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ORIGINAL RESEARCH

If A Tree Falls in A Forest, Why Do People Care? An Analysis of Private Family Forest Owners' Reasons for Owning Forest in the United States National Woodland Owner Survey

David W. Shanafelt[1] · Jesse Caputo[2,3] · Jens Abildtrup[1] · Brett J. Butler[2,3]

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Abstract
At its heart, forest management is grounded in valuation, with questions regarding what, how, and how much individuals value the forest being fundamental for efficient management. In this paper, we try to understand why private family forest owners value their forestland, and how owner and forest characteristics vary depending on the type of value. We estimate the demographic and socio-economic factors behind a suite of stated reasons for owning forest, from traditional market-value reasons to less-traditional, non-market reasons, among others. For our analysis, we use the United States Forest Service's National Woodland Owner Survey (NWOS), a nationwide survey of private forest and woodland ownerships of at least one acre. We are able to identify different groupings of reasons for owning that share similar associated explanatory variables. While our results are generally in agreement with the literature, we find some notable discrepancies, such as a consistent negative association with education level and timber harvest as a reason for owning. This highlights a potential difference between stated and actual preferences. We believe that our results are useful when designing and disseminating information for policy, such as for promoting endangered species conservation or targeting individuals for enrollment in conservation easement, green certification, or cost-share programs.

Keywords National Woodland Owner Survey (NWOS) · Ordered logit · Ownership objectives · Private family forest owners · Reasons for owning

Extended author information available on the last page of the article

Introduction

Researchers have long been interested in forests, from their usage for timber products, hunting, and recreation to refugia for species conservation to their contributions to the global carbon cycle. Regardless of the research domain or end goal, efficient management is a key question. At its heart, management is largely grounded in economic (although not necessarily monetary) valuation, with decisions to harvest, conserve, (re)plant, or do nothing being dependent on the nature of the economic value of the forest. Take, for example, the classic Faustmann rotation model, which considers solely the market price of timber in deriving optimal rotation time (Conrad 1999). In contrast, Hartman (1976) considers both harvest as a market good and the flow of other services, e.g., recreational services (non-market services), finding that the inclusion of these services typically lowers the extraction rate.[1] Building upon use and non-use categories, researchers have come to recognize many different economic values deriving from forests (e.g., Hansjurgens et al. (2017)). With few exceptions, questions regarding what, how, and how much individuals value a resource are fundamental assumptions inherent to utility maximization and resource management (Clark 2010; Conrad 1999; Conrad and Clark 1987).

In this paper, we try to understand why private family forest owners value their forestland by studying how owner and forest characteristics vary depending on the type of value. We examine the demographic and socio-economic factors associated with the type and weight that family forest owners place on market and non-market reasons for owning their woodland property. Certainly, answering the question "why do people value the forest?" in its completeness is beyond the scope of this paper. Here we contribute to this overarching research question by asking what do private family forest owners value in their properties, and how the characteristics of forest owners vary across different reasons for owning. We take the stated reasons for owning forest as proxies for owner preferences, which may act as the underlying mechanisms for owner observed behaviors (e.g., management). These are not necessarily the same as why an individual obtained their property, but rather the current reason(s) for owning or keeping it. We assume that there is a linkage between an individual's core values and preferences and their stated reasons for owning (or keeping) forest property. For example, if an individual values biodiversity, then it is more likely that they will rank "preserving biodiversity" as an important reason for owning their property, which will then be reflected in their management decisions. This idea touches on the notions of "theory of reasoned action" or "theory of planned behavior" (Ajzen 1991; Young and Reichenbach 1997), "value-belief-norm" theory (Stern 2000), and "goal framing" (Lindenberg and Steg 2007), in that we assume that there is a linkage between attitudes or values and behavior.[2]

[1] While frequent in forest economics, the consideration of multiple types of benefits, including nonmarket valuation, is more novel in mainstream resource economics (though see Barbier (2007), Bertram and Quaas (2016), Brock et al. (2010), Nelson et al. (2009), and Shanafelt et al. (2018) for exceptions).

[2] The linkage between preferences, objectives, and behavior is intuitive, but it is far from a foregone conclusion. We know of no study in forestry or forest economics that checks for consistency between them, as doing so would likely require information on stated preferences/objectives and actual management behavior.

We focus on family forest owners in the United States. Privately owned forests – including those owned by individuals or families, corporations, or other private owners (such as Native American tribes and non-governmental organizations or NGOs) – make up more than half of the forests in the United States (US Forest Service 2015). Specifically for private forest owners, the literature is in general agreement on the importance of non-market values (Amacher et al. 2003), though the nature of those values and how they vary among forest owners remains an open question. Numerous surveys of private forest owners exist in the literature which relate forest owner behaviors or decisions to owner and forest characteristics. However, the focus of most of these studies is on understanding the driving factors behind the decision or quantity to harvest (Favada et al. 2009; Garcia et al. 2014; Petucco et al. 2015), the choice to improve or develop the property (Karppinen and Berghall 2015), the decision to bequeath forest to future generations (Amacher et al. 2002), the decision to engage in management behaviors other than timber (Amacher et al. 2003; Eggers et al. 2014; Gruchy et al. 2012; Joshi and Arano 2009; Silver et al. 2015), landowner risk aversion (Andersson 2012), or enrollment in environmental programs (Dickinson et al. 2012; Polomé 2016). Few studies explicitly relate forest and forest owner characteristics to owner objectives other than timber.

Among the suite of different ownership objectives found in the literature, by far timber harvest and supply is the most studied (Amacher et al. 2003; Beach et al. 2005; Silver et al. 2015), with other objectives or values more often being related to timber harvest or supply (Aguilar et al. 2014a, b, 2017; Favada et al. 2009; Garcia et al. 2014; Gruchy et al. 2012; Kuuluvainen et al. 1996, 2014). Less common are studies that estimate the probability of valuing the forest for multiple reasons other than harvest, though see Joshi and Arano (2009), who consider forest owner willingness to deliver regulating ecosystem services as function of, among other factors, how the forest owners assess the importance of the economic and sentimental values of the property.

We consider a broad suite of reasons for owning usually treated separately (Gatto et al. 2019; Joshi and Arano 2009). An exception is Finley and Kittredge (2006), who use 13 reasons for owning forest to group Massachusetts private forest owners into clusters. However, they do not explicitly relate how the stated reasons for owning associate with forest and forest owner characteristics. Similarly, Kuuluvainen et al. (1996), Karppinen (1998), and Kuuluvainen et al. (2014), in surveys of non-industrial private forest owners in Finland, carry out principal component analysis (PCA) and K-means clustering to group forest owners by their stated objectives. Kuuluvainen et al. (1996) and Kuuluvainen et al. (2014) then ask how group participation informs harvest intensity and supply, respectively. Karppinen (1998), in a sparser socio-economic data set, relates group identification to owner and forest holding characteristics and compares silviculture and cutting practices across groups. Matilainen et al. (2019) investigate new non-industrial private forest owners' perceptions of forest ownership in different contextual settings in Europe based on the theory of psychological ownership and qualitative interviews. By comparing reasons for owning side-by-side within a single data set (rather than by combining multiple data sets, *sensu* a meta-analysis approach), we are able to better synthesize common themes among their associated forest and owner attributes. To the best of our knowledge, ours is the most extensive study to date to relate forest and forest owner characteristics to reasons for owning private forest property.

We utilize the United States Department of Agriculture (USDA) Forest Service's National Woodland Owner Survey (NWOS), using reasons for owning forestland as proxies for the type and strength of valuation. The NWOS represents a nationwide survey of private ownerships, with the earliest iteration having been administered in 1953 (Butler et al. 2016a; LaBau et al. 2007). Examples of studies which have used this dataset include: Majumdar et al. (2008), which categorizes family forest owners; Andrejczyk et al. (2016), which analyzes the open-ended, free-response question of the NWOS; and Caputo and Butler (2017), which estimates the benefits provided by forestland and the beneficiaries who receive them. Most recently, Butler et al. (2021a) measure the relationships between forest property size and landowner characteristics and behavior. They find that the property size has a significant impact on the reasons to own their forest property, focusing on timber harvest and wildlife. The present study broadens their perspective by analyzing a variety of reasons for owning, as well as considering owner and forest characteristics other than the size of the property. Furthermore, the present study will contribute to the awareness of the scientific community to this dataset and facilitate future collaborations with the USDA Forest Service.

Differences between reasons for owning matter when designing policies targeting private forest landowners. If a policy does not properly account for the value set of individuals or target the correct demographics, either by ignoring their preferences, wrongly categorizing or pigeon-holing them, then it will lead to inefficiencies in the implementation and maintenance of that policy. Although the focus of this paper is on the United States, the results should be generally applicable to other countries with similar ownership patterns.

Methods

Data

The United States National Woodland Owner Survey (NWOS) is a nationwide survey of private forest and woodland ownerships of one or more acres (Butler et al. 2016b; Service 2015). It includes demographic, ecological and socio-economic data such as previous and current land use practices, reasons for owning and future plans for the property, and concerns for the present and future state of the forestland. For a history of the NWOS, see LaBau et al. (2007) and Butler et al. (2016a). Butler et al. (2005, 2016b), Dickinson and Butler (2013), and Caputo et al. (2020) provide in-depth discussions of the design and implementation of the survey. Our study was conducted based on the 2018 iteration of the NWOS. We present the relevant data for our study below, but a detailed description of the 2017-2018 iteration of the survey, including the presentation of the broad summary statistics, can be found in Butler et al. (2021b). The USDA Forest Service provides a methodology for weighting survey responses to obtain population-level inferences of the survey data (Butler and Caputo

2020; Butler et al. 2021b). However, as this is not the purpose of our study, we use the raw response values.

In particular, we focus on the current *stated* reasons for owning forestland as a proxy for value of that type of benefit. Specifically, these include: beauty or scenery; protection of nature or biodiversity; protection of water resources; protection or improvement of wildlife habitat; land investment; privacy; to raise a family; to pass land on to children/heirs; firewood; harvest of timber products; harvest of non-timber products; hunting; recreation, other than hunting; and other. The last is a general category meant to capture any other reason for owning not included in the previous thirteen. For each reason for owning, respondents were asked to rank separately the importance of said reason on a Likert scale from not important (1) to very important (5).

Explanatory Variables for the Reasons to own Forest Property

Previous analyses have identified the presence of non-market values for private landowners (Amacher et al. 2003; Ficko et al. 2019; Karppinen 2004; Kuuluvainen et al. 1996). By inspecting the relative importance of the reasons for owning, it is clear that the NWOS is no exception (Table 1). We try to understand what socio-economic and behavioral characteristics explain the weight an individual places on a specific reason for owning forestland. We will then compare *how* these traits differ between each of the reasons for owning. Our set of dependent variables consists of the set of fourteen stated reasons for owning land in the NWOS data set.

Our choice of explanatory variables is fairly standard in the literature. We would direct the reader to reviews by Amacher et al. (2003), Beach et al. (2005), Silver et al. (2015), Joshi and Arano (2009) and Garcia et al. (2014), who provide in-depth overviews of the socio-demographic factors affecting management decisions. We consider two sets of independent or explanatory variables. Note the distinction between demographic variables (which relate only to the *primary* owner of the woodland) and characteristics of the ownership unit (which can include multiple owners). First, we consider forest owner age, education level, the number of individual owners in each ownership, and binaries for whether multiple parcels are owned or the property is the owner's primary place of residence. Our second set of explanatory variables are forest-specific and include the total acreage belonging to the ownership (i.e., size of forest holdings), proportion of forested land on the property, the proportion of owner income that comes from their forestland, and how and when the property was obtained. Finally, we include a behavioral variable that partially captures other unobservable characteristics of forest owners. When choosing these types of variables, we proceed with caution, as it is easy to introduce endogeneity into the model. To see this, consider, for example, the practice of recreation. If a person practices recreational activities on their property, then recreation will likely be an important reason for owning the property and would drive the practice of recreation (and vice versa). This is a type of endogeneity known as reverse causality and can potentially bias our results, making estimates of the statistical model unreliable (Angrist and Pischke 2009; Cameron and Trivedi 2005). Specifically, we include a binary variable that indicates if the property is currently enrolled in a conservation easement or green

Table 1 Summary statistics of dependent and explanatory variables (before standardization)

Reason for owning woodland*	Mean	St. Dev.	Skewness
Beauty or scenery	4.26	0.97	-1.403
Protection of nature or biodiversity	4.00	1.06	-0.976
Protection of water resources	3.92	1.11	-0.870
Protection or improvement of wildlife habitat	4.20	0.98	-1.220
Land investment	3.56	1.29	-0.561
Privacy	3.97	1.20	-1.070
To raise a family	3.52	1.43	-0.568
To pass land on to children/heirs	3.97	1.24	-1.067
Firewood	2.36	1.31	0.550
Harvest of timber products	2.78	1.51	0.164
Harvest of non-timber products	1.82	1.12	1.248
Hunting	3.44	1.47	-0.496
Recreation, other than hunting	3.48	1.29	-0.563
Other	4.50	1.07	-2.333
Explanatory variable	**Type**	**Mean**	**St. Dev.**
Owner age	continuous	65.45	11.683
Owner education	categorical		
Less than 12th grade		0.03	0.163
High school/GED		0.18	0.386
Some college		0.20	0.398
Associate's degree		0.08	0.273
Bachelor's degree		0.27	0.444
Advanced degree		0.24	0.429
Percent income from woodland	continuous	4.43	13.260
Primary residence	binary	0.55	0.497
Number of owners of the property	continuous	2.53	6.823
Multiple properties owned	binary	0.40	0.490
Acreage of woodland	continuous	1332.33	9650.603
Proportion of woodland on property	continuous	0.69	0.307
Number of years owned	continuous	25.12	15.347
Acquisition of property§	binary		
Purchased		0.76	0.430
Inherited		0.36	0.481
Gifted		0.03	0.178
Other		0.01	0.081
Enrollment in environmental program(s)	binary	0.42	0.493

* Responses are ranked from not important (1) to very important (5)

§ The survey allows owners to have obtained parts of their property through purchase, inheritance, gift, or other means. Respondents were presented with a single question and asked to "check all that apply"

certification scheme, or whether a cost-share program was used in the last five years to establish or manage the woodland.

We restrict our analysis to family forest owners with greater than or equal to ten acres (0.4 hectares) of forestland. We find that this threshold does a decent job separating people who own substantial, meaningful amounts of forestland from those who own a few hectares here and there, while still providing variation in terms of objectives, intentions, and behaviors. Family forest holdings make up about a third of all forest property in the United States, across an estimated 9.6 million ownerships. Family forest owners with at least 10 acres of land represent 38% of these holdings (Butler et al. 2021b). In order to improve the convergence of our statistical models, we also standardize (scale) all continuous variables by subtracting the value of each observation by its mean and dividing by its standard deviation.

Summary statistics for the reasons for owning and explanatory variables can be found in Table 1. Correlation coefficients among our explanatory variables are included in the online Supplemental Material.

Estimation of Statistical Models

When selecting a statistical model to analyze the data, we choose a modelling framework that we believe best fits the data and the data formation process, which, in our case, is discrete choice modelling. Discrete choice modelling is grounded in utility maximization of choice theory which asserts, by definition, that a decision maker gains utility for each choice in a set of alternatives, and that an individual's selection reflects the one that yields the highest utility or well-being (Marschak 1960; McFadden 1974, 2001; Train 2009). For binary choice responses, if the utility for a given choice passes a certain threshold, then the individual chooses that option over the other alternatives.

Utility can be broken apart into observed and unobserved components (Cameron and Trivedi 2005; Greene and Hensher 2010; Train 2009). The latter is random, usually taken as independently, identically distributed (IID) extreme value. The former is usually taken as a linear combination of observed explanatory variables relating to each alternative.

More formally, we may write the utility that individual i gains from alternative j as,

$$U_{ij} = \beta_j X'_{ij} + \varepsilon_{ij} \tag{1}$$

where X_{ij} and β_j represent observed variables or data (transposed) and their effects on utility, and ε_{ij} are effects unobserved by the researcher. The distribution of and assumptions placed upon the unobserved component of Eq. (1) determine the statistical model to be fitted.[3]

With discrete choice models, we estimate the probability that a certain threshold of gained utility is crossed and the individual chooses option j over the others. More formally, we may write,

[3] Starting with the work of McFadden (1974), empirical estimation of model parameters in (1) under a logistic distribution were shown to be consistent with the theory of utility maximization. This has subsequently been extended to other statistical distributions (Cameron and Trivedi 2005; Green and Hensher, 2009; Train 2009).

$$\begin{array}{lll} y_{ij} = 1 \text{ (not important)} & if & U_{ij} \leqslant u_1 \\ y_{ij} = 2 \text{ (of little importance)} & if & u_1 < U_{ij} \leqslant u_2 \\ y_{ij} = 3 \text{ (moderately important)} & if & u_2 < U_{ij} \leqslant u_3 \\ y_{ij} = 4 \text{ (important)} & if & u_3 < U_{ij} \leqslant u_4 \\ y_{ij} = 5 \text{ (very important)} & if & u_4 < U_{ij} \end{array} \quad (2)$$

where y_{ij} is the ranked response of each individual i for each reason for owning j. Thresholds or cutoffs of utility that mark the transition from one ranking to another are given by u_r, where the response indicates the level of utility gained from that choice.

From Eq. (2) it is clear that our data are ordered in the responses for each reason for owning. That is, there is an intrinsic scaling or natural ordering of preferences within the responses - a hierarchy (e.g., "not important" is less than "moderately important, which is less than "very important"). There are two predominant methods in the literature to deal with this type of data: transform the data into a binary and analyze it as a single decision model, or estimate a model that accounts for multiple choices in the decision process (Cameron and Trivedi 2005; Gelman and Hill 2007; Greene and Hensher 2010; Train 2009).

For the former, we would convert each reason for owning into a decision to value (ranking≥4) or not value (ranking<4) and analyze the model as a logistic or probit regression (Cameron and Trivedi 2005; Greene and Hensher 2010; Train 2009). However, transforming the data into a binary ignores the natural structure of the data. We therefore opt to focus on the latter and present in the main text the decision to choose one of several alternatives, where each possible ranking is an option in the choice set. We include an analysis which considers the binary decision to value or not in online Supplemental Materials A and B.

To model a discrete choice among a set of alternatives, we have a variety of options including Poisson or negative binomial regressions (assumes a count in the data), multinomial logit or probit regressions (assumes no ordering in the choice set), or the ordered logit (assumes a structured ordering in the data). While the Poisson and multinomial can provide reasonable estimates (Cameron and Trivedi 2005; Train 2009), it can lead to problems with model selection if not properly specified to the data (Greene and Hensher 2010).[4]

To better account for the natural ordering of the data, we estimate an ordered logistic model. In this case, we can think of each respondent having some level of utility (or opinion) associated with each reason for owning, with the reported ranking of the response increasing as the utility gained increases past a certain threshold or cutoff

[4] The Poisson, for example, assumes specific forms of the mean and variance of the data, and is not truncated at the maximum ranking (Cameron and Trivedi 2005). Alternatively, consider the multinomial logit. Unlike the ordered logit, there is no ordering in the choices as the value of the ranking increases. That is, each option can be thought of as an independent product, with the option yielding the highest utility being the one that is selected. However, by ignoring the ordered structure of the decision process in the data, this violates the assumption of independent and identically-distributed errors for each alternative: a choice is more similar to those close by than to those far away. Nonetheless, the multinomial can give reasonable estimates or be modified into a nested or mixed logit or probit to account for this fact (Cameron and Trivedi 2005; Train 2009).

(Greene and Hensher 2010; Train 2009). If we assume a logistic distribution, then we may write the probabilities of each response as,

$$\begin{aligned} \Pr(y_{ij}=1|X_i) &= \Pr(\varepsilon_i \leqslant u_1-\beta' X_i) \\ \Pr(y_{ij}=2|X_i) &= \Pr(\varepsilon_i \leqslant u_2-\beta' X_i)-\Pr(\varepsilon_i \leqslant u_1-\beta' X_i) \\ &\vdots \\ \Pr(y_{ij}=r|X_i) &= \Pr(\varepsilon_i \leqslant u_r-\beta' X_i)-\Pr(\varepsilon_i \leqslant u_{r-1}-\beta' X_i) \end{aligned} \tag{3}$$

where y_{ij} is the probability of ranked response $\mathrm{r}=1,2,\ldots,5$ for each individual *i* and reason for owning *j*, β_k is a vector of regression coefficients to be estimated, X_{ik} is a matrix of our independent variables, and ε_i is the error term. The thresholds or cutoffs u_r mark the transitions from one alternative to another and are estimated in the model. While we might expect unobserved heterogeneity between regions, we did not find enough variation in the data to justify the inclusion of a state- or county-level random effect. When selecting our preferred model, we balance the natural structure of the data and the functional form of the statistical models, and lean on Akaike information criteria (AIC) as an explicit measure of model fit. As it is a fairly standard threshold across disciplines, we use the 10% level as our threshold for statistical significance. All models were estimated in R 3.6.2 using the method of maximum likelihood with the *ordinal* package. The code for our analysis is available in Supplemental Material C.

In the context of forestry, ordered logit models have been used to study owner willingness to harvest (Aguilar et al. 2014b; Gruchy et al. 2012), risk aversion (Andersson 2012), and the probability of enrollment in carbon sequestration programs (Dickinson et al. 2012), among others. For more details about this type of model, we would direct the reader to Cameron and Trivedi (2005), Train (2009), and particularly to Greene and Hensher (2010), who provide a detailed development of the intuition behind the model and discussion of its use across disciplines.

Results

Our results are summarized in Table 2. Full tables of the raw results, including the standard errors and p-values, can be found in Supplemental Material B. Recall that estimates are reported as statistically significant at the 10% level.

We find that *owner age* is negatively associated with beauty or scenery (BEA), land investment (INV), privacy (PRI), raising a family (FAM), firewood (FIRE), harvesting non-timber forest products (NTFP), hunting (HUNT), and recreation other than hunting (REC). In other words, an increase in owner age is associated with a lower ranking of each of these reasons for owning. A negative association with FAM is not unexpected, as typically we would expect younger individuals to be more engaged in raising a family. Similarly, land investment is less likely to be important for older people as forest investment may have a long time horizon. At first glance, one could expect REC to be positively associated: older, retired individuals would have more time to enjoy their forest for recreational purposes. However, while hiking

Explanatory variable	Estimates for each reason for owning													
	BEA	NAT	WAT	WIL	INV	PRI	FAM	CHILD	FIRE	TIM	NTFP	HUNT	REC	OTH
Owner age	-0.095	-0.017	0.008	-0.061	-0.098	-0.102	-0.237	-0.010	-0.067	0.003	-0.094	-0.160	-0.196	-0.040
Owner education														
High school/GED	0.161	0.151	0.183	0.138	0.044	0.163	0.004	0.020	-0.200	-0.347	-0.180	0.012	0.140	-0.333
Some college	0.352	0.335	0.299	0.202	0.139	0.184	-0.051	-0.147	-0.333	-0.471	-0.224	-0.200	0.181	-0.209
Associate's degree	0.302	0.316	0.243	0.244	0.156	0.063	-0.002	-0.087	-0.213	-0.356	-0.089	-0.032	0.257	-0.160
Bachelor's degree	0.376	0.287	0.109	0.143	0.074	-0.076	-0.379	-0.365	-0.579	-0.424	-0.474	-0.512	0.149	-0.205
Advanced degree	0.692	0.508	0.249	0.258	0.035	-0.042	-0.411	-0.410	-0.649	-0.501	-0.440	-0.812	0.201	-0.165
Perc. income from woodland	-0.142	-0.096	-0.034	-0.058	0.153	-0.067	0.070	0.112	0.018	0.224	0.025	0.095	-0.027	0.020
Primary residence	0.492	0.320	0.247	0.027	-0.289	0.809	1.412	0.083	0.697	-0.103	0.489	-0.353	-0.019	0.175
Number of owners	0.019	0.024	0.050	0.037	-0.004	-0.020	-0.005	-0.013	-0.078	-0.004	-0.040	-0.015	0.013	0.001
Own multiple properties	-0.346	-0.186	-0.122	-0.098	0.487	-0.375	-0.138	0.161	-0.212	0.600	-0.048	0.329	-0.038	-0.066
Acreage of woodland	0.005	0.004	0.038	0.044	0.192	0.025	0.016	0.123	-0.018	0.076	-0.002	0.049	0.012	0.015
Prop. of woodland	0.211	0.107	0.056	0.163	0.159	0.254	0.047	0.042	0.012	0.298	0.054	0.048	0.193	0.008
Number of years owned	-0.110	-0.028	-0.006	-0.051	-0.020	-0.085	0.169	0.107	0.108	0.232	0.026	-0.019	-0.051	-0.023
Acquisition of property														
Purchased	0.221	0.019	0.008	0.212	0.300	0.365	0.178	0.107	0.109	-0.008	0.081	0.300	0.369	0.052
Inherited	-0.202	-0.098	0.061	-0.092	0.052	-0.167	0.131	0.724	0.124	0.657	0.114	0.215	-0.077	0.056
Gifted	-0.255	-0.326	-0.176	-0.373	-0.023	-0.287	-0.311	0.101	-0.032	0.462	-0.115	-0.022	-0.080	-0.042
Other	-0.067	0.184	0.190	-0.010	0.320	-0.097	-0.105	0.104	-0.198	0.006	0.133	0.047	0.359	-0.322
Enrollment in env. program(s)	0.073	0.162	0.199	0.147	0.133	-0.025	0.004	0.100	-0.132	0.207	0.001	-0.037	-0.042	0.045
Threshold coefficients:														
1 | 2	-3.147	-2.846	-2.770	-3.482	-1.838	-2.271	-1.195	-2.312	-0.663	-0.780	0.253	-1.704	-1.659	-2.810
2 | 3	-2.261	-1.931	-1.707	-2.488	-1.005	-1.491	-0.476	-1.650	0.256	-0.128	1.190	-1.160	-0.972	-2.642
3 | 4	-0.911	-0.487	-0.394	-1.000	0.155	-0.436	0.422	-0.635	1.308	0.718	2.301	-0.373	0.155	-2.047
4 | 5	0.536	0.868	0.874	0.362	1.308	0.808	1.538	0.414	2.443	1.682	3.350	0.598	1.481	-1.171
Number of observations	9294	9264	8967	9315	9060	9029	7296	8873	8315	8357	7257	8823	8845	8906

Coefficients are the presented as the raw estimates of the ordered logistic regressions (not odds ratios). Colors were added to highlight the sign (blue, positive; red, negative) of statistically significant explanatory variables at the ten percent confidence level, and to facilitate comparisons between each reason for owning. Abbreviations for each reason for owing are given as: beauty or scenery (BEA), protection of nature or biodiversity (NAT), protection of water resources (WAT), protection or improvement of wildlife habitat (WIL), land investment (INV), privacy (PRI), to raise a family (FAM), to pass on to children/heirs (CHILD), firewood (FIRE), harvest of timber products (TIM), harvest of non-timber products (NTFP), hunting (HUNT), recreation other than hunting (REC), and other (OTH).

Table 2 Results of the ordered logistic regression

and fishing are accessible to all ages, other recreational activities are more likely to be enjoyed by younger individuals (e.g., biking, camping, horseback riding, skiing, and off-road vehicles). One could suppose that BEA and NTFP are part of the "new age" forestry paradigm (in contrast to "traditional" forestry methods like timber harvest or firewood), which would be more characteristic of younger generations.

As *education* is represented as a categorical or factor variable, our estimates use less than a high school diploma as a baseline for comparison. In all cases, we find consistent trends in our estimates, e.g., if an estimate for one level of education is positive, then all levels of education beyond that point are also positive. What is interesting is that the magnitude of the effect does not always keep increasing as the level of education increases. The level of education was positively associated with BEA, the protection of nature or biodiversity (NAT), the protection of water resources (WAT), the protection or improvement of wildlife habitat (WIL), and REC. These traditionally do not have a market value, and it could be argued that more educated individuals would be more likely to be aware of them. Indeed, the survey does not ask about awareness or appreciation of environmental services. It is feasible that other explanatory variables not included in the NWOS, such as income and housing, food security, or involvement in issues of environmental justice, could help elucidate this association. In contrast, more traditional uses of the forest – FIRE, TIM, NTFP, and HUNT - are negatively associated with education level. It is possible that education is associated with total income (which was not measured), which, if family forest owners depend on the forest or forest products for their livelihoods, might make more utilitarian objectives more of a necessity to households. Consistent with the view that, on average, individuals with higher degrees have children later in life, FAM and CHILD are negatively associated with education.

For the *percentage of income* that comes from the forest property, we find that the reasons for owning that have little or no market value – BEA, NAT, WAT, WIL, and PRI - are negatively associated. Reasons for owning that could potentially hold market value – INV, TIM, and HUNT – are positively associated, suggesting that the potential value in these uses is actually realized by family forest owners. Furthermore, FAM and CHILD are also positively associated, suggesting that financially valuable properties are more likely to be used by a family or be passed on to the next generation.

In terms of the forest property being an individual's *primary residence*, reasons for owning whose benefits are tied to time spent on the property (BEA, PRI, FAM, CHILD, OTH) are positively associated, as are NAT and WAT, which are more altruistic benefits that do not necessarily correspond to personal engagement. We find that others that are more straightforward to benefit from a distance, such as INV and HUNT, are negatively associated. However, FIRE and NTFP, which we would expect to be harvested outside of the primary residence and consumed at home, are an exception to this rule and are positively associated. We would hypothesize that, on average, if individuals harvest firewood and non-timber forest products, they do so locally at their convenience or need, rather than bulk harvest and storage from another site. Indeed, this notion is supported by a negative association with FIRE and owning multiple properties. Alternatively, it is possible that individuals with multiple properties are larger ownerships and more "commercial" and so firewood could be less important (though we do not see a statistically significant association between FIRE and property size). We would expect the signs of the explanatory variables associated with *owner of multiple properties* to be the inverse of those associated with an individual's *primary residence*, which, with exception of CHILD, is the case. This exception is not surprising. If an individual wishes to pass on property to their children or heirs, then s/he is likely indifferent to that property being their home or another site.

The *number of owners* is positively associated with WAT, and negatively associated with FIRE. This result suggests that properties with water resources may be potentially larger, requiring financial investments from multiple owners to purchase, or that properties with water resources are part of joint-share ownerships (e.g., lakeside timeshares).[5] In contrast, properties owned for the production of firewood are more likely associated with single proprietors.

Property *acreage* is positively associated with INV, CHILD, and TIM. The *proportion of forest* on the property is positively associated with all variables except FIRE and OTH (which are insignificant).

While we might expect overlap between owner age and the *number of years owned*, this is not the case. We observe that the number of years owned is negatively associated with BEA, WIL, PRI, and REC. More recently purchased properties are associated with greater importance in these reasons for owning. In contrast, the number of years owned is positively associated with FAM, CHILD, FIRE, and TIM. That is, if an individual has owned their property for a long time, then it is more likely

[5] Neither *acreage* nor the *acquisition of property by purchase* are significantly associated with water resources as a reason for owning, supporting the latter hypothesis, that properties with water resources are more often part of joint-share ownerships. A future study incorporating an interaction term between the *number of owners* and *acreage*/*acquisition* of property by purchase could explicitly test the former hypothesis.

that s/he will wish to pass it on to their children or use to raise their family (if we interpret "family" as children, grandchildren, etc.), and more likely to own property for firewood and timber harvest.

When statistically significant, *acquiring* a property via *purchase* was positively associated with all reasons for owning, namely BEA, WIL, INV, PRI, FAM, CHILD, and HUNT, and REC. *Inheriting* the property and being *gifted* the property exhibit different associations. Inheriting was positively associated with FAM, CHILD, FIRE, TIM, NTFP, and HUNT, and negatively associated with BEA, NAT, and PRI. It is not surprising that inheriting the forest will be strongly and positively associated with CHILD, as it may be tied to family traditions. Being gifted was positively associated with TIM, and negatively associated with BEA, NAT, WIL, PRI, and FAM. *Other* acquisition types were not statistically significant determinants of any of our stated reasons for owning, though this could be due to a low number of observations. Differences between each way of acquiring property highlights an interesting observation, namely that landowners who purchase property are not just investors, but seem to deliberately acquire property for specific reasons or values. This is in contrast to those who are given land by inheritance or gift, who may be more indifferent to specific types of benefits.

Finally, we find that *enrollment in an environmental program* (conservation easement, green certification, or cost-share programs) was positively associated with BEA, NAT, WAT, WIL, INV, CHILD, and TIM, and negatively associated with FIRE. While the positive association with TIM may seem counter-intuitive, it could reflect the fact that the purpose of these programs is not for owners to stop harvesting timber, but to incentivize the management of forest properties for multiple objectives (such as conservation or a green standards). Indeed, green certification and cost-share programs often specifically identify timber production as a desired or intended outcome, incentivizing thinning or selective harvest or subsidizing replanting. It may also reflect that forest owners entering such programs are profit maximisers who see such programs as economically beneficial, while owners using their forest for other uses such as private firewood supply, may want to avoid the administrative burden of such programs.

Discussion

Our results are in general agreement with other studies that incorporate owner objectives in their analyses (Favada et al. 2009; Gatto et al. 2019; Joshi and Arano 2009; Karppinen 1998; Kuuluvainen et al. 1996, 2014), and, if we take our reasons for owning as the underlying mechanisms for behavior (e.g., management), then our results are overall consistent with those in the literature. We believe that systematically comparing all of our results across every reason for owning would be an inefficient exercise, and prefer to direct the reader to reviews by Amacher et al. (2003), Beach et al. (2005), and Silver et al. (2015), as well as Joshi and Arano (2009), Garcia et al. (2014), and Gatto et al. (2019). Rather, we find it better to highlight key differences between our study and the general literature.

For example, in general there is a positive association between education level and the decision to harvest (Aguilar et al. 2014b, 2017; Joshi and Arano 2009). However, we find a consistent negative association between education level and timber as a reason for owning, using less than a high school diploma as a baseline. We attribute this contrast to the subtle but important difference between a binary, absolute decision to manage (or not) and management intensity. A response of "moderately important" or even "of little importance" does not exclude the possibility that no timber harvest occurs, but rather that timber harvest might not be the primary reason for owning the property and that the level of harvest would correspond with its importance as a reason for owning. Harvest may occur, but at lower levels than at higher rankings of importance. Or harvest may occur at high levels, but have only instrumental value and be qualitatively less important to landowners (e.g., if an individual owns land to hunt but harvests timber in order to pay for property taxes). Furthermore, if we assume that landowner intentions and reasons for owning accurately relate to their behavior, then our results combined with that of the literature indicates that more educated individuals may consider timber benefits less important even though they may ultimately harvest more.

What is particularly interesting is that we can identify groups of different reasons for owning that share similar associated explanatory variables, i.e., they have the same statistically significant explanatory variables with the same positive or negative signs. More "traditional" forestry values – harvesting timber, firewood, and hunting – while having some overlap, more or less stand alone and function independently from all other reasons for owning. Less traditional reasons for owning – beauty or scenery, protection of nature or biodiversity, water resources, and wildlife habitat – tend to be associated with similar socio-demographic factors. In general, these reasons for owning are the least tied to market (monetary) value benefits.[6] Owning property to raise a family or pass on to children forms a third grouping.

Several studies classified forest owners into different groups, such as industrial and non-industrial owners (Newman and Wear 1993), farmers and non-farmers (Erickson et al. 2002), or by their stated management objectives and behaviors (Eggers et al. 2014; Favada et al. 2009; Ficko et al. 2019; Ingemarson et al. 2006; Kuuluvainen et al. 1996, 2014). Most of these classifications are based on stated or hypothetical management decisions. One could imagine formally identifying groups or clusters of forest owners based on their intrinsic valuation frameworks. Majumdar et al. (2008) conduct a cluster analysis on the 2002–2004 iteration of the NWOS survey data. They identify three owner attitude types – timber, non-timber, and multiple-objective - based on the "reasons for owning" questions of the survey. Alternatively, one could view these reasons for owning as a network of interactions, with the reasons for owning forming the nodes/hubs and the correlations (associations) between them forming the edges/connections. By studying the structural properties of this "signed associa-

[6] In forestry, non-market or non-use values of the forest have long been recognized (see, for example, Hartman's 1976 model, which considers both the harvest and recreational services). However, this is not true for mainstream resource economics, who only recently have explicitly considered non-market values in utility maximization (Barbier 2007; Bertram and Quaas 2016; Shanafelt et al. 2018).

tion matrix", we may understand how the reasons for owning are related to each other (Felipe-Lucia et al. 2020; Kunegis et al. 2010; Schwarz and McGonigle 2011).

In terms of policy, our results highlight socio-demographic traits associated with each reason for owning, which is useful when designing and disseminating information and policy. Take, for example, targeting specific groups of individuals. If we were designing a policy to encourage a shift in management practices to promote endangered species conservation (such as with the U.S. Endangered Species Act), then we could target individuals that *were less likely to value* "protect nature or biodiversity" or "protection or improvement of wildlife habitat" (e.g., owners of multiple properties whom gain larger proportions of their income from their forest). If we wanted to encourage the organization or coordination of individuals who were *more likely to* value biodiversity or wildlife habitat, then we would target the opposite (e.g., in general, more educated owners of single properties who gain less income from their forest). Or, we could target both groups simultaneously, with different outreach materials and policies for each. A similar story exists if we need to target specific groups of individuals, such as to disseminate information regarding the potential risks of invasive species spread associated with the transport of infested firewood. Of course, targeting individuals based on their socio-demographics is a simplistic point of view, as they do not necessarily reflect behavior (Matilainen et al. 2019). However, it does function as a first step towards understanding who is more or less likely to exhibit a certain behavior, which can be used to identify who to target or where to invest resources.

Public policies often aim to produce a mixture of public and private benefits, which resounds well with our findings of family forest owners. Take, for example, tax easement, cost-share, or green certification programs. There exists a large degree of variation in the type of behaviors being incentivized (Butler et al. 2012; Greene et al. 2006; Kilgore et al. 2018; York et al. 2006), such as encouraging more efficient or sustainable timber harvesting, promoting the passing on of land to future generations, or setting aside land for species conservation, biodiversity, or carbon storage. The benefits of these behaviors are both private (benefitting only the owner of the property, like timber harvesting) and public (benefiting others outside the property, such as biodiversity), presumably being targeted to individuals who value those benefits. We find a similar diversity in the reasons family forest owners own their properties (Table 1), and in the demographic and socio-economic characteristics associated with those reasons for owning (Table 2). Family forest owners value a mixture of private (timber, firewood, hunting) and public (protection of nature, biodiversity, water, and wildlife) benefits of the forest, which must be carefully considered when designing, implementing, and ultimately evaluating policies.

As with any statistical study, our model is not without its limitations. We discuss several of these in turn. First, while we believe that we have minimized it, we cannot completely rule out the potential for endogeneity (Cameron and Trivedi 2005; Train 2009). For example, we find that owners enrolled in environmental programs are more likely to give wildlife as reason for owning forests. But one could also argue that they enrolled in the program because they value wildlife habitat. Therefore, one cannot say that the enrollment in environmental programs drives the reason for owning, but only that there is a correlation between reasons for owning and enrollment.

Nor can we eliminate the possibility for omitted variables bias. In future studies, it would be interesting to couple the NWOS with additional explanatory variables such as owner income or awareness of environmental issues, and interaction terms. Few studies explicitly address issues of endogeneity in forest surveys (though see Garcia et al. (2014) for an exception). Further investigation is warranted. Second, our study is restricted to family forest owners in the United States. We know that differences exist between types of proprietors (families, corporations, or NGOs) and individuals of different countries, and it is difficult to generalize our results outside of our study population (though admittedly, it is still quite broad). While we did not see enough variation in the data to justify the inclusion of a state- or county-level random effects, we would expect some heterogeneity across the United States. In future studies, it would be useful to identify at what spatial scale this unobserved heterogeneity becomes more important. Finally, it is worth pointing out that our dependent variables are the *stated* reasons for owning for owning forest property, which is a subtle departure from objectives revealed through actions and behaviors or the behaviors themselves. In other words, saying what one does (stated objectives) can be different from what they actually do (actual behaviors or management practices). Studies have demonstrated discrepancies between stated intentions and actual management practices (Silver et al. 2015) and inconsistencies in survey and re-survey responses (Egan and Jones 1995). For example, a classic example of is that of Karppinen (1998), who survey non-industrial private forest owners in Finland and evaluate their harvesting practices using market data, sales contracts, and forest inventories. After dividing forest owners into different groups depending on their values (multi-objective owners, recreationalists, self-employed owners, investors), they find surprisingly similar rates of actual cuttings across groups. It would be interesting to check for consistency between stated objectives and stated management practices, or – by using the NWOS in combination with the United States Forest Inventory and Analysis (FIA) – stated objectives and actual management practices. The latter is a question seldom addressed in the literature (Silver et al. 2015).

Understanding what, how, and why people value what they do is the foundation for economic valuation of private forests. In this paper, we estimate the forest owner and forest characteristics associated with a suite of reasons for owning forest, identifying their common threads and antitheses. We hope that our study lays the groundwork for a general synthesis of why individuals own forest property.

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Declarations

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Authors and Affiliations

David W. Shanafelt[1] · Jesse Caputo[2,3] · Jens Abildtrup[1] · Brett J. Butler[2,3]

✉ David W. Shanafelt
david.shanafelt@inrae.fr

[1] Université de Lorraine, Université de Strasbourg, AgroParis Tech, Centre National de la Recherche Scientifique (CNRS), Institut National de Recherche pour l'Agriculture, l'Alimentation et l'Environnement (INRAE), Bureau d'Economie Théorique et Appliquée (BETA), 14 Rue Girardet - CS 14216, 54042 Nancy Cedex, France

[2] USDA Forest Service, Northern Research Station, Amherst, MA, USA

[3] Family Forest Research Center, Amherst, MA, USA