}]. \quad (1)$$

Resource Attributes

Resource attributes include owning sufficient land, preferably in large tracts with a potential to support quality game. Big game (e.g., deer or turkey) in particular requires some minimum area to serve as its home range, and, from a hunter perspective, larger tracts could minimize safety and congestion issues; thus, hunters may be willing to pay more per hectare for larger areas. At the same time, it is important that fee-access does not conflict with other landowner uses (e.g., forestry, agriculture, and personal and family use of land for hunting and other recreational purposes). Although fee hunting may be complementary to forestry, it may conflict with personal recreational use and agriculture.

Landowner Attributes

Economic and sociodemographic characteristics of the landowner are important determinants of the fee-access decision. For instance, on economic grounds, a landowner may not find it attractive to provide fee-access hunting because potential benefits (tangible and intangible, such as stewardship) may not be sufficient to offset the opportunity cost of time and other material resources (Adams et al. 1992, Butler and Workman 1993, Zhang et al. 2006). Sociodemographic characteristics including age, educational attainment, race, residential location, and participation in cost-share and other natural resource management programs have also been found to influence the leasing decision (Messonnier and Luzar 1990a, Raedeke et al. 1996).

User-Related Concerns

Landowner perceptions of access-related problems, potentially induced by hunter behavior, could adversely influence a landowner's decision to provide access. Concerns over loss of privacy, safety, loss of control as to who is using the land, accident liability, and property damage are among the more prominent. Landowners who had a bad experience with hunters or who are aware of hunter problems through neighbors and acquaintances are less likely to provide access (Guynn and Schmidt 1984, Wright and Kaiser 1986, Jones et al. 2001). Finally, media attention to problems with fee hunting may contribute to landowner hesitation to actively engage in fee hunting.

Factors Influencing Hunting Lease Revenue

Hunting lease revenue per hectare (y_i) depends on intrinsic site attributes, wildlife habitat improvement by the landowner, services and amenities, landowner skill in managing a lease operation, lease size (hectare), and location-specific hunting lease market conditions. In brief,

$$y_i = g[\text{Site attributes, habitat improvement, services, management, lease size, lease type, market segmentation}] \quad (2)$$

Site Attributes

Game abundance, diversity, and quality can be expected to positively relate to hunter willingness to pay for access and consequently higher lease revenues. But game attributes are relatively difficult to ascertain a priori. Hunters more likely form their expectations of game quality on the basis of easily observed site attributes (e.g., relative proportions of agricultural, forest, and pasture land and forest cover type) that in turn influence game quality.

Given the importance of site attributes, in the hunting-related literature, there are distinct characterizations of site in terms of wildlife abundance, diversity, and quality. Among others (e.g., McKee 1989, Baen 1997), the characterization by Harris et al. (1984) suggested that natural bottomland hardwoods serve as a benchmark for premium hunting sites because they can support two to five times as many game animals as nearby mixed pine-hardwoods. The high productivity of bottomland hardwoods translates into a comparable richness of wildlife. Next along the continuum are upland hardwoods, followed by mixed pine-hardwoods, and pine lands because unlike pine lands, hardwoods not only provide cover but also food throughout most of the year.

Wildlife Habitat Improvement

Not all sites are intrinsically endowed to support quality game. Landowners may, however, be able to improve the wildlife habitat (e.g., planting food plots, constructing waterfowl impoundments, and maximizing the diversity and interspersion of forest types and other land uses) which, in turn, improves game quality and thus fetches higher lease revenues. Landowners may not be willing to make such habitat improvements, yet if it in their best interest, they may allow hunters to do so. Hunters holding multiyear leases in particular may have an incentive to do so because they are more likely to capture the long-term benefits of their efforts.

Management Attributes

Differences in lease revenue across landowners may exist because of innate and/or acquired management competencies. Lynch and Robinson (1998) noted that technical expertise in managing a fee-access operation in terms of tax and other legal ramifications, hunter relations, and wildlife habitat management could be important. Landowners who have been involved in wildlife enterprises or who have acquired skills through extension programs, therefore, may be expected to earn higher lease revenue than otherwise similar landowners.

Services and Amenities

Evidence regarding the role of landowner services is mixed. Pope and Stoll (1985), Loomis and Fitzhugh (1989), and Messonnier and Luzar (1990b) did not find evidence to support the claim that hunters would be willing to pay more for landowner-provided services and amenities, whereas Zhang et al. (2006) did. This comparison may, however, be invalid because these studies typically bundled several services and amenities together; however, the bundles varied from study to study. As the services included ranged from simple (e.g., stands, guides, and field dressing) to elaborate (e.g., meals, lodging, and airport pickup and drop off), bundling issues probably confounded the link between returns and landowner-provided services.

Lease Size

Pope and Stoll (1985) and Messonnier and Luzar (1990b) noted that in the Texas and Louisiana hunting lease markets revenue per leased hectare and lease size (hectares) were positively related. Both studies attributed this observation to hunters placing a premium on larger parcels as they lend themselves to club leasing, game management, and adequate safety coupled with less congestion. In contrast, Shrestha and Janaki (2004) reported a negative relationship, arguing that there were diminishing returns to scale. Zhang et al. (2006) also reported a negative relationship but argued that landowner management constraints were probably responsible for this result.

Lease Type

Lease revenue per hectare can vary, depending on the type of hunting privileges landowners provide. Mississippi landowners use a variety of arrangements to convey such privileges to their clientele. The most common arrangement is a hunting lease, typically annual or longer, that allows hunters to harvest all species present and permits access to the property throughout the year. Other arrangements include seasonal leases, which typically target specific species and limit access during the remainder of the year; gun fees or permits, which allow hunters access to the property to hunt specific species, in specific places, and/or on specific days; and brokerage leases which convey exclusive hunting rights to an outfitter or guide service who in turn provide hunting opportunities to their own clientele. These arrangements require relatively little effort on the landowner's part. In contrast, landowners can sell "hunts," which are typically 1–3 days in duration and target a specific species, and the landowner provides a range of other services such as guides, meals and lodging, and game processing. In these cases, the landowner is essentially performing the role of an outfitter.

Market Segmentation

Estimates of hedonic prices that ignore location-specific market conditions are likely to be biased (Palmquist 1991, p. 89). It is, thus, important that we account for market segmentation when estimating implicit prices. Segmented hunting lease markets may exist (Freeman 1993, p. 386) because of differences in the structure of demand, supply, or both across segments or some barrier to mobility among market segments that prevents arbitrage from occurring in response to differences in marginal implicit prices.

Data and Construction of Variables

Our sampling strategy was formulated in light of Jones et al. (2001) who indicated that Mississippi landowner participation in fee-access recreation for landowners with less than 40 ha was virtually nonexistent, large landowners were most likely to participate, but they accounted for a very small percentage of the total landowner population, and response rates were likely to be about 30%. Under these circumstances, a simple random sampling would have necessarily yielded a very large number of small landowners with little probability of fee-access participation and a very small number of large landowners with the highest probability of participation. Two accommodations were, thus, made in our sampling scheme. A 40-ha ownership lower limit was imposed to target landowners who participated in fee-access recreation as well as to eliminate urban and suburban properties within the property tax records. Also, large landowners were oversampled to ensure an adequate number of responses from those who engage in fee-access recreation [4].

A total of 2,000 questionnaires were sent to a stratified random sample of NIP landowners owning a minimum of 40 ha in Mississippi. The landowners were identified and randomly selected from available property tax records of 72 of the 82 counties in Mississippi. Four landownership size classes were distinguished: 40–80 ha, 81–202 ha, 203–404 ha, and 405 or more ha. Stratum-specific samples were determined on the basis of the proportion of forestland owned by owners in a given stratum. For instance, because landowners in ownership size class "41–80 ha" owned 30% of the forestland, the number of landowners sampled from this class was accordingly 30% of the total sample (i.e., 600 of 2,000). As this sample allocation entailed oversampling of landowners from "203–404 ha" and "405 or more ha" classes, a weighting variable was used during estimation to account for disproportionate sampling of landowners from the various strata.

Consistent with Dillman (1978), landowners were mailed a reminder postcard 1 week after the first mailing and a second questionnaire 4 weeks after the postcard. After accounting for incorrect addresses, property sales, and deceased landowners, the final sample size was 1,598. A total of 484 questionnaires were returned, for a 30% response rate. However, because of missing data on variables of interest to this study, 21 cases were removed, yielding a usable sample of 463. Finally, even though surveys were mailed to landowners residing in only 72 of the 82 Mississippi counties, the 463 landowners reported properties in all 82 Mississippi counties because some landowners had ownership in multiple counties. Details about the distribution of Mississippi landowners by land size class, sample drawn, and responses received are given in Table 1.

Given that the survey was unusually long (13 pages) and asked detailed financial questions, this response rate was better than expected. Although formal tests were not performed to assess potential nonresponse bias, concerns about nonresponse bias were mitigated by a number of factors. First, any response bias related to ownership size is adjusted for by the weighting scheme used in the analysis, which was based on the number of responses by ownership size category. Second, any response bias associated with other landowner characteristics correlated with ownership size would

Table 1. Forestland ownership in Mississippi and distribution of mail out and received sample

	Landowners*		Hectares*		Mail out sample		Received sample	
Size Class (ha)	No.†	%	No.†	%	No.	%	No.	%
<3.64	123.0	44.64	185.1	3.8				
3.64–7.69	41.0	14.87	234.4	4.8				
7.69–19.83	56.5	20.53	736.6	15.1				
19.83–40.06	29.6	10.74	842.9	17.2				
Subtotal 1	249.9	90.79	1999.0	40.9				
40.46–80.53	15.8	5.73	879.2	18.0	600	30.4	144	31.1
80.53–201.93	7.2	2.62	864.8	17.7	600	29.9	160	34.6
201.93–404.27	1.6	0.59	442.4	9.1	320	15.3	79	17.1
>404.27	0.8	0.27	702.5	14.4	480	24.3	80	17.3
Subtotal 2	25.4	9.21	2888.9	59.1	2000	100.0	463	100.0
Total	275.3	100.00	9775.8	100.0				

* Data from Doolittle (1996).
† No. in thousands.

also be adjusted for, at least in part. Age, education level, and participation in government programs were significantly correlated with ownership size and thus the weighting scheme for ownership size adjusts for biases with respect to these key variables. Finally, comparisons of key variables (e.g., average ownership by size class and land allocation by major use) with Jones et al. (2001) suggested striking similarities in the responses despite the different survey designs of the two studies. Nonetheless, the possibility of nonresponse bias exists, and results should be viewed accordingly.

The set of variables constructed in accordance with the estimation approach presented in the next section are reported in Table 2. Although most of the variables are self-explanatory, a few comments are needed to clarify the rules followed in the construction of certain variables. First, to implement the notion that fee-access may conflict with family use of land for recreation (*personal use*) or that a landowner may be concerned about loss of privacy (*privacy concerned*) and accident liability (*liability concerned*), landowner responses were evoked on a scale of 1 to 5 (with 1 indicating "not important" and indicating 5 "very important") [5]. For estimation purposes, the responses were recoded such that if a landowner response was 1, 2, or 3, the concern was coded 0, and if the response was 4 or 5, it was coded as 1. Second, participation in cost-share programs (*program participant*) was considered to see whether exposure to information and interaction with extension officials mattered and was coded as 1 if the landowner participated in any of the

Table 2. Variables used in the estimation of Mississippi landowner willingness to provide fee-access hunting, and gross annual revenue per leased hectare

Variables	Description
Selection equation: Landowner willingness to provide fee-access hunting	
LESSOR	1 if landowner provided fee-access hunting, otherwise 0 [*Dependent variable*]; *Explanatory variables*
Resource-related attributes	
Log(ownership, ha)	Logarithm of hectares owned;
Personal use	1 if the land is used for personal recreation, otherwise 0;
Landowner-related attributes	
Less than 40 yr old	1 if age is less than 40 yr old, otherwise 0;
40–50 yr old	1 if age is between the age of 40 to 50, otherwise 0;
51 or more yr old	1 if age is more than 50 yr old, otherwise 0 [Base category];
High school	1 if high school educated or less, otherwise 0;
Junior college	1 if junior college (2 yr degree) educated, otherwise 0;
University	1 if university (4 yr degree) educated or more, otherwise 0 [Base category];
Program participant	1 if participated in cost-share programs, otherwise 0;
Race	1 if race is Caucasian, otherwise 0;
Rural resident	1 if residence was within 20 miles of the land, otherwise 0;
User-related concerns	
Privacy concerned	1 if concerned about privacy, otherwise 0;
Liability concerned	1 if concerned about accident liability, otherwise 0;
Regression equation: Factors influencing gross annual revenue per leased ha	
LOGREV	Logarithm of gross annual revenue per leased hectare [*Dependent variable*]; *Explanatory variables*
Lease type	1 if agreement is an annual lease, otherwise 0;
Services and amenities	1 if landowner provides blinds, guides, and lodging, otherwise 0;
Management skills	1 if landowner is knowledgeable about fee-hunting business, otherwise 0;
Market segmentation	
Southeast	1 if land is located in southeast MS, otherwise 0;
Northwest	1 if land is located in northwest MS, otherwise 0;
Southwest	1 if land is located in southwest MS, otherwise 0;
Northeast	1 if land is located in northeast MS, otherwise 0 [Base category];
Size and forestland attributes	
Log(leased, ha)	Logarithm of the number of hectares leased;
% cropland	Percentage of land under row crops;
% other cropland	Percentage of land fallow, orchards, pasture or other;
% aquaculture	Percentage of stock ponds, aquaculture;
% impoundments	Percentage of land flooded behind levees or dams; primarily for waterfowl;
% natural water	Percentage of land under permanent and temporary lakes, streams;
% cutover forest	Percentage of cutover forest land;
% planted pines	Percentage of land planted pine;
% natural pines	Percentage of land natural pine;
% upland hardwood	Percentage of land upland hardwoods;
% pine-hardwood	Percentage of land mixed-pine-hardwoods;
% wildlife food plots	Percentage of land allocated to wildlife food plots;
% other land uses	Percentage of land under other uses (e.g., power lines, residence);
% bottomland hardwood	Percentage of land in bottomland hardwoods [Base category];
Food plot–hunter interaction	Percentage wildlife food plot times dummy; dummy = 1 if hunters managed it; otherwise 0;

programs and 0 otherwise. These programs included the Conservation Reserve Program, Wetland Reserve Program, Environmental Quality Improvement Program, Wildlife Habitat Improvement Program, Conservation Easement, and others (e.g., Ducks Unlimited, National Wild Turkey Federation, or Quail Unlimited).

To account for differences in gross annual revenue per leased hectare due to differences in landowner management competence, landowners were asked to rate the amount of information they had about lease hunting and/or wildlife-related fee-access operations on a scale of 1 to 5 (with 1 indicating "no information" and 5 indicating "complete information"). For estimation purposes, the responses were recoded so that if a landowner rated the information at his disposal as 4 or 5, management skills were coded as 1, and if the rating was 1, 2, or 3, management skills were coded as 0.

Estimation Methods

Local markets for hunting leases are thin and involve significant transactions costs. Appropriate methods of analysis are needed to clarify landowner motivations that could facilitate such markets. In particular, the relation between a landowner decision to provide fee-access hunting and lease revenue per hectare should be taken into account if potential bias in making an inference about the entire market is to be avoided. The small minority of landowners who provide fee-access probably do so because net revenues and hunter-provided benefits, such as protection against trespass and vandalism, more than offset their opportunity cost of leasing inclusive of transaction costs. This scenario necessarily entails modeling a landowner's decision to provide fee-access and factors influencing lease revenue per hectare as a simultaneous equations model because factors influencing the lease decision might be correlated with factors determining the lease rate. The sample selection model provides such a modeling framework (Heckman, 1979) [6].

Sample Selection Model

Following Greene (2003, p. 782), the formulation for the sample selection model is outlined as

Selection model:

$$z_i^* = w_i'\gamma + \mu_i \quad z_i = 1 \quad \text{if } z_i^* > 0; \quad 0 \text{ otherwise} \tag{3a}$$

$$\Pr(z_i = 1|w_i') = \Phi(w_i'\gamma)$$

$$\Pr(z_i = 0|w_i') = 1 - \Phi(w_i'\gamma)$$

Regression model

$$y_i = x_i'\beta + \varepsilon_i \quad y_i \text{ observed only if } z_i = 1 \tag{3b}$$

$$(\mu_i, \varepsilon_i) \sim \text{NID}[0, 0, 1, \sigma_\varepsilon, \rho]$$

where w_i' is the set of factors influencing a landowner decision (z_i) to provide hunting access and x_i' is the set of factors accounting for differences in lease revenue per leased hectare (y_i), γ and β are the associated unknown parameter vectors, σ_μ and σ_ε are variances of μ_i and ε_i, respectively, and ρ is the correlation between μ_i and ε_i [7]. The conditional expectation of observed y_i is $x_i'\beta$ when μ_i and ε_i are uncorrelated; otherwise it is

$$E[y_i \mid z_i = 1] = x_i'\beta + \rho\sigma_\varepsilon\lambda_i(\alpha_\mu). \tag{4}$$

Here $\lambda_i(\alpha_\mu) = \phi(w_i'\hat{\gamma}/\sigma_\mu)/\Phi(w_i'\hat{\gamma}/\sigma_\mu)$ is the sample selection bias correction term (commonly known as inverse Mills ratio) with $\phi(\cdot)$ and $\Phi(\cdot)$, respectively, as the standard normal density function and standard cumulative distribution function. Support for the null hypothesis (H_0: $\rho = 0$) of uncorrelated μ_i and ε_i exists when the coefficient (i.e., $\rho\sigma_\varepsilon$) on the bias correction term is statistically insignificant. Because σ is always positive, the direction of sample selection bias is determined by the sign on ρ.

Consistent estimates of β can be obtained by regressing the observed y_i on x_i' and estimated $\lambda_i(\cdot)$ whereby the unknowns in $\lambda_i(\cdot)$ are obtained from a probit estimation of z_i on w_i'. However, this two-step procedure is problematic because it not efficient; it does not impose the constraint that $\rho \leq 1$ as implied by the underlying model, and standard errors are inconsistent because the regression model is intrinsically heteroskedastic. Thus, Davidson and MacKinnon (1993, p. 545) recommended using the two-step estimation method only as a preliminary assessment tool to be followed by full information maximum likelihood estimation.

Maximum Likelihood Estimation

Given that there are two types of observations for the sample selection model, the likelihood function is the sum of two probabilities. For observations where $z_i = 0$, the likelihood is the marginal probability that $z_i \leq 0$. For observations where $z_i = 1$, the likelihood is the probability of the event that both y_i and $z_i > 0$. For both sets of sample observations, the log-likelihood function is

$$L = \sum_{z=0}\log(\Pr(z_i = 0)) + \sum_{z=1}\log(\Pr(z_i = 1)f(y_i^*|z_i = 1)). \tag{5}$$

Because the proportions of respondents in this study deviated from the corresponding actual shares of landowners in each land size class in the population, the appropriate function is a weighted log-likelihood (Manski and Lerman 1977, Greene 2002 chapter 10, p. 2–3):

$$L = \sum_{z=0} w_i^*\log(\Pr(z_i = 0)) + \sum_{z=1} w_i^*\log(\Pr(z_i = 1)f(y_i^*|\, z_i = 1)), \tag{6}$$

where w_i^* is a weighting variable reflecting the actual distribution of landowners in the population.

Results

Descriptive statistics of variables used in the estimation of Mississippi landowner willingness to provide fee-access for hunting and gross annual revenue per leased hectare are reported in Table 3. Estimation results of the selection model using STATA release 9.2 (StataCorp 2005) are reported in Table 4. Two selection models were estimated with the key difference being whether or not region-specific dummies were included to account for market segmentation. Based on the likelihood ratio test, the unrestricted model, which allowed for market segmentation, performed better than the restricted model. As the null hypothesis (H_0: $\rho = 0$) of zero correlation between the selection and regression equation could not be rejected based on the restricted as well as unrestricted model, sample selection bias was not a problem. Thus, the estimated lease revenue per leased hectare could be considered unbiased. Naive ordinary least squares using data only on lessors (the truncated sample) and the Heckman two-step estimates were also obtained but, as expected, the maximum likelihood results were still superior (Breen 1996, p. 40–42). Results specific to the selection and regression components of the Heckman model follow.

Landowner Decision to Provide Hunting Access

Reporting probit estimation results of the selection model (columns 4–6 in Table 4), the McFadden (pseudo) R^2 (34%) indicated that the model fit the data well. Given that weighted maximum-likelihood estimation was used, other standard goodness-of-fit measures for probit (e.g.,

Table 3. Descriptive statistics of variables used in the estimation of Mississippi landowner willingness to provide fee-access for hunting and gross annual revenue per leased hectare

Variables	Full sample (n = 463)		Nonlessors (n = 389)		Lessors (n = 74)	
	Mean	SE.	Mean	SE	Mean	SE
Selection equation: Landowner willingness to provide fee-access						
LESSOR	0.112	0.013	0.000	0.000	1.000	0.000
Resource attributes						
Log(ownership, ha)	4.657	0.013	4.568	0.018	5.362	0.123
Personal use	0.526	0.026	0.579	0.027	0.106	0.044
Landowner attributes						
Less than 40 yr old	0.179	0.019	0.175	0.021	0.211	0.053
40–50 yr old	0.228	0.021	0.237	0.023	0.159	0.042
51 or more yr old	0.593	0.025	0.588	0.027	0.630	0.062
High school	0.382	0.025	0.400	0.027	0.239	0.056
Junior college	0.416	0.025	0.396	0.027	0.577	0.063
University	0.203	0.020	0.205	0.022	0.184	0.040
Program participant	0.322	0.024	0.308	0.025	0.436	0.063
Race	0.879	0.017	0.870	0.019	0.951	0.033
Rural resident	0.588	0.025	0.604	0.027	0.459	0.063
User-related concerns						
Privacy concerned	0.629	0.024	0.688	0.026	0.164	0.051
Liability concerned	0.635	0.024	0.684	0.026	0.245	0.057
Regression equation: Factors influencing gross annual revenue per leased hectare						
LOGREV					2.217	0.096
Lease type					0.775	0.056
Services and amenities					0.141	0.047
Management skills					0.119	0.038
Market segment						
Southeast	0.221	0.022	0.228	0.024	0.166	0.050
Southwest	0.319	0.023	0.311	0.025	0.389	0.065
Northwest	0.128	0.016	0.129	0.017	0.119	0.038
Northeast	0.332	0.024	0.332	0.026	0.326	0.061
Site attributes						
Log(leased, ha)					4.999	0.122
% cropland					2.462	1.011
% other cropland					6.033	1.399
% aquaculture					0.714	0.539
% impoundments					0.352	0.109
% natural water					1.828	0.989
% cutover forest					6.659	2.383
% planted pines					32.614	4.308
% natural pines					14.544	4.055
% upland hardwood					2.818	1.103
% pine-hardwood					21.976	3.638
% bottomland hardwood					8.147	2.197
% wildlife food plots					0.781	0.254
% other land uses					1.071	0.245
Food plot–hunter interaction					0.244	0.106

Statistics are weighted to account for oversampling of large landowners.

Table 4. Maximum likelihood estimation results of Mississippi landowner willingness to provide fee-access for hunting, and gross annual revenue per leased hectare

Variables	Restricted model			Unrestricted model		
	Coefficient	SE	Marginal effect	Coefficient	SE	Marginal effect
Selection equation ($w_i'\hat{\gamma}$) dependent variable (z_i): Landowner willingness to provide fee-access (LESSOR)						
Resource attributes						
Log(ownership, ha)	0.476[a]	0.074	4.405	0.477[a]	0.072	4.421
Personal use	−0.846[a]	0.308	−8.547	−0.842[a]	0.310	−8.539
Landowner attributes						
Less than 40 yr old	0.121	0.217	1.198	0.132	0.224	1.316
40–50 yr old	−0.350[c]	0.184	−2.772	−0.371[b]	0.182	−2.917
High school	0.010	0.219	0.093	0.008	0.212	0.070
Junior college	0.345[b]	0.169	3.382	0.338[b]	0.171	3.315
Program participant	0.334[c]	0.178	3.437	0.352[b]	0.171	3.656
Race	0.480	0.432	3.277	0.469	0.434	3.232
Rural resident	−0.293[c]	0.159	−2.846	−0.291[c]	0.158	−2.832
User-related concerns						
Privacy concerned	−0.581[a]	0.228	−6.234	−0.582[a]	0.231	−6.263
Liability concerned	−0.419[b]	0.186	−4.311	−0.411[b]	0.187	−4.229
Constant	−3.298[a]	0.626		−3.296[a]	0.615	
Wald $\chi^2(11)$	98.980			98.980		
$P > \chi^2$	0.000			0.000		
McFadden (pseudo) R^2	0.344			0.343		
Regression equation ($x'\hat{\beta}$) dependent variable (y_i): Log-gross annual revenue per leased hectare (LOGREV)						
Lease type	0.126	0.172	4.929	0.005	0.155	0.962
Services and amenities	0.639[c]	0.382	27.965	0.451	0.283	20.364
Management skills	0.199	0.265	6.698	0.331[c]	0.180	16.126
Market segment						
Southeast				0.084	0.271	0.517
Southwest				0.874[a]	0.166	52.660
Northwest				1.006[a]	0.313	57.398
Site attributes						
Log(leased, ha)	0.026	0.080	2.640	0.034	0.064	3.361
% cropland	−0.006	0.005	−0.152	−0.003	0.004	−0.087
% other cropland	−0.017[c]	0.010	−1.123	−0.005	0.007	−0.362
% aquaculture	0.037[a]	0.005	0.298	0.027[a]	0.007	0.215
% impoundments	−0.027	0.055	−0.105	0.034	0.054	0.132
% natural water	−0.011[a]	0.003	−0.219	0.001	0.004	0.008
% cutover	−0.011[a]	0.004	−0.794	−0.005	0.004	−0.334
% planted pines	−0.006[c]	0.003	−2.031	0.003	0.003	1.203
% natural pines	−0.005	0.003	−0.794	0.003	0.004	0.501
% upland hardwood	0.000	0.005	−0.001	0.001	0.004	0.022
% pine–hardwood	−0.011[a]	0.003	−2.770	−0.005[c]	0.003	−1.307
% wildlife food plot	0.064	0.059	0.562	0.055	0.043	0.480
% other land uses	−0.068	0.058	−0.817	−0.099[a]	0.041	−1.193
Food plot–hunter interaction	−0.122	0.083	−6.232	−0.087	0.122	−4.947
Constant	2.562[a]	0.505		1.413[a]	0.501	
ρ	0.068	0.326		0.227	0.310	
σ_ε	0.665[a]	0.063		0.558[a]	0.057	
λ	0.045	0.217		0.127	0.179	
Log pseudo-likelihood	−2602.882			−2441.712		
Wald $\chi^2(17)$	599.060					
Wald $\chi^2(20)$				254.250		
H_0: $\rho = 0$; $\chi^2(1)$		$P > \chi^2 = 0.836$			$P > \chi^2 = 0.480$	

Note: Superscripts a, b, and c, respectively, indicate statistical significance at $\alpha = 1, 5, 10\%$.

proportion of outcomes predicted correctly) could not be used.

Turning to individual coefficient estimates, both resource attribute variables were significant ($P < 0.01$). The positive coefficient on land owned (*log-ownership*) indicated that landowners were more likely to provide fee-access as landownership size increased [8]. In terms of the marginal effect (evaluated at the mean), a 1-unit increase in log-ownership was associated with a 4.42% increase in the likelihood of leasing [9]. Landowner use of land for personal and family recreational activities (*personal use*) significantly reduced the likelihood of leasing. The −8.54% marginal effect was larger in absolute value than all other marginal effects of variables included in the leasing decision equation [10].

As a group, landowner characteristics strongly influenced the landowner decision to provide fee-access. Coefficients on the age class variables indicated that landowners 40–50 years old were the least likely to lease. Coefficients on the education variables indicated that landowners with university degrees were less likely to lease their lands than those with less education, although the effect for *high school* was not significant. Landowners who resided within 20 miles of their forestland (*rural resident*) were significantly less likely to lease compared with landowners who lived farther away. Those landowners participating in government cost-share programs (*program participant*) were significantly more likely to lease than landowners who did not. Finally, although *race* was not significant, its inclusion in the model contributed to a better fit.

Both the user-related concerns, i.e., concern about loss of privacy (*privacy concerned*) and accident liability (*liability concerned*) significantly reduced landowner willingness to engage in fee-access. In particular, landowners concerned about loss of privacy and liability were, respectively, 6.26% and 4.23% less likely to provide fee-access than landowners without the corresponding concern.

Factors Influencing Hunting Lease Revenue

Of the various functional forms considered, the log–log specification provided the best fit for the regression equation. The empirical estimates reported in Table 4 are based on this specification [11]. Furthermore, as mentioned earlier, although the unrestricted model performed better than the restricted model based on the likelihood ratio test, interesting observations could still be gleaned from the latter. Thus, before presenting results based on the unrestricted model, results based on the restricted model are reported.

First, lease type (lease type) and lease size (log of leased hectares) were not significant. Second, consistent with a priori expectations, bottomland hardwoods either commanded a clear premium over most other land uses or were at least as good (Table 4). With few exceptions, the estimated coefficients on the suite of land use variables were negative, indicating that an increase in the percent share of land devoted to these uses, at the expense of bottomland hardwoods, would reduce the revenue per leased hectare. Of the variables with negative and significant coefficients, *% pine-hardwoods*, *% planted pines*, and *% other cropland*, had the largest marginal effect on revenue per leased hectare: −2.77%, −2.03%, and −1.12%, respectively [12]. Although land devoted to aquaculture (*% aquaculture*) had a higher implicit valuation than bottomland hardwoods, the advantage was small. The marginal effect of a 1% increase in the percent share of land in aquaculture relative to bottomland hardwoods was only 0.30% (column 3 in Table 4).

Third, returns attributed to wildlife food plots (*% wildlife food plots*) and waterfowl impoundments (*% impoundments*) were not statistically different than those associated with bottomland hardwoods. It is important to note, however, that if these artificial features are created on less valued site types such as pine-hardwoods or cutovers, increased revenues will result because the marginal value of this land has been increased to that of hardwood bottomlands. The interaction variable (*food plot–hunter interaction*) was not significant, indicating that hunting lease revenues were not any different when landowners left management of wildlife food plots to hunters. Finally, provision of services (*services and amenities*) was significant and management (*management skills*) was not. Thus, landowners who provided services and amenities were likely to earn 28% more than otherwise similar landowners [13].

Findings based on the estimation results of the unrestricted model that allowed for market segmentation provided additional insights (columns 4–6 in Table 4). First, landowners in southwest and northwest Mississippi earned about 53–57% higher revenues per leased hectare than their counterparts in southeast and northeast Mississippi. This finding is important from a methodological point of view because it illustrates the importance of segmenting hunting lease markets in the estimation of hedonic lease functions. Second, bottomland hardwoods (*% bottomland hardwoods*) no longer generated higher lease revenues per hectare than other land uses with the exception of mixed pine-hardwoods (*% pine-hardwoods*) and other land uses (*% other land uses*). This finding is important as it suggests that regional dummy variables are sufficient to capture much of the variation in land uses across Mississippi. Indeed, distinct differences in regional land use are evident with the western part of the State lying within the Mississippi Alluvial Valley and the eastern part lying primarily in the Upper and Lower Coastal Plains. Third, management skills became significant, whereas services and amenities became insignificant. This result suggests that the best allocation of landowner effort, whether in providing services or acquiring managerial skills, depends greatly on the region.

Discussion

Landowner Decision to Provide Hunting Access

Our results clearly demonstrate that landowner participation in the fee-access hunting market is very sensitive to a broad range of resource and landowner attributes as well as user-related concerns. The practical implications of this sensitivity are profound. Coupled with the fact that current participation rates are very low, this sensitivity suggests that the supply of fee-access hunting on private lands will respond readily to changing conditions.

The relatively large marginal effects of resource attributes suggest fruitful ways to increase supply. Increasing property size may be too difficult or expensive for individual landowners to change dramatically. For neighboring landowners, however, the formation of cooperatives to consolidate adjacent lands is an option to meet hunters' minimum area requirements, as well as potentially providing some economies of scale (e.g., insurance costs). In contrast, personal use is a significant deterrent to fee-access hunting. The large marginal effect indicates that overcoming this deterrent would have a large and positive impact on supply. Extension programs demonstrating ways that fee-hunting programs can be compatible with personal use or document financial benefits that exceed the utility derived from personal use, would have a positive impact on supply.

Our findings with respect to landowner attributes have important implications for fee-hunting supply. Higher participation rates for landowners who did not live near their land, coupled with an increasingly urbanized population in the southeastern United States, suggests that, ceteris paribus, the supply of fee-access hunting on private lands will increase in the future. Similarly, the positive relationship between program participation and providing fee-access suggests that the supply of fee-access hunting will vary as funding for these federal programs changes over time; however, the direction of causality is not as clear as in the residency relationship. Although age and education also affect the decision to provide fee-access, at the population level these demographic characteristics are relatively stable, indicating that with respect to these variables, fee-access supply is essentially fixed. Age and education information, however, may provide useful information for targeting specific landowner groups.

User-related concerns provide the most obvious and direct route for affecting the supply of fee-access hunting. Although our results indicate that both privacy and liability concerns limit broad-based landowner participation in fee-access hunting, accident liability has received the most attention. Although Zhang et al. (2006) did not find a significant relation between liability concerns and landowner willingness to provide fee-access, many studies point to its potent relationship with fee-access despite the rarity of actual lawsuits (Lynch and Robinson 1998, Conover and Messmer 2001, Wright et al. 2002). Although admittedly risk of lawsuits is more of a perception than a real problem, Copeland (1998) argued that low participation of landowners in fee-access hunting was not unexpected because the stakes are high. Landowners with land worth millions are reluctant to risk their property for only a few thousand dollars in recreational fees without a clear understanding of the true level of risk. Clearly, a well-designed extension program addressing liability issues, documenting the rarity of such lawsuits, and stressing landowner protections provided by current laws would do much to increase supply.

Indeed, there is increasing interest in providing rural landowners opportunities to increase and diversify revenues from their lands. (See, for example, Natural Resources Enterprises [Mississippi State University 2007].) With limited funding available, outreach and extension programs designed to assist landowners in this regard must target those most likely to participate and focus on issues of greatest interest or concern. To illustrate the importance of correctly targeting and designing extension programs to promote fee-access hunting, the impacts of three counterfactual scenarios were simulated (Table 5). The "base case" scenario used values of the explanatory variables for a typical NIP landowner, which according to descriptive statistics reported in Table 3 (column 2) implied an NIP landowner who was "50 or more" years old, had a junior college education, and did not participate in cost-share programs; who used the land for personal and family recreation activities; who was concerned about privacy and accident liability; and who owned 105 ha (4.657 in natural log units)—the average Mississippi landownership. With these characteristics, the estimated likelihood of providing fee-access was a mere 0.83%.

The first counterfactual scenario illustrated the importance of targeting specific landowners. Ownership size is readily available to extension personnel through county tax records and thus provides a way to segment the landowner clientele. The simulation involved increasing ownership size by 1 logarithmic unit from the mean 4.657 (equivalent to 105 ha) to 5.657 (equivalent to 286 ha). All else being equal, this increased the cumulative likelihood of fee-access to 3%. In scenario 2, we simulated the effects of addressing privacy and liability concerns and minimizing conflicts with personal use in extension short courses, redefining the typical landowner so that privacy and liability concerns and conflicts with personal use were no longer constraining factors. This resulted in a cumulative likelihood of fee-access of 29%. Finally, scenario 3 involved the simultaneous impact of targeting a specific audience (scenario 1) and providing appropriate materials in short courses (scenario 2). The overall cumulative likelihood of providing fee-access was now 47%. These simulation results suggested that

Table 5. Predicted likelihood of Mississippi landowner willingness to provide fee-access for hunting by selected landowner characteristics

Variables	$\hat{\gamma}$	Base $\overline{w}_i$	Base $w_i'\hat{\gamma}$	Scenario 1 $\overline{w}_i$	Scenario 1 $w_i'\hat{\gamma}$	Scenario 2 $\overline{w}_i$	Scenario 2 $w_i'\hat{\gamma}$	Scenario 3 $\overline{w}_i$	Scenario 3 $w_i'\hat{\gamma}$
Resource attributes									
Log(ownership, ha)	0.477	4.67	2.228	5.657	2.221	4.670	2.228	5.670	2.705
Personal use	−0.842	1	−0.842	1	−0.842	0	0.000	0	0.000
Landowner attributes									
Less than 40 yr old	0.132	0	0.000	0	0.000	0	0.000	0	0.000
40–50 yr old	−0.371	0	0.000	0	0.000	0	0.000	0	0.000
High school	0.008	0	0.000	0	0.000	0	0.000	0	0.000
Junior College	0.338	1	0.338	1	0.338	1	0.338	1	0.338
Program participant	0.352	0	0.000	0	0.000	0	0.000	0	0.000
Race	0.469	1	0.469	1	0.469	1	0.469	1	0.469
Rural resident	−0.291	1	−0.291	1	−0.291	1	−0.291	1	−0.291
User-related concerns									
Privacy concerned	−0.582	1	−0.582	1	−0.582	0	0.000	0	0.000
Liability concerned	−0.411	1	−0.411	1	−0.411	0	0.000	0	0.000
Constant	−3.296	1	−3.296	1	−3.296	−3.296	−3.296	1	−3.296
Probit index			−2.387		−1.910		−0.522		−0.075
Simulated likelihood*			0.008		0.028		0.290		0.470
Predicted likelihood at the mean			0.044		0.044		0.044		0.044
Empirical (observed) likelihood			0.112		0.112		0.112		0.112

* Based on cumulative standard normal distribution: $\Pr(z_i = 1) = \Phi(z_o = w_i'\hat{\gamma})$.

for wildlife managers and forestry extension agents to balance the concerns of NIP landowners with the public interest in fee-access, it is important that they target landowners with large ownerships and address personal and family use of land as well as privacy and liability concerns for maximum impact on fee-access decisions. Granted, short courses may not alleviate the concerns of all landowners attending, but even incremental increases in the likelihood of providing fee-access when applied to large numbers of landowners can result in substantial numbers of new landowners providing fee-access hunting, which may be particularly important where the local lease markets are thin.

Factors Influencing Hunting Lease Revenue

Lease type and services are the two characteristics in the lease model that reflect management choices by the landowner and thus are characteristics that can be readily changed to the landowner's advantage. The majority of landowners providing fee-access stipulate annual or longer leases and do not provide services. These arrangements require minimal input by the landowner. Providing services such as guides, food, and lodging requires substantially more effort by the landowner. Typically, landowners providing services exercise much greater control over who is using the property and when; gun permits, 1- to 3-day package hunts, and short-term leases, instead of annual leases, are the most commonly controlled items. Lease type, however, is not significant in our model, possibly because of the number of different lease types lumped together in the other (nonannual lease) category. Based on its large marginal effect, however, returns to services are substantial. Landowners would first need to determine whether these differential returns are commensurate with the cost of providing services. Our findings contrasted with Pope and Stoll (1985), Loomis and Fitzhugh (1989), and Messonnier and Luzar (1990b), who found that the link between the provision of services and lease revenue was weak, although services were bundled differently from study to study.

In general, site attributes cannot be dramatically altered by the landowner in the short run. Of the two sites attributes under the immediate control of landowners, (i.e., *% impoundments* and *% wildlife food plots*), neither was significantly different from bottomland hardwoods. This was in agreement with a priori expectations that landowners may be able to improve hunting sites and thus enhance the revenue potential of their lands even if they did not have intrinsically well-endowed hunting sites with bottomland hardwoods. In the long run, the shares allocated to various land uses are all under the control of the landowner. The implicit prices given by the model provide valuable input as to how shares should be adjusted. Given that the Wetland Reserve Program heavily subsidizes converting cropland to bottomland hardwoods, any fallow or pasture land included in *% other cropland* is an obvious choice for conversion. Marginal croplands included in *% cropland* also warrant consideration, albeit primarily because of the subsidy. Clearly, cutover lands should be reforested as quickly as possible, but if improving habitat and increasing lease revenues are a consideration, replanting to hardwoods instead of planted pines are a viable option. Converting mixed pine-hardwoods to hardwoods would generate the largest marginal effect, followed closely by converting pine plantations. Although direct returns to the land uses probably dominate the landowner decision process, these implicit prices can also contribute if made known to landowners.

A unique finding of this study with respect to site attributes was the lack of any significant relationship between lease revenue per hectare and number of hectares leased. This contrasted with findings by Pope and Stoll (1985) and Messonnier and Luzar (1990b), who reported a positive relationship between lease revenue per hectare and lease size in the Texas and Louisiana hunting lease market. The result did not corroborate the findings by Shrestha and Janaki (2004) and Zhang et al. (2006) either, who noted that in Florida and Alabama lease revenue and lease size were negatively related. All these diverse findings about the revenue-size relationship are conceivable because economic theory does not suggest that one or the other type of relation will always exist.

The region-specific dummy variables were significant, which implied that the Mississippi hunting lease market was segmented. This observation resonated with similar findings by Messonnier and Luzar (1990b), who noted that in Louisiana segmented hunting lease markets coexisted simultaneously essentially because of differences in the supply structure. This is probably true in the case of the Mississippi hunting lease market as well, where regional differences in land use patterns and quality differences in wildlife habitat exist (Munn et al. 2007). Whereas Gray (1998) also identified regional differences, his regions were too large (e.g., Southeast United States, Pacific United States, US Rocky Mountains, and US Midwest) to be comparable with these results. With regional dummies in the model, most of the site attribute variables are no longer significantly different from those for *% bottomland hardwoods.* This unfortunate drawback of market segmentation arises because the number of observations within segments is necessarily much less with subsequent loss of degrees of freedom (Palmquist 1991, p. 89).

The coefficient on management (*management skills*) in the unrestricted model is positive and significant. Thus, landowners who are knowledgeable about planning and operating a fee-hunting operation may have an advantage (16%) over otherwise similar landowners. Public agencies with a mandate for outreach efforts would advance the cause of natural resource–based enterprises and increase landowner revenues if such efforts were focused on the landowner's entrepreneurial skills.

Concluding Remarks and Implications for Future Research

This article examines jointly NIP landowner decisions in Mississippi to provide fee-access hunting and factors influencing hunting-lease revenue per leased hectare in a sample-selection framework. Results show that landowners are more likely to provide hunting leases if they are owners of larger parcels, are older than 50 years, are less educated, and participate in some type of cost-share program. Characteristics that decrease the likelihood of providing leases include personal use of property and privacy and liability concerns. Factors positively influencing lease revenue per hectare are landowner management skills, forestland location, and a greater proportion of bottomland hardwoods relative to other land uses (although not aquaculture).

The study complements previous research (e.g., Shrestha and Janaki 2004, Zhang et al. 2006) on hunting lease supply and addresses several important omissions. In particular, we incorporate key issues identified by previous studies (e.g., the need to account for market segmentation, modeling participation and lease rate jointly) as well as to contribute to the fee-access hunting literature in several additional ways. First, given the fact that landowner participation in the fee-access hunting market is not uniformly distributed across ownership size classes, we adopt stratified random sampling scheme, and use WMLE that this sampling survey design necessitates. The benefits of this approach include obtaining information-rich data from the segment of the population of most interest, which results in more reliable estimators than would be provided by simple random sampling and unweighted estimation techniques. Second, we estimate a hedonic price function that finely differentiates site characteristics (e.g., land allocation across forest types, agricultural, and other land uses) and includes other important determinants such as market segmentation. By doing so, we are able to show subtle variations in implicit prices, which provide landowners guidance when facing choices in changing their land use composition. Finally, using the selection component of the estimated model, we simulate the impact of key policy variables on the prospects of expanded fee-access. The results of this simulation provide valuable insights to natural resource managers in furthering resource management goals.

A take-home lesson for other researchers is that the literature on fee-access hunting markets is far from complete. A number of issues still need to be addressed. Several are suggested by this study. First, as state-level surveys of hunting leases are fraught with lack of variation because of sparse data, certain data items have to be necessarily lumped together (e.g., other leases instead of distinguishing 1-day, 3-day, and 3-month leases and services instead of specific groups of services), but this combining results in loss of unique information. To overcome data limitations of this type, future research on hunting leases would benefit from studies designed specifically to address these key issues. For example, what type of fee-access provides the greatest financial opportunity for landowners and what are the relevant trade-offs? What services should landowners provide to maximize net profits? What marketing techniques promise the greatest opportunities for landowners to maximize demand for their properties? Second, this study and others have identified a number of issues such as liability and safety concerns that limit landowner involvement in fee-access. No researchers have followed up with empirical studies to ascertain how best to address these issues. Third, it would be worthwhile to determine what are the impacts of fee-access hunting on financial aspects of landownership such as land appraisal and ad valorem tax implications across the United States, how land values vary depending on fee-access hunting market conditions, and how financial institutions are responding to emerging hunting markets. Fourth, although this study illustrated that hectares leased was a subset of hectares owned, further investigation is warranted to determine the factors that influence which subset of hectares owned is ultimately leased. Indeed, the selection process may shed considerable light on why the various studies have found such divergent impacts of lease size on lease rate per hectare. Finally, a number of studies have investigated the demand and supply sides of the fee-access hunting market separately; however, none has modeled supply and demand simultaneously. Until such an effort is successfully made, our understanding of this market will fall considerably short of that for other forest and agricultural markets.

Endnotes

[1] Texas is probably an exception in which a large proportion of landowners provide fee-access and economists have started to factor in hunting lease income into land appraisals and other associated impacts on the economy (Baen 1997, Torell et al. 2005, Henderson and Moore 2005).

[2] Although the forest industry is actively engaged in the hunting lease market, insights gleaned from hunting leases on industry lands (Roach et al. 1996) do not necessarily translate to NIP lands because the forest industry is motivated in part by nonpecuniary considerations such as community goodwill, arson reduction, protection from timber theft, and gaining leverage in anticipation of environmental regulations (Busch and Guynn 1988, Marsinko et al. 1992, Brown et al. 2001).

[3] Research on the demand side of the hunting lease market is relatively extensive compared with research on the supply side. See, for example, Livengood (1983), Dharmaratne (1989), Mackenzie (1990), Creel and Loomis (1992), Goodwin et al. (1993), Gan and Luzar (1993), Fried et al. (1995), Boxall et al. (1996), and Hussain et al. (2004).

[4] According to Doolittle (1996), 91% (or 249,941) of nonindustrial private forestland landowners in Mississippi owned less than 40 ha and as a group commanded 41% of the NIP forestland. The sample under consideration, thus, pertained to 9% (or 25,360) of Mississippi landowners who owned 59% of Mississippi NIP forestland. Note also that this skewed pattern of landownership is a characteristic of the southeastern United States (Birch 1996).

[5] Other concerns queried about but excluded on the basis of principal component analysis for discrete data (Kolenikov and Angles 2004) were compatibility of fee-access hunting with agriculture and forestry, loss of control over who is using land, damage to property, and fear of arson and vandalism.

[6] Sample selection models fall in the class of limited dependent variable and duration models. The unique nature of hunting lease markets and estimation challenges that ensue suggest the use of these models. Given time-series data on landowners' fee-access decisions, for instance, a formal recruitment model (like a survival model) would be appropriate to gain insights about landowners leasing behavior because once a landowner gets a satisfactory leasing arrangement, the probability of continuing to lease year after year rises.

[7] Because γ and σ_μ are not separately identifiable in the probit, σ_μ is set to 1.

[8] The log of ownership size provided a better fit than ownership size expressed in level terms.

[9] A unit increase in land owned from 4.657 natural log units (equivalent to 105 ha) to 5.657 natural log units (equivalent to 286 ha) implied a 2.71-fold increase in average land ownership.

[10] Computed based on the expression $[\partial\Phi(w_i'\hat{\gamma}/\partial \mathrm{w}_j] * \hat{\gamma}_j$.

[11] The Box-Cox transformation could not be used because all of the explanatory variables except land leased (hectares) violated the criterion of strictly positive values.

[12] Marginal effects for continuous variables (i.e., percent pine-hardwoods), evaluated at the respective means, were based on $\partial \mathrm{LOGREV}/\partial x_j = \hat{\beta}_k \bar{x}_k$. The marginal effect for log (leased hectares) was based on $\partial \mathrm{LOGREV}/\partial \log \text{ leased ha} = \hat{\beta}_{\mathrm{ha}}$. For details, see Johnson et al. (1987, p. 251)

[13] Following Halvorsen and Palmquist (1980) and Kennedy (1981) marginal effects for dummy variables were based on $\{\exp[\hat{\beta}_k - V(\hat{\beta}_k)/2] - 1\} * 100$.

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