Land use and land cover decision-making: An ecosystem services and extreme weather perceptions study of Gulf of Mexico private forest owners

by

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Abstract

The northern Gulf of Mexico has a distinct contrast in land cover between the highly urban coastline and rural and forested areas inland. Regular occurrence of extreme weather events leaves both urban and rural landowners at regular risk of severe damage. One area of particular concern is known as the “Emerald Coast”, and it stretches from Apalachicola Bay to the western edge of the Florida panhandle. In this region, upstream forest landowners have been increasingly deciding to convert their woodland out of forest cover in recent years. The purpose of this project was (1) to investigate the underlying factors which affect private forest owner land use and land cover decisions, (2) to assess risk perceptions of forest professionals and the representation of risks in Emerald Coast newspapers, and (3) to measure private forest owners’ social valuation of the ecosystem services provided by their forests. From July to September 2022, we conducted a quantitative survey of private forest landowners in coastal Alabama and the Florida panhandle. In winter and spring of 2023, we interviewed large scale forest professionals and conducted a content analysis of local and regional newspapers. We found that most of the private forest owner sample planned to retain forest cover for most of their woodland in the next decade, that they did not perceive tropical cyclone patterns to be an important driver of their land use decisions, and we identified several social and ecological factors which influenced decision-making. We found that the large-scale forest professionals and regional newspapers most frequently emphasized socio-political and economic categories of risks, followed by natural hazards, and that the professionals’ risk management strategies were influenced by their levels of risk tolerance and perceived control. Finally, we found that the forest owner sample valued biodiversity higher than all categories of ecosystem services and that the majority of respondents showed interest in incentives for maintaining ecosystem services.

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List of Abbreviations

GOM	Gulf of Mexico
LULC	Land use and land cover
SECAS	Social Ecological Complex Adaptive System(s)
SES	Social Ecological System(s)
PCA	Principal components analysis
EPPM	Extended Parallel Process Model
OR	Odds ratio
FL	Florida
AL	Alabama
S1	Scenario 1
S2	Scenario 2
S3	Scenario 3

Chapter 1. Land use and land cover decision-making: Perceptions of Southeastern coastal private forest owners

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Land use and land cover decision-making: Perceptions of Southeastern coastal private forest owners

Abstract

Across the northern Gulf of Mexico (GOM) coast, upstream private forests provide ecosystem services which support coastal watersheds. Forest landowners may underestimate their forest's impact on the coastal ecosystem, and they have been increasingly deciding to convert their land out of forest cover in recent years. There is limited research on how private forest landowners perceive hurricane activity will influence their land use and land cover (LULC) decisions in the future. We administered a mail survey to a randomly selected population of private forest landowners in coastal Alabama and the Florida panhandle. We found that landowner-stated plans for LULC supported current projections of forest retention in the United States south, that landowners do not perceive increases in hurricane impacts to be major drivers of their LULC decisions, and we identified several characteristics which influence decision-making across hurricane activity scenarios.

Keywords: Decision-making, hurricane perceptions, land use and land cover, private forest landowners, forest retention

Introduction

Forest landowners make decisions to achieve goals set for livelihood or company objectives. These decisions can include selling portions of woodland, converting portions to non-forest uses like crop farming or residential development, or designating portions to conservation programs and agreements, to name a few. Aspects of social structures (e.g., markets, population growth, policy, technology, culture) and environmental context (e.g., climate, hurricanes) are underlying causes of land use and land cover (LULC) change, while landowner decision-making (e.g., agricultural expansion, urban development) lead to the proximate causes (e.g., forest conversion, fragmentation) (H.J. Geist and Lambin 2002; Morse et al. 2013). Climate change uncertainties are not easily quantified in forest management, and forest owners plan for uncertainty in all phases, so the role of climate change, and its subsequent changes to hurricane patterns, on landowner motivations is ambiguous (Vilar et al. 2021). However, climate change remains an underlying cause of decision-making because it impacts the ecological context in which landowners operate. Additionally, changes in social structures like timber markets and population growth influence decision-making because they alter the profitability and economic feasibility of ownership (H.J. Geist and Lambin 2002; Lambin, Geist, and Lepers 2013). These decisions ultimately alter the landscape and ecosystem, but they have not been studied in the context of hurricane patterns across the northern Gulf of Mexico (GOM).

The northern GOM is renowned for its scenic coastlines, but its land use is multifaceted. The region hosts a distinct LULC pattern which is characterized by stark transitions from the urban coastline to rural and forested areas inland. Private forest owners often own timberland (forest active in or capable of wood production) and they populate much of the rural zone. Across the southern United States, the "wood basket" of the nation, private landowners own

approximately 86% of forest land and manage approximately 71% of the nation's planted timberland (B. J. Butler et al. 2021; Oswalt et al. 2019). In Florida and Alabama, 63% and 93%, respectively, of the forest is privately owned, and approximately one-third of the total timberland in each state is planted (B. J. Butler et al. 2021). The planted timberland proportions are consistent with several other southern states, but they are higher than any states in any other region (Oswalt et al. 2019). Because of the composition of forest ownership in this region, landowners are the primary decision-makers, and therefore, the managers and stewards of the forest's role in the surrounding ecosystem. These two states represent the significance of private forests and timberland relative to both regional and national forest cover.

Forest owners have been increasingly deciding to convert their land to pasture or urban use over the past 20 years due to many underlying social and ecological factors (Yang and Liu 2005; D. T. Cohen 2018; Proctor 2017). A co-produced mapping project found that an estimated 17.7 million acres of southern forests are at risk of loss by 2060, largely driven by market and profitability changes due to population increases and urbanization (Greene et al. 2020; Wear and Greis 2013; H.J. Geist and Lambin 2002). Areas with prominent timber markets, like the northern GOM, have higher likelihoods of forest retention; however, small-scale forestry and the importance of non-timber amenities are increasing (Zhang et al. 2009; Greene et al. 2020). Mean holding size of family forestland is shifting from medium sized parcels to smaller parcels, often due to the intergenerational transfer of land from aging landowners, and population growth exacerbates this parcelization (Gruver et al. 2017; Mehmood and Zhang 2001; Zhang et al. 2009). The northern GOM is one of the fastest urbanizing and growing regions in the United States (D. T. Cohen 2018; US Census Bureau 2021). Studying forest conversion across the GOM as population and urbanization (the leading underlying factors for southeastern United States

deforestation (Nagy and Lockaby 2011)) continue to expand is critical as these changes will affect biodiversity, wildlife habitat, coastal watersheds, and overall forest health (H.J. Geist and Lambin 2002; Dale et al. 2000; Lehrter 2006). Parcelization, fragmentation, and rapid or poorly planned development are some of the underlying drivers that change timber markets and land valuation and lead to the decrease of contiguous land cover and amplify the negative impacts of forest loss.

Hurricanes, forest disturbance, and decision-making

Hurricanes, another underlying ecological driver of LULC change, play a role in impacting landowners as they reduce the economic viability of forests with extensive damage (Etters 2019). Large scale forest owners and managers have considered regular hurricane occurrence to be a moderate influence on investment value, however outlier events, like Hurricanes Katrina, Rita, and Michael, can disrupt market pricing and strategies more dramatically (Prestemon and Holmes 2004; Yin and Newman 1996; Stanturf, Goodrick, and Outcalt 2007). It is likely that climate change will amplify tropical cyclone-induced coastal flooding and wind damage across the GOM, increase the proportion of major tropical cyclones, and increase their duration upon impact (Knutson et al. 2021; Marsooli et al. 2019). While climate change is not likely to affect the average global tropical cyclone frequency, human-caused greenhouse gas emissions have contributed to the increase in North Atlantic hurricane activity since 1970 (Sobel et al. 2016). Global hurricane frequency has remained within the range of historic variability, but North Atlantic hurricane frequency has increased while tropical cyclones in some regions of the Indian Ocean and the Pacific Ocean have decreased (Murakami et al. 2020). Another recent study projected that North Atlantic coastal hurricane landfalls are increasing across the northern GOM and the Florida peninsula but decreasing in the northeastern United States (Balaguru et al. 2023).

More outlier impacts to forests would mean more influence on investment value and a shift in the historic management strategies for coastal forests.

The 2017 hurricane season was extremely damaging in the United States with costs exceeding $250 billion due to three Category 4 hurricane landfalls (Blake 2018). The Florida panhandle is still recovering from their first Category 5 landfall in Hurricane Michael in 2018. As a result of Michael, the region is now familiar with the devastation of a direct hit of great magnitude. Direct hits from hurricanes can bring monumental storm surge, especially in regions like the northern GOM developed along shallow shorelines (Halverson 2018). Hurricanes can be disastrous to landowners and lack of insurance or recovery funds can devastate a forest owner. Hurricanes usher further forest disturbances by increasing fuel loads for wildfires and increasing human activities which elevate the risk of the spread of invasive species (van den Burg, Brisbane, and Knapp 2020; Myers and Van Lear 1998). Forest market products drop in price following initial hurricane damage; however, they rise once the demand returns to normal (Henderson et al. 2022). Hurricanes affect markets and forests in a paradox, though, because their impacts on forests are cumulative over the seasons, while markets respond to the single storm events (Henderson et al. 2022). If the intensity of those cumulative events increased over the decades with climate change, landowners may find greater economic risk within forest production or conservation as a livelihood. Climate change and social structure intersect when considering hurricane landfalls, and it is unclear how landowners will respond.

Forest landowner beliefs about the likelihood of a disturbance occurring on their woodland can influence whether they will take mitigating action (Huff et al. 2022). A national study estimated that most adults (72%) believe in climate change, but the estimate for the northern GOM (65%) is lower than the national estimate (Marlon et al. 2021; Howe et al. 2015).

Further estimates for the region showed that 54% of adults are worried about climate change, less than half (47%) attribute climate change to human activity, and fewer still (38%) perceive that they have personally experienced the effects (Howe et al. 2015; Marlon et al. 2021). When people perceive local impacts of climate change, they tend to have higher concern, and when they have higher concern, they indicate more preparedness to engage in mitigating action (Spence, Poortinga, and Pidgeon 2012). A recent study found that less than half of Southeastern forest landowners are implementing recovery or long-term planning strategies for hurricane impacts, and that they often view hurricane damage to timber as inescapable and recovery from the damage ineffective (Weiner et al. 2021). Although anthropogenic climate change skepticism is common across the northern GOM, recent events like Hurricane Michael could impact landowner concerns, and whether they attribute the impacts to climate change. Hurricane activity is a major climate change planning uncertainty, and if landowners do not perceive changes in hurricane regimes due to climate change, nor implement planning or recovery activities, they may not be prepared for the potential alteration to their forest structure and function. Because private landowners maintain most southern forests, and they conduct limited management activities related to hurricanes, it is important to investigate their decision-making given potential changes in the hurricane regime.

Theoretical approach

Private forest ecosystems exemplify the concept that the environment is both a setting for and the result of human interactions, a trademark of Social Ecological Complex Adaptive Systems (SECAS) (Morse et al. 2013). The theoretical building blocks for these systems come from patchwork dynamics and structuration theory (Giddens 1984; Stones 2005; White and Pickett 1985). Patches are discrete spatial patterns within a given landscape and together they

construct a patch mosaic of land cover (White and Pickett 1985). Forest parcels are inherently different patches based on variations in the structure of the forest (e.g., a timber stand versus an unmanaged plot of forestland), but the patch can change more dramatically when a forest owner decides to convert to uses with limited or no tree cover (Pickett, Wu, and Cadenasso 1999). Structuration theory demonstrates that agents' decisions in a social system occur in a recursive process wherein the agent is both the medium and the outcome of an action (Giddens 1984). Complex adaptive systems include interactions between and among agents and the environment, and agents build anticipation capabilities given the recursive nature of a system (Holland 1992; Manson 2001; Rindfuss et al. 2008). SECAS theory integrates these social and ecological perspectives to encompass agent-structure interactions within an ecological framework and allows investigation of linked social systems and biophysical patterns, like LULC change (Morse et al. 2013).

Both the social system and the patch mosaic of land cover are external structures. The landowners and their livelihoods (social) and the patches (ecological) are the internal structures, and LULC change is the action (social) and/or disturbance (ecological). Previous studies on landowners identified age (Gruver et al. 2017), gender (S. M. Butler et al. 2017), absenteeism (i.e., not residing on forest) (Snyder et al. 2020), personal obligation to forest (Pradhananga and Davenport 2022), previous experience with and perceptions of conservation (Mook and Dwivedi 2023; Kreye et al. 2021), and concern level for ecological factors like invasive species (Clarke et al. 2023) as internal social structures influencing decision-making. SECAS theory illustrates that LULC change happens in a complex adaptive system wherein landowners make decisions due to resource, structural, and opportunity influences while the decisions made, in return, impact those drivers of LULC (Lambin, Geist, and Lepers 2013; Morse et al. 2013).

Coastal SECAS have high capacity for resilience and recovery to disaster, however, climate change erodes such capacity and landowners may not perceive the changes in their own capacity for resilience (Adger et al. 2005). Previous research targeting private forests and hurricanes across the GOM has primarily focused on mapping potential LULC changes (Greene et al. 2020; Yang and Liu 2005), communication (Mike et al. 2020; Weiner et al. 2021), opportunities and challenges for resilience (Mcconnell and Shmulsky 2009; Wiener, Álvarez-Berríos, and Lindsey 2020), timber market economics (Henderson et al. 2022; Prestemon and Holmes 2004; Prestemon and Holmes 2010; Susaeta, Carter, and Adams 2014), invasive species (Clarke et al. 2023), and wildfire (Clarke et al. 2023; Myers and Van Lear 1998). These studies primarily address economic and biophysical dimensions of hurricane impacts, and while some address decision-making implications for hurricane management strategies (Clarke et al. 2023; Wiener, Álvarez-Berríos, and Lindsey 2020), there is minimal study on landowner perceptions of future hurricane activity related to LULC decision-making. The purpose of this study was to investigate (1) planned LULC decisions across northern GOM private forest land and (2) the impacts of socioecological factors in driving LULC decision-making related to potential future hurricane activity.

Methods

Study site

We identified eleven counties as the study site across the northern GOM, specifically in Alabama (one county) and the Florida panhandle (ten counties) (Figure 1). This region is renowned for the scenery of its coastal waters (it is also known as the "Emerald Coast") and there were ten federal policy-relevant watersheds (Hydrologic Unit Code-8) whose boundaries encompassed the counties (U.S. Department of Agriculture 2008). While we were not studying watershed

perceptions, we considered this study region to be relevant for practical implications in policy and biodiversity (Greene et al. 2020; Nagy et al. 2012). Landowners in upstream systems often don't connect impact of their forest cover to the coastal watershed, so studying LULC change within watershed boundaries is important to inform policy decision-makers on how and where to support landowners for conducive maintenance of watershed services (Armstrong and Stedman 2020; Kenter et al. 2015; Davis, Asah, and Fly 2015).

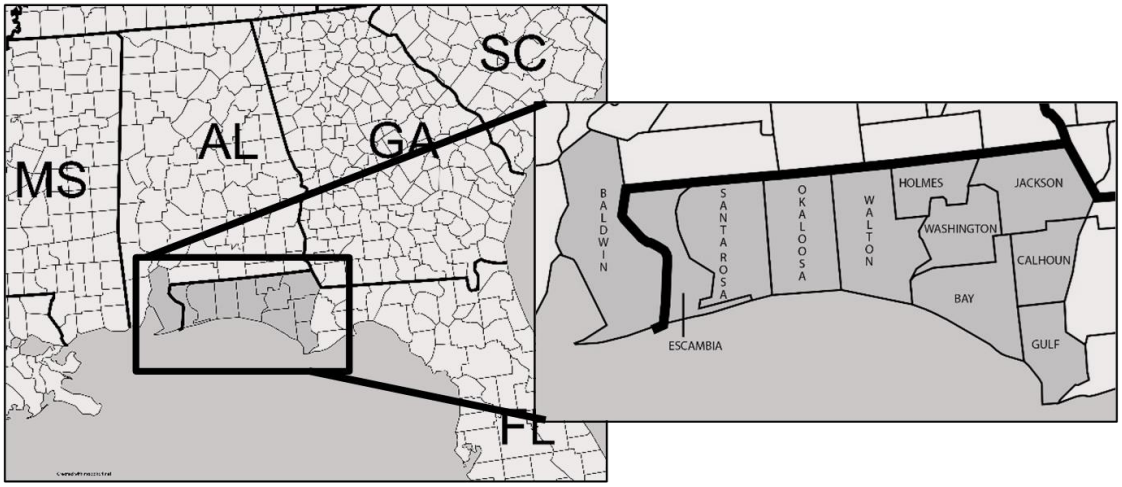

Figure 1. Study site map. Respondent sample identified via the county tax appraisal office information from each of the pictured counties (N = 11). Thin black lines demarcate county boundaries and bold black lines demarcate state boundaries.

Data collection

From July to September 2021, we conducted a mail survey using a modified Tailored Design Method (Dillman, Smyth, and Christian 2009; Vaske 2008). Mail survey response rates have continuously declined since the 1970s and a recent study projected an average response rate under 30% by 2025 (Stedman et al. 2019). Rates tend to be lower when either (1) a population is not specific or (2) a study area is broad (Stedman et al. 2019). There were three points of contact

with recipients: First, the survey packet and introduction letter, then a reminder postcard, then a final reminder letter. These letters are available in Appendix B. To attempt to increase response rates reduce non-response bias, the final reminder letter included instructions for the option to take the survey online, allowing respondents to complete the survey using their preferred (and most accessible) method (Millar and Dillman 2011). Recipients were also encouraged to contact us to request a new copy for any reason, if necessary. Our study investigates a specific population over a moderately broad geographic area. We targeted a subpopulation of forest owners to investigate potential for conversion to other land uses, along with the underlying market, policy, and environmental factors. Using public county tax appraiser information, we identified all timberland owners of parcels of at least 50 acres, with no maximum parcel size, within the study area and randomly reduced the sample down to 3000 landowners to receive surveys. After adjusting for undeliverable packets, we determined that 2885 landowners received surveys.

The questions in this survey elicited landowner characteristics, current land uses, history with and interest in conservation, perceptions of hurricane risk (including potential increases in frequency, strength, and wind damage) and underlying influences on decision-making (e.g., timber markets, forest policy), and a forest decision-making assessment. The decision-making assessment included three hurricane frequency scenarios: (S1) Remain the same as the previous two decades, (S2) increase by 25%, and (S3) increase by 50%, and landowners indicated LULC decisions (to sell, convert, and/or conserve woodland) in the given contexts. Appendix A depicts the full questionnaire used in this study. We designed the questionnaire with tropical cyclone frequency as an indicator of hurricane risk for three reasons. First, while climate change will not likely change the average global frequency of tropical cyclones, there has been a trend of

increasing landfalls in the northern GOM since 1970, and that trend has been projected to continue due to wind steering and tropospheric circulation patterns (Balaguru et al. 2023; Sobel et al. 2016). We illustrated that trend when introducing the decision-making questionnaire (Appendix A). For simplicity, we refer to the tropical cyclone scenarios as "hurricane scenarios" for the remainder of the chapter. Next, two recent years (2017 and 2020) were record breaking years for the frequency of named storms and people tend to make decisions based on the most recent information available (Rudiawarni, Made Narsa, and Tjahjadi 2020; Sundali and Rachel Croson 2006). Finally, given that individuals in our study region were less likely to believe in climate change than the national average, and that in the Southeast, forest landowners with lower acceptance of anthropogenic climate change view researchers less favorably if they discuss the topic, we determined the risk of non-response bias due to reactions to climate change topics to be a higher risk than using frequency as an indicator for hurricane risk in the questionnaire (Florida Department of State 2023; Hamilton et al. 2015; Krantz and Monroe 2016; Marlon et al. 2021). All survey materials and methods were approved by the Auburn University Office of Human Subjects Research Institutional Review Board Protocol #20-271 EX 2007 prior to mailing.

Data analysis

To evaluate the influence of the underlying market factors ("markets") and the importance of personal responsibility in landowner management goals ("responsibility"), we created two aggregated scales. We used principal components analysis (PCA) and Cronbach's α reliability analysis to confirm that our aggregated scale variables were reliably representing predictor variables. The purpose of the PCA was to confirm the items loaded together to explain the variance of a concept in each scale and Cronbach's α determined internal reliability (i.e., if a respondent rated one item in a scale highly, they likely rated another item in the scale highly) for

each scale (Harpe 2015; Shrestha 2021; Sijtsma 2009). For PCA, we reviewed the correlation matrix for any potential multicollinearity ($r > 0.800$, $r < -0.800$), and we conducted the analysis using oblique rotation and interpreted the component matrix. For Cronbach's α, we determined any $\alpha > 0.650$ and $\alpha > 0.800$ to represent a scale with acceptable or strong internal reliability, respectively (DeVellis 2016; Vaske 2008).

We conducted a Wilcoxon Sign Rank test on the reported proportion of LULC change (sell, convert, conserve) given the different decision-making options across the three scenarios. The data violated the assumptions for parametric testing and did not have characteristics well suited to justify the use of pairwise *t*–tests by robustness alone, so while we reported means, we assessed individual differences in proportion of LULC change by this non-parametric test and the subsequent effect size (Scheff 2016; Kim 2015; Kühberger et al. 2015). For Cohen's *d* effect size, we interpreted $d < 0.200$ as very small, $d > 0.200$ as small, $d > 0.500$ as medium, and $d > 0.800$ as large (J. Cohen 1988)

We conducted a multinomial logistic regression (MLR) to investigate the effect of different predictors on the odds on each combination of decisions for three hurricane activity scenarios. SECAS theory and previously identified underlying and proximate causes of forest LULC dictated logit model variable selection (Geist and Lambin 2002; Lambin, Geist, and Lepers 2013; Morse et al. 2013). We verified that there was no multicollinearity between the factors (for all, VIF < 2.000). Each dependent variable represents a discrete combination of decisions given the hurricane scenarios, and we interpreted the odds ratios for each predictor's effect on the likelihood of a given decision compared to making no LULC changes (Hair et al. 2010). Odds ratios above one indicated that a predictor increased the odds of selecting a specific LULC decision combination, as opposed to the decision of no LULC changes, and odds ratios

below one indicated decreased odds, (i.e., 1.000 = 0% increase/decrease in the odds of selecting a decision). We conducted all statistical analyses with SPSS statistical software.

Results

There were 565 returned surveys, 541 of which were usable, yielding a response rate of 19%. To assess non-response bias, we compared our respondent characteristics to the most recent National Woodland Owner Survey data for the Southeast and Alabama; however, the Appendix for Florida was unavailable (B. J. Butler et al. 2021). We found that 96% of our sample were family forest owners, meaning individuals, joint ownerships, family partnerships, trusts, and/or estates who own woodland. This is about a 35% overrepresentation, so our findings should be interpreted in the context of family forests (B. J. Butler et al. 2021). Our respondent composition of age, gender, and residence were all representative of the range for family forest owners in the Southeast and Alabama (B. J. Butler et al. 2021). For family forest owners with at least 50 acres, 75% in the Southeast and 70% in Alabama own less than 200 acres, and for our respondents, 60% own less than 200 acres, so our sample may be over representative of landowners with over 200 acres (B. J. Butler et al. 2021). However, 80% of our sample (Southeast = 90% and Alabama = 88%) owns less than 445 acres, so it is likely that our sample overrepresents family forest owners with 200-500 acres (B. J. Butler et al. 2021). We did not draw conclusions with land size as a predictor for the following analysis.

Confirmatory PCA and reliability

Our aggregated predictor variables were appropriate for PCA (KMO > 0.500; Bartlett's Sphericity test, $p < 0.001$), and the PCA results confirmed that our markets scale and our responsibility scale each extracted only one component, meaning each scale described the variance for a single concept (for both scales, Eigenvalue > 1). The responsibility scale exhibited

acceptable (α = 0.786) internal reliability and the markets scale displayed strong (α = 0.907) internal reliability. Table 1 depicts the descriptive results for these scales, including individual items and aggregated variables.

Table 1. Descriptive information for decision-making perceptions relative to storm factors, "markets," and "responsibility."

	Variable	Mean	Standard Deviation
Markets[1]	Change in forest product market prices	3.064	1.976
	Change in environmental regulations	3.221	1.968
	Change in woodland tax incentives	3.555	2.171
	Prices in other agricultural markets	2.733	1.866
	Subsidies for land uses other than forestry	2.908	1.883
	Aggregated	3.110	1.698
Storm increases[1]	Frequency of hurricanes	2.479	1.720
	Strength/intensity of hurricanes	2.625	1.837
	Wind damage to forest	2.874	1.929
Responsibility[2]	Forest conservation	5.499	1.688
	Being a forester is one of my responsibilities to my family	3.956	2.146
	Being a forester is one of my responsibilities to my community	3.806	2.064
	Beauty and scenery	5.469	1.736
	Aggregated	4.693	1.519

[1] = Agreement (on a 7-point scale) that the factor would influence the respondent's decision to sell or convert some or all of their woodland.
[2] = Importance (on a 7-point scale) of the item in the respondent's woodland management goals.

Decision-making under hurricane scenarios

The results for landowner characteristics and past activities showed that the average age of the responding landowners was 68 (σ = 2.51), that 77% were male, 36% had their primary residence within a mile of their woodland, 27% had additional land on which they profited from non-timber agricultural activities such as crop farming or cattle ranching, and 14% had designated some woodland in conservation in the past decade (Table 2).

On average (on a 7-point scale), landowners were moderately concerned (M = 4.56, σ = 1.82) about future hurricanes and their potential damage to their woodland, moderately interested (M = 4.97, σ = 2.06) in potential incentives for maintaining forest ecosystem services and rated

Table 2. Descriptive information for hurricane scenario decision-making predictors.

Predictor	Descriptor	Proportion or mean (σ)
Age	Mean (σ)	68 (11.194)
Gender	Female	22%
	Male	78%
Own any land that is farmed or ranched	Yes	27%
	No	73%
Resident	Yes, home is within 1 mile of woodland	35-36%
	No, home is not within 1 mile of woodland	64-65%
Designated any land in conservation in the past decade	Yes	13%
	No	87%
Level of concern for future hurricane damage to woodland	Mean (σ), 7-point scale	4.56 (1.824)
	No - Low concern (rating < 4)	28%
	Moderate - High concern (rating ≥ 4)	72%
Interest in potential incentives for maintaining ecosystem services	Mean (σ), 7-point scale	4.97 (2.060)
	None - Not very interested (rating < 4)	21%
	Interested - Very interested (rating ≥ 4)	79%

N = 414 – 422, depending on the scenario. Proportions rounded to the nearest whole percentage are static across scenarios.

their responsibility to forest and community as important (*M* = 4.78, σ = 1.50; Table 2). They slightly disagreed that market factors may influence their decision to sell or convert their woodland in the future (*M* = 3.14, σ = 1.71). They also disagreed that an increase in the number of hurricanes (*M* = 2.48, σ = 1.72), increased strength of hurricanes (*M* = 2.63, σ = 1.84), and/or an increase in wind damage (*M* = 2.87, σ = 1.93) to their forest would influence their decision to sell or convert in the future (Table 1). These three storm variables were all highly correlated with each other ($r > 0.700$).

Across all three hurricane scenarios, we found that 48% of landowners had no plans to sell, convert, or conserve any portion of their woodland. Connecting this with landowners who only planned to conserve woodland without selling or converting any portion, across all scenarios, 50-56% (depending on the scenario) plan to keep all their land in forest cover. The other 44-50% of landowners planned to sell or convert some portion of their woodland in the next decade (Figure 2). The ascending mean percentage of woodland which landowners would be likely to sell or convert given scenarios one, two, and three were 27%, 30%, and 36%, respectively (Figure 3). Therefore, the average landowner planned to retain 64-73% of their

woodland in the next decade. The percentage of woodland they would likely place in conservation remained relatively static for the ascending scenarios: 22%, 22%, and 23% (Figure 3).

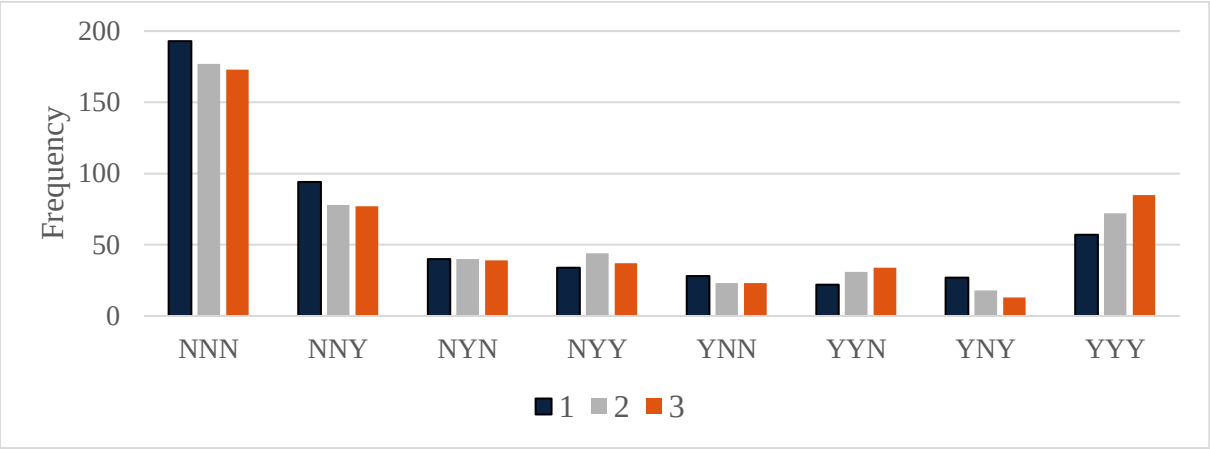

Figure 2. Frequencies of decisions organized by hurricane scenarios.

Listwise: Scenario 1 *N* = 422, Scenario 2 *N* = 415 Scenario 3 *N* = 414. For all "Decisions," N = 0% of forest indicated for decision in next decade, Y = <0% of forest indicated for decision in the next decade. Each X abbreviation is in the sequence sold, converted, conserved, e.g., NNN = No land sold, no land converted, no land placed in conservation.

Mean decision-making comparisons across hurricane scenarios

The results of the Wilcoxon Sign Rank test showed that there was a statistically significant increase in the proportion of land sold from S1 to S2 (z = -2.759, p = 0.006), from S1 to S3 (z = -4.814 , p < 0.001), and from S2 to S3 (z = -6.030, p < 0.001). However, for all comparisons of land sold, the effect sizes were very small or small (S1-S2, d = 0.132; S1-S3, d = 0.200; S2-S3, d = 0.288) and 80% (S1-S2), 76% (S1-S3), and 83% (S2-S3) of pairs were ties.

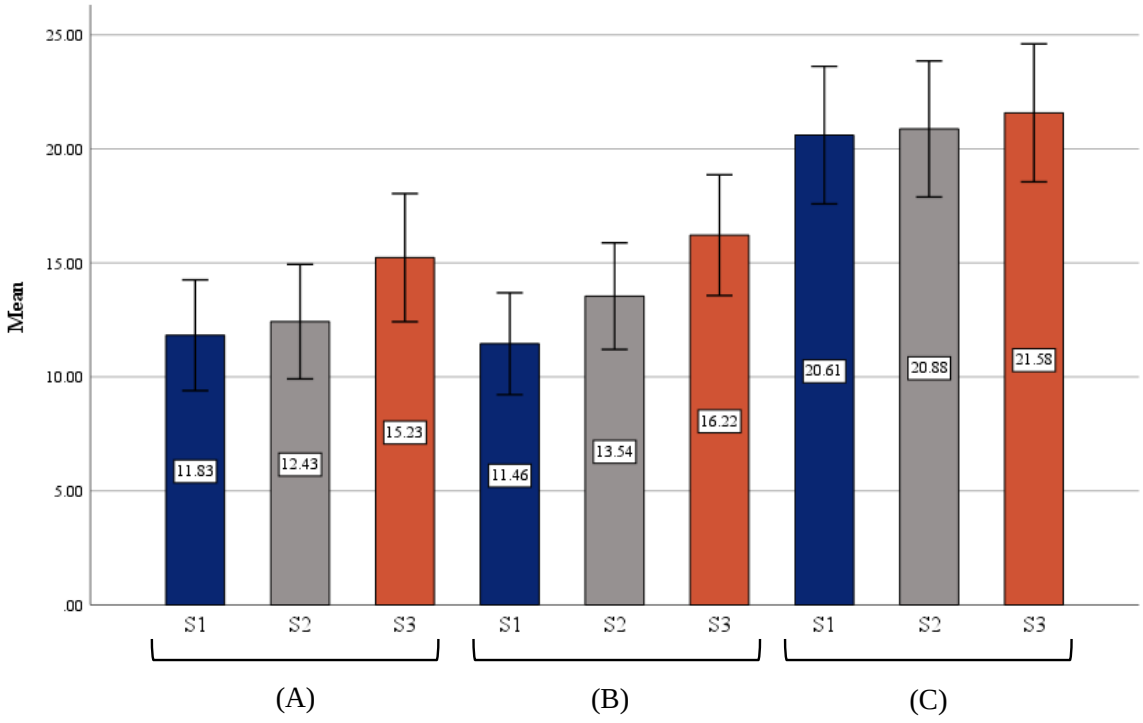

Figure 3. Mean (± 2S.E.) proportion of forest LULC changes for all respondents. Forest retention was calculated by subtracting the mean percent forest sold and converted from 100. (A) = % woodland sold, (B) = % woodland converted, (C) = % woodland conserved.

The results also showed that there was a statistically significant increase in the proportion of land converted from S1 to S2 (z = -5.247, p < 0.001), from S1 to S3 (z = -7.003 , p < 0.001), and from S2 to S3 (z = -5.308, p < 0.001). The effect size was small, but more moderate than the others, for the increase in conversion from S1 to S3 (d = 0.33). However, for all other comparisons of land converted, the effect sizes were small (S1-S2, d = 0.249; S2-S3, d = 0.252) and 75% (S1-S2), 70% (S1-S3), and 75% (S2-S3) of pairs were ties.

Finally, the results the results showed that there was a statistically significant increase in the proportion of land placed in conservation in only one case: From S2 to S3 (z = -2.688, p = 0.008). However, the effect size was very small (d = 0.128) and 83% of pairs were ties.

Scenario 1: No increase in hurricane activity

The results showed that the MLR model variables were a good fit for predicting the decision-making outcomes, with the reference category set as no LULC changes, in S1 (Nagelkerke's R^2 = 0.451, X^2 = 243.180, $p < 0.001$; Table 3). The summary results for S1 showed that 46% of respondents planned to make no LULC changes, 22% planned to conserve woodland without converting or selling any portion, 14% planned to sell, convert, and conserve woodland, and no more than 10% of respondents chose any other course of LULC action (Figure 2).

Age, gender, residence, recent conservation, markets, responsibility, and incentives interest all had statistically significant impacts on the odds of landowner decisions given S1 (for all, $p < 0.050$; Table 3). For each 1 year increase in age, the odds of respondents deciding to make LULC changes, except for solely selling a portion or selling in tandem with conservation, decreased by 3-7%. For male landowners, there was a 53% decrease in the odds of choosing to place a portion of forest in conservation without selling or converting any. For landowners residing on woodland, there was a 73% decrease in the odds of selecting to concurrently sell and convert some woodland and a 57% decrease in the odds of selecting to sell, convert, and conserve. If respondents recently conserved some woodlands, the odds of them choosing to solely conserve woodland or conserve and convert a portion (without selling any) increased by 252% or 370%, respectively. For each 1 point increase in the rating of the influence of market factors on decision making, the odds of choosing all actions including selling and/or converting some woodland increased by 40% to 88%, and there was no statistically significant impact of market factors on choosing to solely convert some woodland. For each 1 point increase in respondents' responsibility as forest owners, the odds of them choosing to solely conserve woodland increased (by 35%) and the odds of them choosing to take all LULC action decreased

(by 24%). For each 1 point increase in interest in potential conservation incentives, there were increased odds (29%-71%) of them choosing any options which included conserving a portion of woodland, and there was no statistically significant impact on the odds of choosing to sell and/or convert without conserving woodland.

Scenario 2: Moderate (25%) increase in hurricane activity

The results showed that the MLR model variables were a good fit for predicting the decision-making outcomes, with the reference category set as no LULC changes, in S2 (Nagelkerke's R^2 = 0.490, X^2 = 268.804, $p < 0.001$; Table 3). The summary results for S2 showed that fewer respondents (43%) relative to S1 planned to make no LULC changes and fewer planned to conserve woodland (19%) without converting or selling any portion (Figure 2). More respondents (17%) planned to sell, convert, and conserve, more respondents (11%) planned to convert some woodland along with some conservation, and no more than 10% of respondents chose any combination of decisions (Figure 2).

Age, gender, residence, recent conservation, markets, responsibility, and incentives interest, and level of concern all had statistically significant impacts on the odds of landowner decisions given S2 (for all, $p < 0.050$; Table 3). Increasing age also significantly decreased the odds of most LULC change for S2 (4-10%) with the addition of decreasing the odds of selling in tandem with conserving woodland (6%). Age still did not significantly impact the odds of deciding to sell without any other actions. Male landowners still had decreased odds of placing a forest solely in conservation (55%) relative to female landowners. Residents had decreased odds of selling their woodland with no other actions (80%) and taking all LULC change action (57%). Respondents who recently conserved woodland still had increased odds of solely conserving woodland (267%), but this no longer significantly impacted their odds of choosing to convert

and conserve woodland in tandem. Increasing ratings of market factors (39-96%) and incentives interest (30-84%), significantly increased the odds of the same decisions as S1. Responsibility still increased the odds (29%) of respondents solely conserving woodland and decreased the odds (24%) of respondents taking all LULC action, but it additionally decreased the odds (28%) of landowners selling and converting woodland in tandem under S2. Landowner concern for future hurricane damage to their woodland increased the odds (28%) of choosing to take all LULC change action (sell, convert, and conserve in tandem).

Scenario 3: Extreme (50%) increase in hurricane activity

The results showed that the MLR model variables were a good fit for predicting the decision-making outcomes, with the reference category set as no LULC changes, in S3 (Nagelkerke's R^2 = 0.462, X^2 = 247.977, $p < 0.001$; Table 3). The summary results for S3 showed that, similar to S2, 42% of respondents planned to make no LULC changes, 19% planned to conserve woodland without converting or selling any portion, 21% (the highest of the scenarios) planned to sell, convert, and conserve, and no more than 10% of respondents chose any other course of LULC action (Figure 2).

Age, gender, residence, recent conservation, markets, and incentives interest all had statistically significant impacts on the odds of landowner decisions given S3 (for all, $p < 0.050$; Table 3). Increasing age decreased the odds of the same LULC decisions as in S1 (4-9%), and again, did not significantly impact the odds of solely selling a portion or selling in tandem with conservation. Gender affected the odds the same as both other scenarios (male = 55% decrease for solely conserving), residents had decreased odds (51%) of taking all LULC change action. Respondents who recently conserved woodland had increased odds of solely conserving (239%). Increasing ratings of market factors increased the odds of fewer decisions than the other

scenarios and no longer had a statistically significant impact on the odds of deciding to sell with no other action or sell in tandem with some conservation. The decisions for which market factors still increased the odds (28-88%) were the same as the other two scenarios. Increasing interest in conservation incentives increased the odds (39-74%) of the same decisions as both other scenarios. Whether landowners owned land that they farmed or ranched was not a significant predictor for decision-making across all scenarios.

Table 3. Odds ratios of the multinomial logistic regression model for hurricane scenarios.

		Predictors								
Decisions	Scenario	Age[1]	Gender[2]	Farm/ranch[2]	Resident[2]	Recent Conservation[2]	Market[1]	Responsibility[1]	Concern[1]	Incentive Interest[1]
NNY	1	0.971*	0.486*	1.017	0.652	3.520**	1.049	1.347*	0.926	1.513***
	2	0.961*	0.446*	0.932	0.752	3.666**	1.017	1.291*	1.013	1.543***
	3	0.963*	0.448*	1.131	0.696	3.391*	0.963	1.136	1.062	1.652***
NYN	1	0.940***	1.181	2.173	0.793	1.482	1.793***	0.910	1.143	0.849
	2	0.896***	0.998	2.090	0.573	2.396	1.842***	0.977	1.270	0.984
	3	0.909***	1.672	2.250	0.787	1.991	1.683***	0.945	1.203	0.935
NYY	1	0.946**	0.680	1.853	1.136	4.698**	1.397*	1.242	0.857	1.293*
	2	0.917***	0.595	1.973	1.075	2.167	1.394**	1.213	0.930	1.565***
	3	0.932***	0.687	2.117	1.381	1.724	1.284*	1.126	0.954	1.544***
YNN	1	1.011	1.015	0.539	0.333	1.875	1.509**	0.757	1.002	0.935
	2	0.963	0.750	0.171	0.204*	1.359	1.697**	0.718	1.298	0.866
	3	0.980	0.792	0.171	0.323	0.620	1.392	0.762	1.128	0.965
YYN	1	0.934**	0.786	1.908	0.696	0.969	1.882***	0.924	1.190	0.858
	2	0.919***	0.876	0.415	0.482	0.415	1.961***	0.716*	1.270	0.919
	3	0.934***	0.720	0.664	0.414	1.728	1.861***	0.807	1.221	0.947
YNY	1	0.987	1.701	2.086	0.269*	1.561	1.512**	0.757	1.338	1.711**
	2	0.941*	0.913	1.594	0.324	2.065	1.464*	0.915	1.435	1.837*
	3	0.955	1.063	0.574	0.525	1.578	1.243	0.921	1.514	1.741*
YYY	1	0.957**	0.672	0.687	0.430*	1.173	1.848***	0.758*	1.195	1.419**
	2	0.944***	0.769	0.849	0.446*	1.277	1.919***	0.763*	1.276*	1.289*
	3	0.947***	0.721	0.832	0.490*	1.237	1.878***	0.804	1.156	1.392*

[1] = Continuous variable, [2] = Categorical variable.
N = 0% of forest indicated for decision in next decade, Y = <0% of forest indicated for decision in the next decade.
For all "Decisions," where X = Y or N, e.g., NNN = 0% sold, 0% converted out of forest, 0% designated in conservation.
Reference category: NNN.
*Statistically significant at 5%, **Statistically significant at 1%, ***Statistically significant at 0.1%. OR: Odds Ratio.
If OR > 1.000, (OR – 1.000) * 100 = % increase in odds; If OR < 1.000, (1.000 – OR) * 100 = % decrease in odds.

Discussion

The results from this study expanded the research base on planned LULC decision-making across the northern GOM's private forests. The responses demonstrated novel understanding of landowners' perceived long-term forest retention, the range of that retention based on potential hurricane patterns, personal and structural factors which influence the likelihood of various

LULC decisions, and how the statistical significance of some of these factors varied based on potential hurricane patterns.

Forest risk and retention perceptions

Across all hurricane scenarios, nearly half of landowners indicated that they plan to retain their entire forest in the next decade, and on average, they indicated that they would retain 64-73% of their forest. These results support recent projections for forest retention in the southern United States. which indicated that approximately 65% of forest was high or very high likelihood for retention by 2030 (Greene et al. 2020). The same study found that 69% of Alabama's forest had high or very high retention likelihood and that 75% of Florida's forest shared the same likelihood; additionally, they concluded that regions with more prominent timber markets displayed higher likelihood of retention (Greene et al. 2020). Our findings based on landowner perceptions of individual forest retention supported geospatial projections and furthered our understanding of individual drivers of decision-making.

While we found most of the private forest in the sample is likely to be retained through 2031, this implies approximately a quarter is at risk of conversion even with no assumed changes in hurricane patterns. Other researchers (Greene et al. 2020) have identified our study region as a high biodiversity area at risk of fragmentation and development, so understanding the projections and drivers of forest loss is paramount (Mehmood and Zhang 2001; Zhang et al. 2009). We found statistically significant relative increases in the average proportion of land at risk of sale or conversion as hurricane scenarios increased in severity; however, even in S3, the risk did not convey more than 1% deviation from recent retention projections (Greene et al. 2020) and the effect sizes of the increases were small. Another study conducted in the same period as ours found that, on average, non-industrial private forest landowners living in the counties most

affected by Hurricane Michael were unlikely to sell, convert, or pass on their forest land in the future, and there was not a statistically significant relationship between these decisions and whether they experienced timber damage from the hurricane (Clarke et al. 2023). We observed that higher risk hurricane scenarios had a small effect size on decision-making even though more than half of the counties in our study region experienced damage from Hurricane Michael. However, both our results and those of Clarke et al. (2023) did not directly investigate how forest landowner perceptions may have changed because of Michael, regardless of damage experienced, or how they may be impacted if another severe hurricane made landfall soon. Forest landowners may consider the potential for a shortened return period to be an amplified risk to their capacity for salvage and recovery (Wiener, Álvarez-Berríos, and Lindsey 2020; Brandeis et al. 2012; Henderson et al. 2022). Future research should investigate perceptions of the different aspects of storm damage (e.g., effective recovery of downed timber, reduced storm return periods, self-efficacy for mitigation) and how they influence decision-making.

Factors driving forest decision-making

Landowner demographics demonstrated a few patterns of influence on decision-making across all scenarios. Older landowners and resident landowners were less likely to choose to sell or convert a portion of their woodland than younger or absentee landowners, respectively. Age had the smallest effect on decision-making odds; however, it significantly affected the odds of more decision classes than any variable other than market factors. Older landowners were also less likely to place woodlands in conservation, but age did not impact the odds of respondents deciding to sell land with no other action, so older landowners may just be less likely to make management intensive-LULC changes overall. The population in the study region is older (B. J. Butler et al. 2021), and aging has been identified as a leading factor in forest parcelization and

fragmentation (Gobster and Rickenbach 2004; Gruver et al. 2017), which means understanding the intergenerational transfer of woodland is urgent for preventing fragmentation (Mehmood and Zhang 2001; Stone and Tyrrell 2012), especially considering our findings that younger respondents were more likely to decide to sell and/or convert portions of woodland. We also found that absentee landowners were more likely to sell their woodland, but the concurrent LULC decisions they would make in tandem with sale depended on the scenario. They were more likely than resident landowners to take all LULC change action (sell/convert/conserve in tandem) across all scenarios, but they were also more likely to sell with no other action under S2, and more likely to sell and conserve land in tandem under S1. Absentee landowners have often been identified as less likely to undertake certain forest management activities (like invasive species management or reducing wildfire fuels) (Snyder et al. 2020), but they have also been found to be more likely to enroll in tax programs (Fortney, Arano, and Jacobson 2011) or enroll woodland in conservation easements (LeVert, Stevens, and Kittredge 2009), which aligns with our results showing their higher likelihood for conserving in tandem with other choices. Age and residential location affected the likelihood of LULC decisions, but there was some variation in decisions given the hurricane scenarios.

Gender was only significant for one decision class, however, female respondents were at least twice as likely as male respondents to decide to only conserve woodland across all scenarios. Our sample population was predominantly male, which is representative of forest owners in general (B. J. Butler et al. 2021). However, the proportion of female private forest landowners is increasing, often due to inheritance from a spouse, and in Alabama, female landowners tend to be less involved in management and have less access to information and support (B. J. Butler et al. 2016; S. M. Butler et al. 2017; Schelhas et al. 2012). Our results were

consistent with a study which found that female forest landowners in Georgia were concerned about forest conservation, and they, like Alabama female forest landowners, wanted or needed to learn more about forest management to achieve their goals (Mook and Dwivedi 2023; Schelhas et al. 2012). Internal social structures like age and/or gender can affect a person's access to resources, information, or opportunities (Kondrat 2002). We did not investigate whether female landowners in this Florida/Alabama coastal region felt that they lacked information, support, or preparation for forest management, so future research should specifically study female forest landowners in this region given that we found some similarities to research in the surrounding area.

Interest in incentives and recent conservation activity had mostly static influences on the likelihood of decisions across the scenarios. Landowners with recent conservation activity had the highest affect size out of any of the predictors and significantly increased the likelihood of respondents deciding to conserve some forest across all scenarios; however, under S1, landowners with recent conservation were also more likely to convert some woodland along with conservation. The trends in decision-making likelihood were similar for landowners with higher ratings of interest in conservation incentives; however, they also were more likely to sell and conserve land in tandem or to take all LULC change action. Participation in conservation incentives programs has previously been found to be influenced by factors like landowner dependence on forest, personal obligation, and self-efficacy (or confidence in making a difference) (Mook and Dwivedi 2023; Pradhananga and Davenport 2022). Our survey included a responsibility factor that resembled personal obligation, and high responsibility ratings displayed higher likelihood to choose to only conserve woodland, but unlike the past and potential conservation activity factors, higher responsibility also displayed lower likelihood to choose to

choose to sell and convert woodland. Responsibility was not a significant factor for any decisions in S3, though, so in an extreme scenario, risk may begin to outweigh responsibility. The average landowner in our study planned to convert or sell some portion of woodland, but if they had history with or interest in conservation decisions, they were still more likely to decide to conserve woodland alongside other activities, and if they had high values of responsibility attached to their forest, they were less likely to choose to sell and convert under stable or moderate hurricane activity increases.

Ratings for market factors and concern for future hurricane damage to woodland had various influences on the likelihood of decisions. Across all scenarios, landowners who rated market factors as higher influences on their decision-making were more likely to decide to convert (including options to sell and/or conserve in tandem) some woodland. They were also more likely to sell their woodland solely (or sell in tandem with conservation); however, market factors no longer significantly influenced these decisions given S3. In the southern United States, forest owners expect hurricane impacts, and economic studies have found that while timber damage affects prices in the short run, in the long run these prices typically rebound due to the short supply and high demand for timber (Henderson et al. 2022; Prestemon and Holmes 2010). However, hurricanes can compound the risk of further costly disturbances (i.e., wildfires due to increased fuel loads and invasive species die to human traffic for relief activities) which impact landowner financial risks past market factors (Myers and Van Lear 1998; van den Burg, Brisbane, and Knapp 2020). Because market factors lost some significance of effect on the likelihood of decisions given S3, forest owners may be worried about the cumulative effect which more hurricane damage could have on their timber and the markets.

Respondents' level of concern was only significant in increasing the likelihood of respondents selling, converting, and conserving forest in tandem given S2. This was contrary to our expectations given that the average respondent was moderately concerned about future hurricane damage to their woodland. It was also contrary to a previous study found that people with higher concern for climate change are more likely to take action to mitigate its effects (Spence, Poortinga, and Pidgeon 2012), and while our results show that respondents with higher concern for hurricane damage decided to take more LULC change action given S2, it seems likely that they are not seeking to mitigate environmental impacts, but to mitigate economic losses. One limitation of our scenario assessment it that it is possible that a respondent's belief about the likelihood of a scenario could impact their indicated decision-making, causing concern to play a smaller role in decision-making, but we did not measure belief (Huff et al. 2022). Landowner perceptions of market influences and their concern for future hurricane damage to their woodland did not have similar patterns of influence in decision-making, in fact level of concern only had a minimal influence, but their demonstrated decision-making across the scenarios were consistent with their reported influence of market factors. Also, ratings for market factors lost significant influence on the likelihood of some decisions given S3, so like the responsibility factor, an extreme increase in hurricane activity may outweigh market factors in decision-making.

Implications for policy and research

Our results provide novel insights into how the influence of factors affecting private forest landowner decision-making may fluctuate given future hurricane activities. We observed a disconnect between the scenario results and the descriptive results of landowners' ratings of the potential influence of increases in hurricane frequency, strength and/or intensity, and wind

damage. For the scenarios, on average, landowners perceived that increasing hurricane activity influences decision-making, but the effect is small, and for the descriptive ratings landowners rated hurricane frequency, strength, and wind damage to have similar levels of influence on decision-making, but on average, they rated all factors as low influence. Effective risk communication can increase how people view the relevance of climate change risks, but if a study population is biased towards climate change topics, we can communicate risk in the context of climate change symptoms (e.g., hurricane activity) for which they have concern (Spence, Poortinga, and Pidgeon 2012). In the future, however, studies like these should assess more specific risks associated with hurricanes which are projected by climate models, such as severity of timber damage, return periods, direct hits, and infrastructure disruption (Stanturf, Goodrick, and Outcalt 2007; Weiner et al. 2021; Hendrickx, Vlek, and Oppewal 1989; Sobel et al. 2016). A researcher could design a similar assessment given these other symptoms regardless of interpretation or belief of changing hurricane frequency/intensity patterns (Halverson 2018).

Identifying factors which influence decision-making can inform policy decision-makers about which characteristics and priorities may be supported to prevent forest conversion and/or increase conservation (Adhikari et al. 2021). These findings are important for assessing risks to biodiversity, watersheds, and the coastal ecosystem in general (Ford et al. 2011; Alvarenga et al. 2017; Lehrter 2006). Our results support previous research which demonstrated that policy decisions geared toward forest resilience and management for climate change should support timber market stability and reduce regulatory and/or economic burdens on private forest owners (Martin et al. 2017). The public in the southeast United States has also showed support for policy which empowers forest landowners, rather than regulating them, but public indifference towards forest management also appears to be increasing (Kreye, Rimsaite, and Adams 2019).

Additionally, previous research found that the importance of non-timber amenities of forests is increasing, and policy decision-makers must be wary of shifting goals because constructive policy to support landowner goals helps prevent costly objections to decisions (Kenter et al. 2015; Zhang et al. 2009).

In the lens of SECAS, we found that of the underlying factors influencing LULC decisions, timber and agricultural market factors (external social structure) played a more explicit role in decision-making than hurricane activity (external ecological structure) (Geist and Lambin 2002; Morse et al. 2013). However, these structures cannot be separated in a coastal SECAS. With the projected increase in hurricane intensity due to climate change, and the potential regional increase in landfalls across the northern GOM, it is likely that hurricanes' impacts on markets, as well as other costly disturbances, will increase (Balaguru et al. 2023; Henderson et al. 2022; Myers and Van Lear 1998; van den Burg, Brisbane, and Knapp 2020). Internally, age, gender, absenteeism, recent conservation activities, responsibility attached to forest, concern about future hurricane damage (to a lesser extent), and interest in potential conservation incentives all influenced the likelihood of LULC decisions. It will be important for policy decision-makers in the region to consider such factors as they consider methods to prevent parcelization and fragmentation in this high biodiversity region.

Conclusion

External factors in decision-making, such as hurricanes and timber markets, can drive LULC change in SECAS. Our study found that market factors widely influenced landowner decision-making and supported current projections for the proportion of forest retention likely by 2030 and we provided insights into the factors which influence the likelihood of private forest fragmentation. Our findings for significant predictors echoed previous research and depicted

pertinent directions for future research. We found that landowners do perceive that potential changes in hurricane activity will influence their decisions to sell or convert portions of their woodland; however, the effect size of the scenarios was small. There was also some variation in the influence of internal and external factors on decision-making given the most extreme hurricane scenario, so hurricane activity may influence decision-making more than landowners perceived, and future assessments should investigate other aspects of hurricane patterns like direct hits. Our research is primarily useful for policy decision-makers, forest owner consulting networks, extension professionals, and private forest landowner researchers.

References

Adger, W. Neil, Terry P. Hughes, Carl Folke, Stephen R. Carpenter, and Johan Rockström. 2005. 'Social-Ecological Resilience to Coastal Disasters'. Science 309 (5737): 1036–39. https://doi.org/10.1126/SCIENCE.1112122.

Adhikari, Ram K., Robert K. Grala, Stephen C. Grado, Donald L. Grebner, and Daniel R. Petrolia. 2021. 'Landowner Concerns Related to Availability of Ecosystem Services and Environmental Issues in the Southern United States'. Ecosystem Services 49 (June): 101283. https://doi.org/10.1016/J.ECOSER.2021.101283.

Alvarenga, Lívia Alves, Carlos Rogério de Mello, Alberto Colombo, and Luz Adriana Cuartas. 2017. 'Hydrologic Impacts Due to the Changes in Riparian Buffer in a Headwater Watershed'. CERNE 23 (1): 95–102. https://doi.org/10.1590/01047760201723012205.

Armstrong, Andrea, and Richard C. Stedman. 2020. 'Thinking Upstream: How Do Landowner Attitudes Affect Forested Riparian Buffer Coverage?' Environmental Management 65 (5): 689–701. https://doi.org/10.1007/S00267-020-01271-Y/TABLES/3.

Balaguru, Karthik, Wenwei Xu, Chuan Chieh Chang, L. Ruby Leung, David R. Judi, Samson M. Hagos, Michael F. Wehner, James P. Kossin, and Mingfang Ting. 2023. 'Increased U.S. Coastal Hurricane Risk under Climate Change'. Science Advances 9 (14). https://doi.org/10.1126/SCIADV.ADF0259/SUPPL_FILE/SCIADV.ADF0259_SM.PDF.

Blake, Eric S. 2018. 'Atlantic Hurricane Season: Catastrophic Losses and Costs' 71 (3): 28–37. https://doi.org/10.1080/00431672.2018.1448147.

Brandeis, Thomas J, Andrew J Hartsell, James W Bentley, and Consuelo Brandeis. 2012. 'Economic Dynamics of Forests and Forest Industries in the Southern United States'. USDA Forest Service. www.srs.fs.usda.gov.

Burg, Matthijs P. van den, Jeanelle L.K. Brisbane, and Charles R. Knapp. 2020. 'Post-Hurricane Relief Facilitates Invasion and Establishment of Two Invasive Alien Vertebrate Species in the Commonwealth of Dominica, West Indies'. Biological Invasions 22 (2): 195–203. https://doi.org/10.1007/S10530-019-02107-5/TABLES/2.

Butler, Brett J., Sarah M. Butler, Jesse Caputo, Jacqueline Dias, Amanda Robillard, and Emma M. Sass. 2021. 'Family Forest Ownerships of the United States, 2018: Results from the USDA Forest Service, National Woodland Owner Survey'. General Technical Report NRS-199. Madison, WI: U.S. Department of Agriculture, Forest Service, Northern Research Station. https://doi.org/10.2737/NRS.

Butler, Brett J., Jaketon H. Hewes, Brenton J. Dickinson, Kyle Andrejczyk, Sarah M. Butler, and Marla Markowski-Lindsay. 2016. 'Family Forest Ownerships of the United States, 2013: Findings from the USDA Forest Service's National Woodland Owner Survey'. Journal of Forestry 114 (6): 638–47. https://doi.org/10.5849/jof.15-099.

Butler, Sarah M., Emily S. Huff, Stephanie A. Snyder, Brett J. Butler, and Mary Tyrrell. 2017. 'The Role of Gender in Management Behaviors on Family Forest Lands in the United States'. Journal of Forestry, April. https://doi.org/10.5849/jof.2016-076r2.

Clarke, Mysha, Ajay Sharma, Taylor Stein, Jason Vogel, and Jarek Nowak. 2023. 'Forest Disturbances and Nonindustrial Forest Landowners: Management of Invasive Plants, Fire Hazards and Wildlife Habitats after a Hurricane'. Journal of Forestry fvad022 (June). https://doi.org/10.1093/jofore/fvad022.

Cohen, Darryl T. 2018. 'Coastline County Population Continues to Grow'. U.S. Census Bureau. 2018.

Cohen, Jacob. 1988. Statistical Power Analysis for the Behavioural Sciences. NJ: Lawrence Earlbaum Associates. New York, NY: Routledge Academic.

Dale, Virginia H., Linda A. Joyce, Steve McNulty, and Ronald P. Neilson. 2000. 'The Interplay between Climate Change, Forests, and Disturbances'. Science of The Total Environment 262 (3): 201–4. https://doi.org/10.1016/S0048-9697(00)00522-2.

Davis, Miriam L E Steiner, Stanley T Asah, and J Mark Fly. 2015. 'Family Forest Owners' Forest Management Understandings: Identifying Opportunities and Audiences for Effective Outreach and Education'. Forest Science 61 (1): 105–13. https://doi.org/10.5849/forsci.13-014.

DeVellis, R. F. 2016. Scale Development: Theory and Applications. Los Angeles, CA: Sage Publications. https://www.worldcat.org/title/scale-development-theory-and-applications/oclc/953860312?referer=di&ht=edition.

Dillman, Don A., Jolene D. Smyth, and Leah M. Christian. 2009. Internet, Phone, Mail, and Mixed-Mode Surveys: The Tailored Design Method. 4th ed. Hoboken, NJ: Wiley & Sons.

Etters, Karl. 2019. 'Timber Farms in Florida, Georgia Suffering After Hurricane Michael'. Insurance Journal. 2019.

Florida Department of State. 2023. 'Voter Registration - By County and Party'. Florida Division of Elections. 2023.

Ford, Chelcy R, Stephanie H Laseter, Wayne T Swank, and James M Vose. 2011. 'Can Forest Management Be Used to Sustain Water-Based Ecosystem Services in the Face of Climate Change?' Ecological Applications 21 (6): 2049–67.

Fortney, Jennifer, Kathryn G. Arano, and Michael Jacobson. 2011. 'An Evaluation of West Virginia's Managed Timberland Tax Incentive Program'. Forest Policy and Economics 13 (1): 69–78. https://doi.org/10.1016/J.FORPOL.2010.08.002.

Geist, H.J., and E.F. Lambin. 2002. 'Proximate Causes and Underlying Driving Forces of Tropical Deforestation'. BioScience 52 (2): 143–50.

Giddens, Anthony. 1984. The Constitution of Society: Outline of the Theory of Structuration. Cambridge: Polity Press.

Gobster, Paul H., and Mark G. Rickenbach. 2004. 'Private Forestland Parcelization and Development in Wisconsin's Northwoods: Perceptions of Resource-Oriented Stakeholders'. Landscape and Urban Planning 69 (2–3): 165–82. https://doi.org/10.1016/J.LANDURBPLAN.2003.09.005.

Greene, Rachel E., Kristine O. Evans, Michael T. Gray, D. Todd Jones-Farrand, and William G. Wathen. 2020. 'Using a Coproduction Approach to Map Future Forest Retention Likelihood in the Southeastern United States'. Journal of Forestry 118 (1): 28–43. https://doi.org/10.1093/JOFORE/FVZ063.

Gruver, Joshua B., Alexander L. Metcalf, Allyson B. Muth, James C. Finley, and A. E. Luloff. 2017. 'Making Decisions About Forestland Succession: Perspectives from Pennsylvania's Private Forest Landowners'. Society and Natural Resources 30 (1): 47–62. https://doi.org/10.1080/08941920.2016.1180728.

Hair, J, WC Black, BJ Babin, and RE Anderson. 2010. Multivariate Data Analysis. 7th ed. Upper Saddle River, NJ: Pearson Educational International.

Halverson, Jeffrey B. 2018. 'The Costliest Hurricane Season in U.S. History'. Weatherwise 71 (2): 20–27. https://doi.org/10.1080/00431672.2018.1416862.

Hamilton, Lawrence C., Joel Hartter, Mary Lemcke-Stampone, David W. Moore, and Thomas G. Safford. 2015. 'Tracking Public Beliefs about Anthropogenic Climate Change'. PLoS ONE 10 (9). https://doi.org/10.1371/journal.pone.0138208.

Harpe, Spencer E. 2015. 'How to Analyze Likert and Other Rating Scale Data'. Currents in Pharmacy Teaching and Learning. Elsevier Inc. https://doi.org/10.1016/j.cptl.2015.08.001.

Henderson, Jesse D., Robert C. Abt, Karen L. Abt, Justin Baker, and Ray Sheffield. 2022. 'Impacts of Hurricanes on Forest Markets and Economic Welfare: The Case of Hurricane Michael'. Forest Policy and Economics 140 (July): 102735. https://doi.org/10.1016/J.FORPOL.2022.102735.

Hendrickx, Laurie, Charles Vlek, and Harmen Oppewal. 1989. 'Relative Importance of Scenario Information and Frequency Information in the Judgement of Risk'. Acta Psychologica 72: 41.

Holland, John. 1992. 'Complex Adaptive Systems'. Daedalus 121 (1).

Howe, Peter D., Matto Mildenberger, Jennifer R. Marlon, and Anthony Leiserowitz. 2015. 'Geographic Variation in Opinions on Climate Change at State and Local Scales in the USA'. Nature Climate Change 5 (6): 596–603. https://doi.org/10.1038/nclimate2583.

Huff, Emily S., Angela de Oliveira, Ezra M. Markowitz, Meaghan L. Guckian, and Lauren Lomonoco. 2022. 'Family Forest Owner Perceptions of Wildfire and Invasive Pest Risk: The Role of Interpersonally-Produced Risks'. International Journal of Disaster Risk Reduction 83. https://doi.org/10.1016/j.ijdrr.2022.103417.

Kenter, Jasper O., Liz O'Brien, Neal Hockley, Neil Ravenscroft, Ioan Fazey, Katherine N. Irvine, Mark S. Reed, et al. 2015. 'What Are Shared and Social Values of Ecosystems?'

Ecological Economics 111 (March): 86–99. https://doi.org/10.1016/J.ECOLECON.2015.01.006.

Kim, Tae Kyun. 2015. 'T Test as a Parametric Statistic'. Korean Journal of Anesthesiology 68 (6): 540–46. https://doi.org/10.4097/kjae.2015.68.6.540

Knutson, Thomas R, Maya V Chung, Gabriel Vecchi, Jingru Sun, Tsung-Lin Hsieh, and Adam J P Smith. 2021. 'Climate Change Is Probably Increasing the Intensity of Tropical Cyclones'. Critical Issues in Climate Change Science, ScienceBrief Review. https://doi.org/10.5281/zenodo.4570334

Kondrat, Mary Ellen. 2002. 'Actor-Centered Social Work: Re-Visioning "Person-in-Environment" through a Critical Theory Lens'. Social Work 47 (4). https://doi.org/10.1093/sw/47.4.435.

Krantz, Shelby A, and Martha C Monroe. 2016. 'Message Framing Matters: Communicating Climate Change with Forest Landowners'. https://doi.org/10.5849/jof.14-057.

Kreye, Melissa M, Damian C Adams, José R Soto, Sophia Tanner, and Renata Rimsaite. 2021. 'Economic and Ethical Motivations for Forest Restoration and Incentive Payments'. Society and Natural Resources 34 (8): 1093–1110. https://doi.org/10.1080/08941920.2021.1938320.

Kreye, Melissa M., Renata Rimsaite, and Damian C. Adams. 2019. 'Public Attitudes about Private Forest Management and Government Involvement in the Southeastern United States'. Forests 10 (9). https://doi.org/10.3390/f10090776.

Kühberger, Anton, Astrid Fritz, Eva Lermer, and Thomas Scherndl. 2015. 'The Significance Fallacy in Inferential Statistics Psychology'. BMC Research Notes 8 (1). https://doi.org/10.1186/s13104-015-1020-4.

Lambin, Eric M., Helmut J. Geist, and Erika Lepers. 2013. 'Dynamics of Land-Use and Land-Cover Change in Tropical Regions'. Annu. Rev. Environ. Resour. 28: 205–41. https://doi.org/10.1146/annurev.energy.28.050302.105459.

Lehrter, John C. 2006. 'Effects of Land Use and Land Cover, Stream Discharge, and Interannual Climate on the Magnitude and Timing of Nitrogen, Phosphorus, and Organic Carbon Concentrations in Three Coastal Plain Watersheds'. Water Environment Research 78 (12): 2356–68. https://doi.org/10.2175/106143006X102015.

LeVert, Michael, Thomas Stevens, and Dave Kittredge. 2009. 'Willingness-to-Sell Conservation Easements: A Case Study'. Journal of Forest Economics 15 (4): 261–75. https://doi.org/10.1016/J.JFE.2009.02.001.

Manson, Steven M. 2001. 'Simplifying Complexity: A Review of Complexity Theory'. Geoforum 32 (3): 405–14. https://doi.org/10.1016/S0016-7185(00)00035-X.

Marlon, J, L Neyens, M Jefferson, P Howe, Matto Mildenberger, and A Leiserowitz. 2021. 'Yale Climate Opinion Maps 2021'. Yale Program on Climate Change Communication. 2021.

Marsooli, Reza, Ning Lin, Kerry Emanuel, and Kairui Feng. 2019. 'Climate Change Exacerbates Hurricane Flood Hazards along US Atlantic and Gulf Coasts in Spatially Varying Patterns'. Nature Communications 10, 3785. https://doi.org/10.1038/s41467-019-11755-z.

Martin, Timothy, Damian Adams, Matthew Cohen, Raelene Crandall, Carlos Benecke-Gonzalez, Jason Smith, and Jason Vogel. 2017. 'Managing Florida's Plantation Forests in a Changing Climate'. In Florida's Climate: Changes, Variations, & Impacts. https://doi.org/10.17125/fci2017.ch09.

Mcconnell, T Eric, and Rubin Shmulsky. 2009. 'The Effects of Hurricane Katrina on the Structure, Performance, Capacity, and Future of the Lumber Industry in the United States Gulf States'. Journal of Forest Products and Business Research 6. https://hdl.handle.net/11668/14902

Mehmood, Sayeed R., and Daowei Zhang. 2001. 'Forest Parcelization in the United States'. Journal of Forestry 99 (4): 30–34. https://academic.oup.com/jof/article/99/4/30/4614372.

Mike, Moses R., Shelli D. Rampold, Ricky W Telg, and Angela B. Lindsey. 2020. 'Utilizing Extension as a Resource in Disaster Response: Florida Extension's Communication Efforts during the 2017 Hurricane Season'. Journal of Applied Communications 104 (1). https://doi.org/10.4148/1051-0834.2308.

Millar, Morgan M., and Don A. Dillman. 2011. 'Improving Response to Web and Mixed-Mode Surveys'. Public Opinion Quarterly 75 (2). https://doi.org/10.1093/poq/nfr003.

Mook, Anne, and Puneet Dwivedi. 2023. 'Shifting Forest Landownership Interests over the Life-Course of Female Forest Landowners in Rural Georgia, United States'. Journal of Rural Studies 100 (May). https://doi.org/10.1016/j.jrurstud.2023.103008.

Morse, Wayde C, William J Mclaughlin, J D Wulfhorst, Celia Harvey, W C Morse, W J Mclaughlin, and C Harvey. 2013. 'Social Ecological Complex Adaptive Systems: A Framework for Research on Payments for Ecosystem Services'. Urban Ecosystems 16: 53–77. https://doi.org/10.1007/s11252-011-0178-3.

Murakami, Hiroyuki, Thomas L. Delworth, William F. Cooke, Ming Zhao, Baoqiang Xiang, and Pang Chi Hsu. 2020. 'Detected Climatic Change in Global Distribution of Tropical Cyclones'. Proceedings of the National Academy of Sciences of the United States of America 117 (20): 10706–14. https://doi.org/10.1073/PNAS.1922500117/SUPPL_FILE

/PNAS.1922500117.SAPP.PDF.

Myers, Richard K., and David H. Van Lear. 1998. 'Hurricane-Fire Interactions in Coastal Forests of the South: A Review and Hypothesis'. Forest Ecology and Management 103 (2–3). https://doi.org/10.1016/S0378-1127(97)00223-5.

Nagy, R. Chelsea, and B. Graeme Lockaby. 2011. 'Urbanization in the Southeastern United States: Socioeconomic Forces and Ecological Responses along an Urban-Rural Gradient'. Urban Ecosystems 14 (1): 71–86. https://doi.org/10.1007/s11252-010-0143-6.

Nagy, R. Chelsea, B. Graeme Lockaby, Latif Kalin, and Chris Anderson. 2012. 'Effects of Urbanization on Stream Hydrology and Water Quality: The Florida Gulf Coast'. Hydrological Processes 26 (13). https://doi.org/10.1002/hyp.8336.

Oswalt, Sonja N., W. Brad Smith, Patrick D. Miles, and Scott A. Pugh. 2019. 'Forest Resources of the United States, 2017'. Gen. Tech. Rep. WO-97. Washington, DC: U.S. Department of Agriculture, Forest Service, Washington Office. https://doi.org/10.2737/WO-GTR-97.

Pickett, S T A, Jianguo Wu, and M L Cadenasso. 1999. 'Patch Dynamics and the Ecology of Disturbed Ground: A Framework for Synthesis'. In Ecosystems of Disturbed Ground, edited by L. R. Walker, 707–22. Amsterdam: Elsevier.

Pradhananga, Amit K., and Mae A. Davenport. 2022. '"I Believe I Can and Should": Self-efficacy, Normative Beliefs and Conservation Behavior'. Journal of Contemporary Water Research & Education 175 (1): 15–32. https://doi.org/10.1111/j.1936-704x.2021.3370.x.

Prestemon, Jeffrey P, and Thomas P Holmes. 2004. 'Market Dynamics and Optimal Timber Salvage After a Natural Catastrophe'. Forest Science 50 (4). https://academic.oup.com/forestscience/article/50/4/495/4617260.

Prestemon, Jeffrey P., and Thomas P. Holmes. 2010. ‘Economic Impacts of Hurricanes on Forest Owners’. General Technical Report PNW-GTR-802. Vol. 2.

Proctor, C. 2017. ‘Pasture-Ized: Hundreds of Thousands of Northwest Florida Acres Go from Timber to Pasture’. 2017. https://www.floridatrend.com/article/22916/pasture-ized-hundreds-of-thousands-of-northwest-florida-acres-go-from-timber-to-pasture.

Rindfuss, Ronald R, Barbara Entwisle, Stephen J Walsh, Li An, Nathan Badenoch, Daniel G Brown, Peter Deadman, et al. 2008. ‘Land Use Change: Complexity and Comparisons’. Journal of Land Use Science 3 (1): 1–10. https://doi.org/10.1080/17474230802047955.

Rudiawarni, F A, I Made Narsa, and B Tjahjadi. 2020. ‘Are Emotions Exacerbating the Recency Bias?: An Experimental Study’. International Journal of Trade and Global Markets 13 (1): 61–70.

Scheff, Stephen W. 2016. ‘Nonparametric Statistics’. In Fundamental Statistical Principles for the Neurobiologist, 157–82. Academic Press. https://doi.org/10.1016/B978-0-12-804753-8.00008-7.

Schelhas, John, Yaoqi Zhang, Robert Zabawa, and Bin Zheng. 2012. ‘Exploring Family Forest Landowner Diversity: Place, Race, and Gender in Alabama, Unites States’. International Journal of Social Forestry (IJSF) 5 (1): 1–21.

Shrestha, Noora. 2021. ‘Factor Analysis as a Tool for Survey Analysis’. American Journal of Applied Mathematics and Statistics 9 (1): 4–11. https://doi.org/10.12691/ajams-9-1-2.

Sijtsma, Klaas. 2009. ‘On the Use, the Misuse, and the Very Limited Usefulness of Cronbach’s Alpha’. Psychometrika 74 (1): 107–20. https://doi.org/10.1007/s11336-008-9101-0.

Snyder, Stephanie A., Zhao Ma, Kristin Floress, and Mysha Clarke. 2020. ‘Relationships between Absenteeism, Conservation Group Membership, and Land Management among

Family Forest Owners'. Land Use Policy 91 (February). https://doi.org/10.1016/j.landusepol.2019.104407.

Sobel, Adam H., Suzana J. Camargo, Timothy M. Hall, Chia Ying Lee, Michael K. Tippett, and Allison A. Wing. 2016. 'Human Influence on Tropical Cyclone Intensity'. Science 353 (6296): 242–46. https://doi.org/10.1126/SCIENCE.AAF6574.

Spence, Alexa, Wouter Poortinga, and Nick Pidgeon. 2012. 'The Psychological Distance of Climate Change'. Risk Analysis 32 (6): 957–72. https://doi.org/10.1111/J.1539-6924.2011.01695.X.

Stanturf, John A., Scott L. Goodrick, and Kenneth W. Outcalt. 2007. 'Disturbance and Coastal Forests: A Strategic Approach to Forest Management in Hurricane Impact Zones'. Forest Ecology and Management 250 (1–2): 119–35. https://doi.org/10.1016/J.FORECO.2007.03.015.

Stedman, Richard C., Nancy A. Connelly, Thomas A. Heberlein, Daniel J. Decker, and Shorna B. Allred. 2019. 'The End of the (Research) World As We Know It? Understanding and Coping With Declining Response Rates to Mail Surveys'. Society and Natural Resources 32 (10): 1139–54. https://doi.org/10.1080/08941920.2019.1587127.

Stone, Rebecca Sanborn, and Mary L Tyrrell. 2012. 'Motivations for Family Forestland Parcelization in the Catskill/Delaware Watersheds of New York'. Journal of Forestry 110 (5): 267–74. https://doi.org/10.5849/jof.11-015.

Stones, Rob. 2005. Structuration Theory. London, ENG: Red Globe Press.

Sundali, James, and Rachel Croson. 2006. 'Biases in Casino Betting: The Hot Hand and the Gambler's Fallacy'. Judgement and Decision Making 1 (1): 1–12.

Susaeta, Andres, Douglas R. Carter, and Damian C. Adams. 2014. 'Impacts of Climate Change on Economics of Forestry and Adaptation Strategies in the Southern United States'. Journal of Agricultural and Applied Economics 46 (2). https://doi.org/10.1017/s1074070800000778.

US Census Bureau. 2021. 'Annual Estimates of the Resident Population for the United States, Regions, States, District of Columbia, and Puerto Rico: April 1, 2020 to July 1, 2021'. 2021.

U.S. Department of Agriculture, Natural Resources Conservation Service. 2008. 'General Index Map of Hydrologic Units in Florida'.

Vaske, J. J. 2008. Survey Research and Analysis: Applications in Parks, Recreation, and Human Dimensions. State College, PA: Venture Publishing.

Vilar, L., S. Herrera, E. Tafur-García, M. Yebra, J. Martínez-Vega, P. Echavarría, and M. P. Martín. 2021. 'Modelling Wildfire Occurrence at Regional Scale from Land Use/Cover and Climate Change Scenarios'. Environmental Modelling and Software 145 (November). https://doi.org/10.1016/j.envsoft.2021.105200.

Wear, David N., and John G. Greis. 2013. 'The Southern Forest Futures Project: Technical Report'. Gen. Tech. Rep. SRS-GTR-178. Asheville, NC: USDA-Forest Service, Southern Research Station. 542 p. Vol. 178. Asheville, NC. https://www.srs.fs.usda.gov/pubs/44183.

Weiner, Roberta, Sarah P. Church, Junyu Lu, Laura A. Esman, Jackie M. Getson, Michelle Fleckenstein, Brennan Radulski, et al. 2021. 'Climate Change Coverage in the United States Media during the 2017 Hurricane Season: Implications for Climate Change

Communication'. Climatic Change 164 (3–4): 1–19. https://doi.org/10.1007/S10584-021-03032-0/TABLES/5.

White, P. S., and S. T.A. Pickett. 1985. 'Natural Disturbance and Patch Dynamics: An Introduction'. The Ecology of Natural Disturbance and Patch Dynamics, January 3–13. https://doi.org/10.1016/B978-0-08-050495-7.50006-5.

Wiener, Sarah S., Nora L. Álvarez-Berríos, and Angela B. Lindsey. 2020. 'Opportunities and Challenges for Hurricane Resilience on Agricultural and Forest Land in the U.S. Southeast and Caribbean'. Sustainability (Switzerland) 12 (4). https://doi.org/10.3390/su12041364.

Yang, Xiaojun, and Zhi Liu. 2005. 'Using Satellite Imagery and GIS for Land-Use and Land-Cover Change Mapping in an Estuarine Watershed'. International Journal of Remote Sensing 26 (23): 5275–96. https://doi.org/10.1080/01431160500219224.

Yin, Runsheng, and David Newman. 1996. 'The Effect of Catastrophic Risk on Forest Investment Decisions'. Journal of Environmental Economics and Management 31 (2): 186–97. https://doi.org/10.1006/jeem.1996.0040

Zhang, Yaoqi, X Liao, Brett J. Butler, and John Schelhas. 2009. 'The Increasing Importance of Small-Scale Forestry: Evidence from Family Forest Ownership Patterns in the United States'. Small-Scale Forestry 8: 1–14. https://doi.org/10.1007/s11842-008-9050-6.

Chapter 2. Drivers of Southeastern land cover change: A mixed-methods study of risk perceptions in the timber industry

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Drivers of Southeastern land cover change: A mixed-methods study of risk perceptions in the timber industry

Abstract

In the southern United States, woodland investment value is important to private forest landowners who own most of the region's forest cover. Cumulative damage from frequent disturbances can reduce the economic viability of forest ownership. Disturbances occur naturally in forest ecosystems, but the way they alter the forest structure is amplified when they occur outside their natural range of variation. Hurricane damages have increased in costliness since the 1980s and researchers expect hurricanes to increase in intensity due to climate change. The purpose of this study was to develop an understanding of how forest professionals perceive hurricane risk, what strategies they use to manage for risks, and to compare these findings to the news media's representation of risk to private forests. We also sought to understand how forest professionals developed their understanding of risk and appropriate mitigations strategies. We conducted a mixed-methods study to investigate these ideas at the regional scale across the northern Gulf of Mexico. We identified economic, socio-political, and environmental themes surrounding the discussion of issues which drive changes in forest management and land cover. We also found that large scale forest professionals described their strategies related to hurricane risks in the context of their lack of perceived control of storms and varied risk tolerance. Our findings highlight important considerations for outreach and education related to management for hazards with widespread perceptions of low control.

Keywords: Hurricane risk, risk tolerance, risk communication, private forest management, newspaper content analysis

Introduction

Forests support the environment through functions such as carbon storage and water filtration, but they also provide recreation opportunities, natural scenery, and revenue through timber products. Disturbances occur naturally in forest ecosystems, but when they occur outside their natural range of variation, they can inflict extreme changes to forest structure and function (Dale et al. 2000; 1998). Fire, drought, introduced species, insect and pathogen outbreaks, hurricanes, and windstorms are all major forest disturbances, but hurricanes are the most important natural forest disturbance in eastern North America (Dale et al. 2000; A. Fischer, Marshall, and Camp 2013). Some natural tree cover loss occurs following disturbances, but human-induced factors (i.e., increasing wildfire fuel loads by failing to remove woody debris, invasive species incursion due to increased presence of humans and equipment) interact with and can amplify the effects on forest structure and function (Dale et al. 2000; Stanturf, Goodrick, and Outcalt 2007).

In the United States south, private landowners hold approximately 86% of forests, and most of these landowners consider investment value important (Sass et al. 2021; Butler et al. 2021). Hurricanes account for over half of the billion-dollar disaster events in the United States (Viinikainen 2021). Timber values drop following disturbances, but the prices fluctuate and typically increase enough to offset losses in the long-term; however, cumulative damage from frequent disturbances can reduce the economic viability of forest ownership (Henderson et al. 2022; Prestemon and Holmes 2010; Brandeis et al. 2012). These natural disturbances and facets of the social systems (e.g., regulations, market fluctuations, population, demographics) they interact with are the underlying drivers of land use and land cover (LULC) change (i.e., loss of forest cover) in Social Ecological Systems (SES) (Morse et al. 2013; Geist and Lambin 2002; Ban et al. 2013; A. P. Fischer 2018). Regions with high concentrations of private forests

exemplify SESs because landowners interact with the social and ecological conditions and processes which in turn influence management and landscapes (A. P. Fischer 2018). How landowners manage the risks associated with disturbances like hurricanes has implications for the entire SES.

Landowners operate within a realm of uncertainty, and they consistently plan and work through market and policy variation, but climate change effects add novel sources of variability and uncertainty (Blennow 2012; Khanal et al. 2016). Researchers expect that climate change will increase the intensity and destructive potential of hurricanes which adds significant uncertainty to future disturbances for landowners (Emanuel 1987; 2005; Marsooli et al. 2019; Hayhoe et al. 2018; Lugo 2008; Knutson et al. 2021). Uncertainty in management is further compounded because landowners experience amplified effects of disturbances based on the outcomes of management and/or recovery activities on neighboring forest patches (e.g., a neighbor does not reduce fuel loads following hurricanes, therefore wildfires may become more severe adjacent to an owner's property) which can accumulate based on the frequency and scale of the decisions (Epanchin-Niell and Wilen 2010; Epanchin-Niell et al. 2010; Pickett, Wu, and Cadenasso 1999; A. P. Fischer 2018). Large scale forest professionals have historically considered hurricane damages to offset over time due to timber market fluctuation and therefore only exert moderate risk to investment (Prestemon and Holmes 2010; Stanturf, Goodrick, and Outcalt 2007; Henderson et al. 2022; Susaeta, Carter, and Adams 2014). However, recent outlier events, like major Gulf Coast hurricanes Ivan (2004), Katrina (2005), Rita (2005), and Michael (2018), impacted forest products markets and recovery strategies more dramatically. Timber products do not typically qualify for disaster relief through the United States Department of Agriculture, but there was a novel Block Grant relief funding program following Hurricane Michael which

designated $800 million to cover losses to agricultural producers (including timber owners) in Alabama, Florida, and Georgia (USDA Farm Service Agency 2019). If the proportion of outlier events increased, so too does the disruption to the SES, so novel policies like the Block Grant could be significant for landowner capacity to maintain forest cover.

Environmental stressors like severe hurricanes trigger individuals to evaluate risk, form a perception, and make decisions about their response strategies (Bell 2001; Reser and Swim 2011). Risk perceptions of environmental stressors are characterized by an individual's assessment of the threat and their understanding of possible coping strategies (Reser and Swim 2011; Bell 2001). Personal beliefs affect perceptions of climate change risk and its subsequent effects on weather patterns (Stedman 2004; Spence, Poortinga, and Pidgeon 2012). Previous studies found that forest owners' likelihood to manage and respond to risk are related to their perceptions and concerns (i.e., their level of worry about perceived susceptibility to risk-related damages) about the risk (Stårdal, Lien, and Hardaker 2007; Blennow and Sallnäs 2002; Peek and Mileti 2002; Eriksson 2014). When forest owners have high risk perception, personal levels of risk tolerance and perceived control affect what form of response or mitigation they take (Eriksson 2014). Landowners may prepare for or conduct management activities to reduce a hazard's impacts, or they may abandon the hazardous area (A. P. Fischer 2011). Higher risk perceptions trigger responses to risk, but risk mitigation responses vary based on the perceived controllability of the risk in question.

Individuals who share similar activities and experiences can develop shared understandings and values through a sense of loyalty and identity (Blennow 2008; Wenger 2000; Beck and Young 2005). In these communities of shared experiences, the individuals view certain individuals and groups as epistemic authorities, meaning they are perceived as the providers of

legitimate, valid, and relevant knowledge and risk information (Weick, Sutcliffe, and Obstfeld 2009; Lidskog and Sjödin 2016). Previous studies have found that private forest landowners have increasingly engaged in collaborative management behaviors, and many landowners rely on the knowledge of consulting and management networks to inform their individual decision-making (Sample 1994; A. P. Fischer, Klooster, and Cirhigiri 2019; Kittredge 2005; Rickenbach and Reed 2002; A. P. Fischer and Charnley 2012). This means that the prevailing knowledge and perceptions of risk amongst large, influential forest management and consulting groups in a region may influence the widespread individual perceptions for private forest owners; however, due to factors like risk tolerance and perceived control, individual responses to prevailing knowledge and advice become more uncertain given dramatic shifts in the underlying drivers of decision-making (Lidskog and Sjödin 2016; Geist and Lambin 2002; Eriksson 2014). Large scale forest professionals provide advice and knowledge which influence individual perceptions, concerns, beliefs, and knowledge; however, individual landowners may veer away from established practices when faced with new system risks like climate change impacts.

Another important consideration in individual perceptions of risk is public risk communication. Effective risk communication should create awareness, enhance understanding, and suggest motivating action for a hazard (Rowan 1991). The mass media bridges science and policy to the public and play a vital role in shaping perceptions of environmental problems (Boykoff 2009; Gunderson, Stuart, and Petersen 2020). The United States media has portrayed a conflict over scientific explanations of anthropogenic climate change which has fostered a public perception of scientific uncertainty (Boykoff 2007; Chinn, Hart, and Soroka 2020). However, the news media often separates natural disaster coverage from anthropogenic climate change, and they have emphasized topics of human (e.g., labor), built (i.e., houses), and social (i.e.,

communities) livelihood capital vulnerabilities over natural (i.e., biodiversity) capital in hurricane coverage (Miles and Morse 2007; Molder and Calice 2023). The media also has paid less attention to hazards like hurricanes and wildfires over time (Molder and Calice 2023). Media visibility is critical in shifting the public perception of environmental problems from conditions to issues to policy concerns (Hannigan 2014). When people perceive closer proximity to and have higher awareness of an issue, they may be more likely to take mitigating action, and frequency of discussion of issues in newspapers can be an indicator of public awareness (Spence, Poortinga, and Pidgeon 2012; Rodríguez et al. 2013).

Historically, the news media has covered forest risks related to the timber industry more than the environmental role of forests and journalists have acted as the dominant problem framers and gatekeepers of issue visibility (Arvai and Mascarenhas 2001; Park and Kleinschmit 2016). Studies of media and policy content of forest issues show that the major debates and coverage encompass forest user interests (Logmani, Krott, and Giessen 2016; Sténs and Mårald 2020; Elomina and Pülzl 2021; Karnatz et al. 2021), their role in energy and economy (Amos 2007; Deak et al. 2023), and forest conservation and protection (Park and Kleinschmit 2016; Boykoff 2009). There is limited research (Karnatz et al. 2021) directly quantifying the media representation of various risks and issues related to private forests and/or the timber industry, and there is no research on this topic in the southeast United States.

Studying the broad representation of risks in a region can provide insight into widespread risk awareness. The purpose of this study was to develop an understanding of how forest professionals perceive hurricane risk, how those perceptions influence their forest management decisions, and to compare these findings to the news media's representation of risk to private forests. We also sought to understand how forest professionals developed their understanding of

risk and appropriate mitigations strategies. We developed the following research questions to investigate these topics:

(1) How do large scale forest professionals describe hurricane risk related to private forests?

(2) What strategies do these professionals use to respond to hurricane risk?

(3) What aspects of private forest and timber industry risks are the most represented by professionals and newspapers across the northern Gulf of Mexico (GOM)?

There have been several studies across the United States southeast which investigate nonindustrial private forest landowner risk perceptions and decision-making related to various hazards, but there is limited understanding about the broader risk perceptions and representation amongst influential forest professionals and the regional news media. Understanding widespread risk representation is an important consideration for outreach and education related to management for unavoidable hazards.

Methods

This study was a mixed-methods approach to understanding the perceptions and representations of timber industry/private forest issues and hurricane risk across the northern GOM. We conducted quantitative content analysis of local and regional newspapers and qualitative analysis through semi-structured interviews. The mixed-methods strategy enabled us to discuss the spectrum of risk representation between professionals and the media. This study is the first analysis of the media's framing of broad timber issues in the southeast United States and expands on the literature for large scale forest stakeholder perceptions and decision-making. The Auburn University Office of Human Research (IRB) Protocol 22-536 EX 2212 approved the interview protocol for this study.

Semi-Structured Interviews

We conducted semi-structured interviews with large scale forest landowners and management groups in north Florida and Alabama. The participants were identified via expert opinion from a collaborating university affiliated forestry consultant, Richard Hall. We used this selective sampling as the purpose of this study was not to use a representative population to generalize but to identify influential professionals and larger scale landowners in the region whose decisions have implications for markets, other landowners, and future forest management. The participants owned and managed land across the southeast United States, and we determined them to be key informants for insights into hurricane and forest management risk perceptions across the northern GOM. There were ten (N = 10) stakeholders identified initially, and they were invited to participate via email. If the potential participant was non-responsive, further contact methods were attempted, such as phone contact to company offices, follow up emails, and company contact forms. Five (N = 5) of the stakeholders identified were responsive and willing to participate. The interviews were conducted via Zoom video conferencing software or telephone call, and if the participant consented, they were recorded, and all interviews were transcribed. The interviews took 20-40 minutes and included 6 questions concerning property information and 7 open-ended questions concerning timber industry perceptions. The structured interview questions are included in Appendix C.

We analyzed the interviews using a Grounded Theory approach wherein we conducted several rounds of coding focused on relating the responses to LULC change (Glaser & Strauss, 1999). First, the audio recordings were anonymized and transcribed verbatim to represent all potential nuances in the discussion. Coding is a process through which meaning is assigned to individual sections of data (in this case, participant responses) by patterning, classifying, and

reorganizing each datum into categories for analysis (Saldaña, 2011). These codes were developed through an iterative process wherein they began as verbatim sections (words, phrases, sentences, or other blocks of conversation relating to specific topics) of responses and were funneled into more specific categories that are symbolic, summative, or capture the essence of the responses. I analyzed all the responses in gradually condensed spreadsheets. Coding occurred in multiple repeated phases, and analytical notes were stored throughout the process. Through the iterative coding process, we developed a codebook and identified prominent themes in timber stakeholder perceptions of timber industry issues and hurricane risks. In addition, we quantified the mentions of specific risks and the described responses to risk.

Newspaper Content Analysis

We collected our sample of newspapers from Newsbank, an Access World News database which provides primary source content from around the world. This study only included "newspapers" as data and we filtered out any other online resource. There were six (N = 6) locations which we identified as local to the study region: Destin (FL), Fort Walton Beach (FL), Marianna (FL), Panama City (FL), Santa Rosa Beach (FL), and Mobile (AL). Initially, we also included Tallahassee (FL), but we removed the *Tallahassee Examiner* due to no relevant articles. There were seven (N = 7) newspaper titles across these locations, and we included all titles: *The Destin Log*, *Jackson County Floridian*, *The News Herald*, *The News Herald: Archive*, *Northwest Florida Daily News*, *Press-Register*, and *The Walton Sun*. We condensed *The News Herald* and *The News Herald: Archive*. We included papers from 1990 to 2022. We identified potential newspaper articles with the following search terms: "timber industry," or "timber produc*," "private forest," or "forest* AND landowner," or "production AND timber." There were 940 articles returned and I reviewed titles and topics of all articles. We removed any duplicates or

other articles if the focus was not on private forest/timber industry, an issue connected to the industry, or if they did not mention any issues relevant to forestry. The elimination process led to our final sample of 310 articles for analysis.

We conducted a quantitative content analysis of the newspaper sample. For the initial analysis, we identified issues presented and the frequencies of mentions of each issue. The frequency of mentions has been identified as an indicator of awareness of a topic on top of portraying its representation in the media (Rodríguez et al., 2013). Following this initial count, we coded each issue in each article into two categories of framing: logical (general, statistics-based, and non-image evoking) or emotional (image evoking) (Geng et al. 2018; Johnson et al. 1993; Choi and Lin 2008). For all articles referring to hurricanes, we also coded them into categories of risk communication based on previous hurricane content analysis research and the Extended Parallel Process Model (EPPM): Anticipated outcomes or damages, severity of storm, risk mitigating actions, and expected outcomes of mitigation actions (Choi and Lin 2008; Witte 1992). If the article discussed the storms in hindsight, we interpreted "anticipated" as "observed," "risk mitigating actions" as "recovery actions" or mitigation suggestions for the future, and "expected outcomes of mitigating actions" as expected outcomes of recovery actions or expected outcomes of mitigating actions taken in the future. We quantified these categories by their mentions across articles. We did not quantify more than one mention per issue per article. For example, no articles were coded as "two mentions of hurricane risk," but they could be coded as "one mention of hurricane risk, one mention of policy," and the same was true for risk communication using the EPPM. We also quantified the names of hurricanes to which articles referred. The mentions of issues, the frame of issues mentioned, and the hurricane risk

communication categories all had to be related to private forests or the timber industry in some way to remain relevant to research question three.

Two coders participated in a two hour intercoder reliability session prior to construction of the codebook. The coders completed all categories of analysis. Coders analyzed 7% (N = 23) of the dataset and agreed on 98 out of 111 individual coding decisions for an overall coefficient of reliability of 88% (Holsti 1969). The two coders discussed any discrepancies to come to consensus and communicated uncertainties, both about an assigned code and about relevancy to research question three, throughout the coding process through comments on the codebook spreadsheet.

Results

Forest professional interviews

The participants in the qualitative portion of this study included representatives from forest management groups (otherwise known as consulting firms) and large landowning entities. They collectively owned and/or managed approximately 1.6 million acres of private forest in the Southeast and all participants' highest priority for their owned or managed woodland was to maximize return on investment, primarily through timber production of pine plantations. Each entity's presence in the Southeast varied from two years of ownership to 80+ years. The results presented below represent the range of ideas we heard in these interviews, although they may not represent a total range of ideas or be representative of all forest landowners in the region.

The major themes of discussion we observed when participants characterized hurricane risks to woodland were perceived control, recovery capacity, and single event impact. They also discussed longevity of resilience to risks and how the scale of ownership impacts capacity for recovery and effectiveness of conventional responses to risk. Finally, there were three major

categories identified as drivers of regional LULC change: Social processes, market changes, and natural hazards. Participants related all risks to the capacity to earn returns on investments. Each of these themes are outlined below.

Risk tolerance and perceived control

Participants discussed hurricane concerns in terms of relativity stating that their level of concern for hurricane damage was higher than in the past while others reported that it has not changed over time. They did not mention level of concern without offering a discussion of perceived control, and all professionals explained that there are few to no possible mitigating actions for hurricane damages, but that there are aspects of recovery which affect the long term impacts. One participant summarized the collective sentiment of lack of control when asked about potential changes to management due to future hurricane patterns:

> I don't know that it will [change] a lot, you might see some change, but again, what are you gonna do different? You're either gonna grow trees or you're not gonna grow trees. That's the only way you're gonna do something with that risk.

The same participant offered one potential management strategy for resilience:

> We don't really make decisions based on those types of events. Having said that, there's been a lot of talk since [Hurricane Michael] about maybe changing the way we look at thinning.

They elaborated that they observed the properties they managed which they thinned less intensively were less damaged by the Category 5 storm in 2017. Another participant described a

similar perspective, recounting how two mild storms in the penultimate hurricane season leveled a set of recently thinned young stands which were planted following Hurricane Rita in 2005. Reducing thinning was the only form of preclusive management offered as a mitigation strategy, and while both participants who identified this strategy expressed there is not much to do to prepare for future hurricanes, they referenced specific events which prompted these observations.

Recovery strategies, capacity, and single event impacts

While hurricane landings are not novel to landowners, participants discussed the potential for single events like Hurricane Michael to influence private forest owner perceptions and the novelty of recovery funding following the storm. These participants identified that Hurricane Michael changed perceptions; however, whether those perceptions include changes to future management depends on personal capacity for recovery activities and certainty about recovery funding. Several of the participants viewed forms of self-insurance, existing relationships with salvage contractors, and immediate mobilization as effective forms of response to earn profit. One described the main challenges they anticipate:

> We are concerned but have no plan other than keeping our road network in good usable condition and having a good base of contractors available.

Another participant described that the relative rate of liquidation offsets the damage and market pricing as a form of self-insurance:

So, it's not nearly as bad…as it may seem the first. So, if you've got $10 million that you're gonna cut over 10 years, and you discounted all that, and you know, you get $4 million, you only get 40%, but you get it all in year 1, then it offsets the discounting effect.

They explained that large landowners can typically self-insure their woodland by relying on salvage revenue or by strategically saving timber profits. However, they described different responses indicative of various tolerance of risk (Figure 1). Some participants described examples of landowners who are disposing of parcels and geographically diversifying their

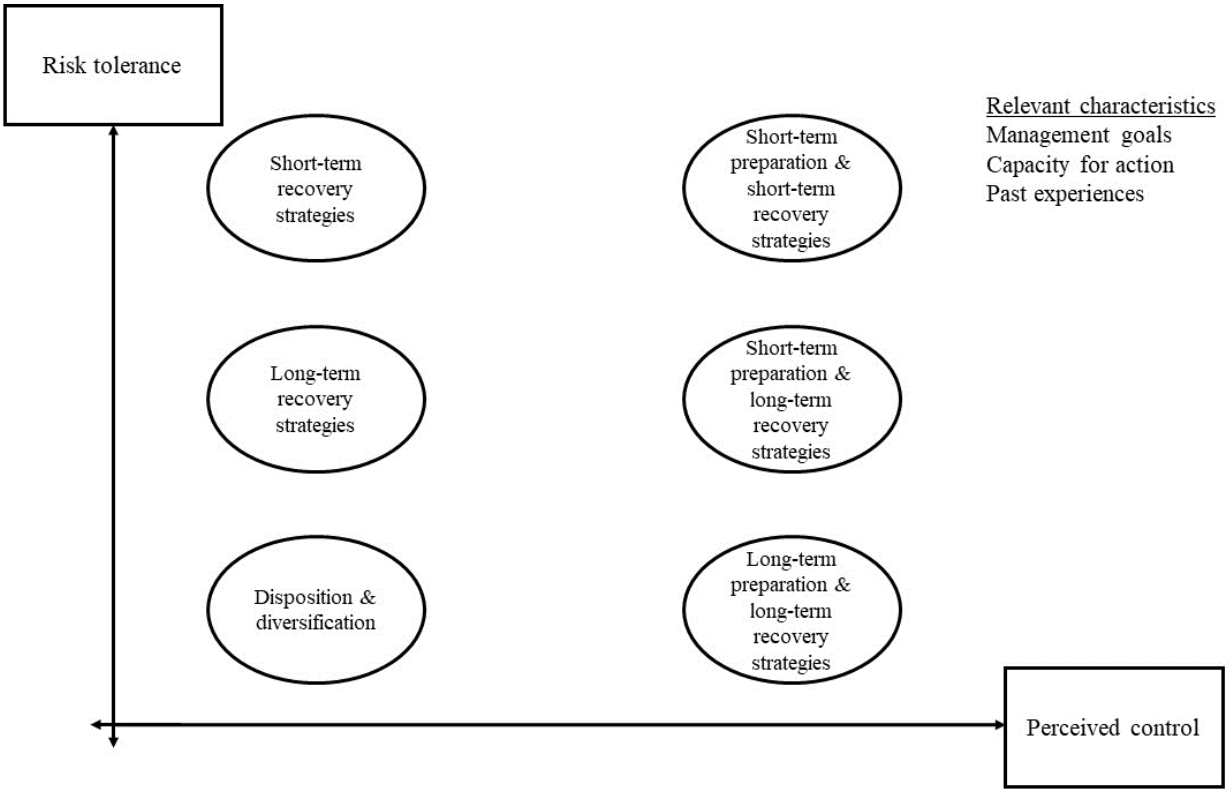

Figure 1. Adapted illustration of potential risk mitigation strategies given two dimensions of risk (Eriksson 2014): Risk tolerance and perceived control

portfolio by investigating woodland ownership away from the coast as a direct result of Hurricane Michael. They noted that many smaller-scale landowners would need more guaranteed

relief funding or affordable casualty insurance to feasibly recover in the future and that many would not have done any salvaging or cleaning without the relief grants following Michael. One emphasized that changes in increased risk of severe hurricanes would impact landowner acquisition (buying land) and disposition (selling land) more than their management strategies. Some participants emphasized their own concerns about the ability to efficiently mobilize in time to effectively salvage wood for relying on recovery revenue. Some participants did not discuss existing relationships with salvage contractors. Regarding managing for future hurricanes, one stated:

> Well, yeah, there is an industry standard on it to ignore it. That's industry standard right now. After Michael that's not gonna happen again. And so, I mean for us it's tough.

However, another participant contrasted this statement by emphasizing that memory of disasters is short:

> Yeah, I mean I think it's just like any other damage though, people tend to forget after about 10 years… in Katrina and Ivan, Mobile was without power for 14 days, so those were 2004 and 2005, and it takes about 10 years to forget how bad it was, in my experience, and people kind of start getting lackadaisical. I'm sure that's the same thing you know on the timber side as well.

While discussing conservation incentives and experience with renewable energy markets such as solar and wind power leasing, we found that all participants have been involved in some conservation programs, but that they must support the overall investment value of the property. Managers explained that incentives are more popular with their smaller landowners. One

participant explained that their company mission guides them to consider sustainability alongside the investment value and another described a strategy to target conservation and preservation of woodland adjacent to their planned community development. Some participants identified some tree cover reduction for solar leasing and most mentioned the high profit of solar leasing, one stating:

> If they got the money, we got the time. You can't ignore solar if they come knocking.

They described that clearing trees for solar is a "drop in the bucket" especially because they perceived that the solar market is slowing down and only has popularity in regions aggressively marketing it.

Perceived drivers of change

To conclude the interviews, we asked participants to broadly discuss the risks which they perceived to be drivers of management and LULC change in GOM region. Based on their responses, we identified three themes in perceived drivers of LULC and management change: Sociopolitical, economic, and natural hazards. The sociopolitical drivers of change identified were policy change, population growth, development, and generational ownership change. The participants who discussed generational change stated that the younger inheritors are only concerned about the properties as assets and are less engaged with managing the forest for production. Participants also mentioned population growth and development and one noted that they plan to prioritize development of their own properties over timber production in the future. The three economic management influences mentioned repeatedly were forest products demand (discussed twice in relation to a paper mill near Panama City, FL) and emerging carbon markets.

Finally, natural hazards included hurricanes, wildfires fueled by hurricane debris, and poor growing conditions; however, only one participant explicitly stated these factors in this final question while the others implied these only if they affect long term investment value. All participants emphasized economics and related factors from the other themes to emphasize that drivers of change are factors which influence the investment value of the forest. The largest scale participant we spoke with described reaching their limit to risk tolerance due to a combination of market and natural hazards, stating:

> "…risk of hurricanes, risk of fire post-hurricanes, poor markets, crappy site index, and you can quote me on crappy because the Panhandle of Florida is a lousy place to grow trees. Lack of a new market entrance. Population growth, that's probably top of the list."

Content analysis

We found 310 relevant newspaper articles covering private forests, the timber industry, or issues related to them in the southeast United States. The Mobile *Press-Register*, a regionwide newspaper, published 83% of the articles in our sample. The other 6 localized newspapers published the remaining 17% of articles ranging from 1 to 25 articles at each. Figure 2 depicts the volume of mentions for each issue identified and the proportion of framing applied for each issue. The most frequently mentioned issue was policy (184 times; 38% mentions, 59% articles) followed by issues associated with forest products markets (63 times; 13% mentions, 20% articles), mills (51 times; 11% mentions, 16% articles), hurricanes (38 times; 8% mentions, 12% articles), wildfire (26 times; 5% mentions, 8% articles) and other extreme weather events (28 times; 6% mentions, 9% articles), environmentalist perceptions (26 times; 5% mentions, 8%

articles), invasive species (23 times; 5% mentions, 7% articles), development (21 times; 4% mentions, 7% articles), effective management (13 times; 3% mentions, 4% articles), and finally, other social factors (11 times; 2% mentions, 4% articles). The papers applied an emotional frame

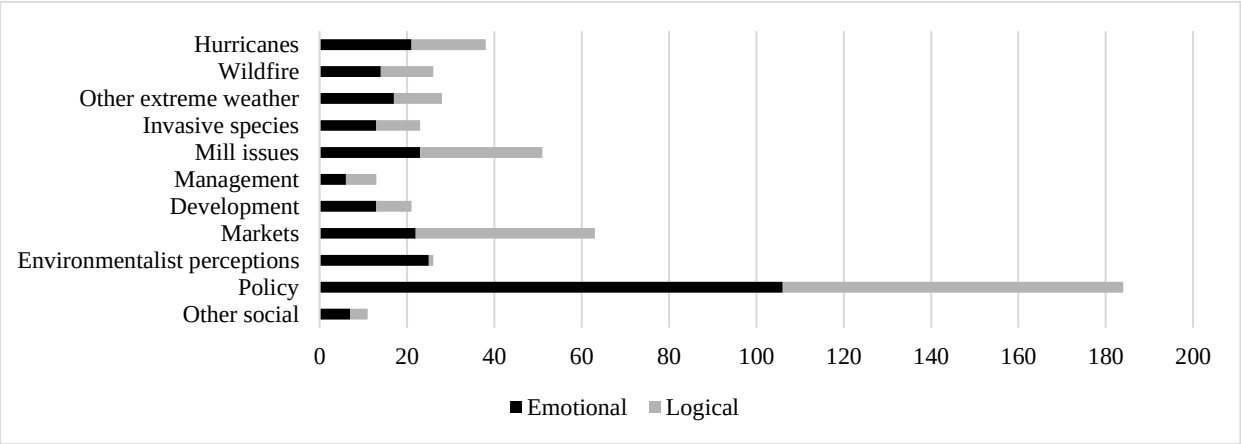

Figure 2. Frequency of issues represented in newspaper articles and proportion of the primary framing context for each issue (N = 483)

when covering 55% of the issues and a logical frame for the other 45%. Environmentalist perceptions had the most skewed discourse with 96% of mentions using an emotional frame (1 logical frame in 26 articles). This issue emerged through editorials and letters to the editor where debate arose about the environmental impacts of production forestry or through policy focused papers that illustrated the dichotomy of environmental lobbyists versus timber lobbyists. A quote from the *Press-Register*, for example:

> As is usually the case these days, the environmentalists with their massive media support carried the day as political pressures caused the closing of huge tracts of timberland to foresters simply due to the possible presence of those cute little spotted owls.

The articles applied a logical frame for the majority of mentions of market changes (65%), management activities (54%), and mill issues (55%). For all other issues, the proportion of emotional frames applied outweighed logical frames (54%-64%).

We identified three categories to condense the issues represented by the newspapers: Natural hazards (83 mentions; 21% mentions), socio-political factors (199 mentions; 59% mentions), and economic factors (117 mention; 29% mentions). There were 226 articles (73%) which only mentioned one category of issue, the remaining 84 articles (27%) mentioned a combination of issues. Natural hazards were mentioned with sociopolitical issues in 33 articles (11%) and with economic issues in 10 articles (3%). Economic and sociopolitical factors were mentioned together in 34 articles (11%) and all three categories were mentioned together in 5 articles (2%).

We found that there were 5 temporal peaks in the volume of coverage of these categories since 1992, but total media coverage of timber and private forests has decreased over time (Figure 3). From 1992 to 1999, newspapers published 44% of the articles, then 32% from 2000 to 2009, and 21% since 2010. then peaked again in 1998, and again in 2004 alongside natural hazards which continued a coverage peak into 2005, then economic issues peaked 2008-2009, and finally all three issues peaked between 2018 and 2020.

Economic and sociopolitical issues peaked in 1993, associated with the 1990 listing of the northern spotted owl under the Endangered Species Act which resulted in regulations affecting loggers in the northwestern United States, subsequently increasing sociopolitical and economic focused papers in the Southeast which discussed implications of the policy for markets and reported on the actual market fluctuations of the time. This event overlapped with coverage

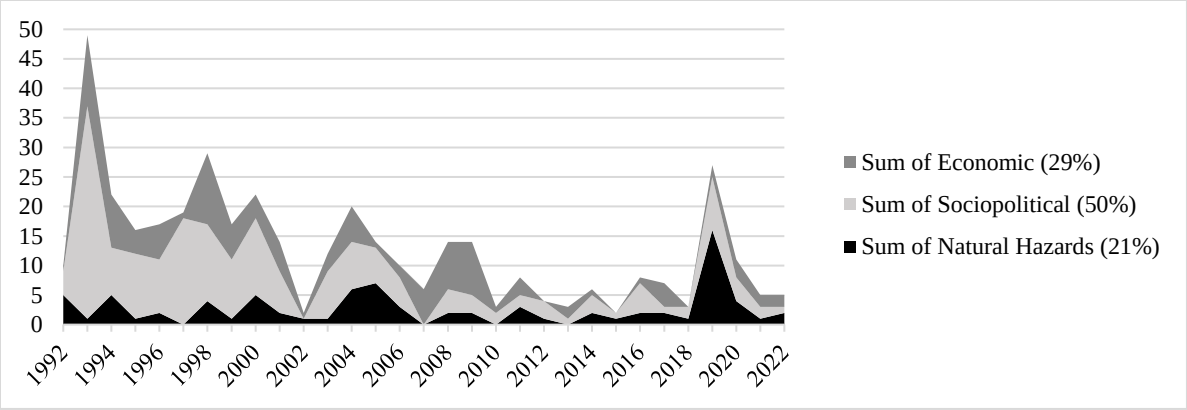

Figure 3. Total frequency of mentions of major themes of issues in newspaper articles, 1992-2022 (*N* = 399 mentions; 310 articles)

referring to the economic recession which began in 1990. Economic and socio-political volume peaked again from 1998 to 2000 when newspapers were reporting coverage of a few issues: The debate of several proposed Southeastern species listings under the Endangered Species Act, debate over a current-use designation tax policy, and a major mill closure. All categories peaked in 2004-2005 due to Hurricanes Ivan and Katrina, economic issues peaked in 2008-2009 with the Great Recession as well as a resurgence of mill issues including discussion of layoffs and unemployment, and finally all categories peaked in 2018-2020 due to Hurricane Michael, the subsequent relief: The Block Grant Program, and local updates about recovery. The Mobile *Press-Register* covered all these events.

Hurricanes were the most frequently mentioned natural hazard (45%) followed by wildfires (31%), and other extreme weather events (34%). Other extreme weather events included tornadoes, droughts, climate change, severe storms (non-tropical cyclone), and tree disease. Only four articles mentioned climate change over the 30 year period, two of which mentioned drought, one mentioned invasive species, and one mentioned Hurricane Michael to illustrate the effects of climate change. The only article to apply a logical frame was the article

discussing climate change and invasive species. Hurricane Michael was the most frequently mentioned hurricane (19 mentions, 50%), followed by Ivan (12 mentions, 32%), Katrina (5 mentions, 13%), and all other hurricanes or hurricanes in general (5 mentions, 13%). We found that the most frequently mentioned aspect of the risk communication context (Table 1) for hurricanes was expected (or observed) outcomes (34 mentions, 89%), followed by risk mitigating actions (26 mentions, 68%), then expected outcomes of actions (23 mention, 61%), and finally hurricane severity (18 mentions, 47%).

Table 1. Frequencies of risk communication content based on EPPM (N = 38)

Hurricane	Outcomes (expected or observed)	Severity	Risk mitigating actions	Expected outcomes of risk mitigating actions
Other or unspecified	3	2	2	2
Ivan	9	5	7	6
Katrina	3	1	3	3
Michael	19	10	14	12
Total	34	18	26	23

Discussion

The results from both the interviews and the content analysis showed the same themes in risk representation: Sociopolitical, economic, and natural hazards. These themes are consistent with a recent content analysis on forest certification news which found that, in the south, in socio-cultural themes were the most frequently applied (Karnatz et al. 2021). However, we found a higher volume of economic themes than natural hazards represented while they found the opposite. Other recent studies identified financial motivations as important for large landowners, so high representation of risks to profit is consistent with this (Sass et al. 2021; Tran et al. 2020). The media applied a logical frame to all economic issues, but an emotional frame to all others which may be more effective for reader comprehension of risks (Hendrickx, Vlek, and Oppewal 1989; Rudiawarni, Made Narsa, and Tjahjadi 2020; Weiner et al. 2021). Both aspects of our study depicted natural hazards, policies and regulations, product demand, and societal changes as

risks to private forests and the timber industry. Forest professionals broadly perceived risks as anything that affects the investment value of the forest and both the news and participants primarily discussed market demand, mill issues, and policies/regulations affecting harvest or product processing.

Representation of risks related to forestry

We found that participants characterized their risk perceptions according to two dimensions previously identified by private forest owners: Risk tolerance and perceived control (Eriksson 2014; Figure 1). We answered research question one by applying these dimensions of risk perception to the qualitative data from the interviews. Previous research on natural hazard risk mitigation found that the public and forest owners alike are more likely to take action to mitigate the effects when they are aware and concerned about a hazard (Peek and Mileti 2002; Stårdal, Lien, and Hardaker 2007; Blennow and Sallnäs 2002; A. P. Fischer 2011; Spence, Poortinga, and Pidgeon 2012). However, awareness of does not necessarily predict concern about them (Eriksson 2014). Interview participants emphasized the lack of control over mitigation of hurricane damages, and news coverage focused on reporting outcomes and relief efforts while neglecting to discuss preclusive mitigation, but participants perceived control over the effectiveness of their recovery efforts. Further, we found that the news and the forest professionals in our study region did not distinguish natural hazards damages from investment value, and some perceived the only effective damage mitigation to be land disposition. Because of the prevailing perception of low control of natural hazards, we found that an individual's tolerance of risk was primarily related to the risk of economic losses and profit inconsistency.

Participants and news articles both mentioned that the new generation of landowners alongside continued development and population growth present risks to private forests. These

perceptions of sociopolitical forest issues agree with previous research which found Southeastern forest landowners have increasingly converted their tree covered properties to pasture or urban uses, that the mean parcel sizes for family forest owners are decreasing, and that these types of fragmentation are amplified by population growth and inheritance-based ownership change (Pan et al. 2009; Gobster and Rickenbach 2004; Mook and Dwivedi 2023; Nagy and Lockaby 2011). Interview participants perceived the next generation of landowners to be detached to their woodland and only consider its role as an asset, but many inheritors are widows who value their woodland for family connections and legacy, conservation, and income (Mook, Goyke, and Dwivedi 2022; Mook and Dwivedi 2023). Inheritors also may perceive low control over their decisions to subdivide their forests (Gruver et al. 2017).

The next generation of forest owners varies in knowledge and capacity for effective management as well as access to resources to improve such capacity, but the participants in our study only discussed the perceived detachment of the next generation (Schelhas and Zabawa 2009; Schelhas et al. 2012). Few news articles mentioned generation or gender related to forestry, and when they did, they applied logical frames, but more news coverage about resources and education opportunities for new landowners could increase inheritors' capacity to take action to mitigate risks (Luxon 2019). Additionally, news coverage of private forest topics has decreased over time, and there is a growing public indifference towards forest management in the United States, so the media is positioned to play a role in maintaining public awareness about private forest cover and the risks to continued feasibility of ownership (A. Fischer, Marshall, and Camp 2013; Brandeis et al. 2012). As coverage decreases over time, the novelty and dramatization decrease and limit not only public awareness, but also policy relevance (Molder and Calice 2023). Regardless, the shift in ownership will have important implications

for widespread risk perceptions and it will be important to understand new landowner capacity for management, goals, and perceptions.

Dimensions of hurricane risk related to other forestry risk factors

Previous research (Zwick 2005) assessing risk perceptions found that people will identify different risks when asked broadly without listed suggestions, and while we wanted to study hurricane risk specifically, we found that participants reported the risks associated with the social and economic structure more often when not prompted to discuss hurricanes. This held true even though some participants reported relatively high concern for future damage. For interview participants, hurricanes (along with subsequent fires fueled by downed trees) were the only natural hazard mentioned when we broadly asked about risks to management and land cover, but the news articles mentioned several other natural hazards related to forestry (Figure 4). All news articles which

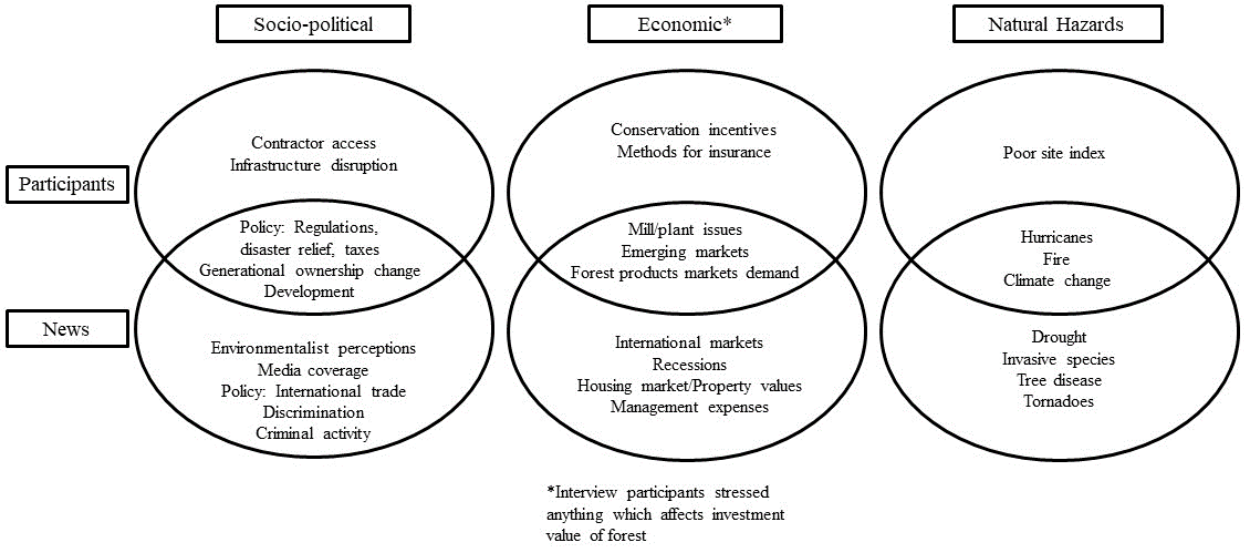

Figure 4. Comparison of issues and risks mentioned by participants and newspapers, 1992-2022.

mentioned hurricanes as a risk to forestry also mentioned the related economic or policy factors which may indicate that forest professionals tend to discuss natural hazards with widespread

damage and industry impact, as opposed to events like invasive species, drought, or severe (non-hurricane) storms which are either smaller scale or may receive preclusive management attention (A. P. Fischer and Charnley 2012).

A typical forest stand is likely to be affected by one hurricane within any single tree life cycle (Prestemon and Holmes 2010), but previous researchers (Blake 2018) and our participants both discussed how the conventionally perceived offset of losses over time can be impacted by shorter return periods between severe storms. The temporal news results for natural hazards implied this as well given the volume of articles about Hurricane Michael compared to Ivan. Further, hurricane seasons are becoming more costly (Emanuel et al. 2006; Emanuel 1987; Halverson 2018; Blake 2018). A recent study (Clarke et al. 2023) found that non-industrial private forest landowners who experienced damage from Hurricane Michael were not significantly more likely to sell, pass on, or convert their land than those who did not experience damage, but they did not assess if perceptions of hurricane risk changed because of the storm regardless of damage. Given that we found examples of large-scale diversification and disposition as direct responses to Hurricane Michael, it will be important for future research to investigate risk tolerance across the coastal forested region.

Hurricane response strategies

Southeastern land managers have previously reported low perceived control over disaster impacts on crops like timber, primarily focusing on short-term recovery strategies, and they identified power outages, downed trees, and blocked roads as the highest risks to hurricane recovery (Wiener, Álvarez-Berríos, and Lindsey 2020). Similarly, our results from applying the EPPM to code for risk-communication context showed that news articles more frequently mention the outcomes and mitigation in the form of disaster relief than they do pre-storm

mitigation. These findings answered research question one, depicting that strategies for hurricane risk response primarily encompass short and long term recovery strategies more than preclusive mitigation strategies. Media coverage reduces the psychological distance (i.e., increases public awareness) of an issue and this reduction can increase concern and likelihood of mitigating action (Spence, Poortinga, and Pidgeon 2012). Interview participants also mentioned a lack of control over hurricane risks via preclusive management activities, but they discussed proactive (self-insurance, contractor relationships) and reactive (efficient salvage logging) long-term strategies to manage recovery challenges. Some participants mentioned that it's possible to adapt thinning strategies to improve forest resilience to wind damage, which has been previously suggested in management research (Stanturf, Goodrick, and Outcalt 2007), but they explained they never considered discussing these strategies prior to Hurricane Michael.

We observed a division in the perceptions of the effectiveness of hurricane recovery strategies, though, given an implied difference in social (contractor relationships and networks) and human (skills, active labor, equipment) capital and the scale of forest management (Bebbington 1999; DFID 2001). Another study found that small woodlot owners in the northeast United States were less willing than forest professionals to improve road maintenance prior to storms and they were more reliant on financial incentives (Wiener, Álvarez-Berríos, and Lindsey 2020; Soucy et al. 2020). News articles following Hurricane Michael primarily discussed the novel Block Grant Program relief funding for forest owners, and interview participants emphasized the novelty of such relief and how policy change to guarantee future relief could impact landowners' capacity for recovery.

Implications and limitations

Our findings provide a novel summary of influential professionals' perceptions of sociopolitical, economic, and environmental risks associated with owning private forest in the southeastern United States. We found that the local and regional media represented the most important risks as described by the forest professionals, but that there is a professional consensus of low perceived control and various levels of risk tolerance which can impact the likelihood to explore options to mitigate future risks (Blennow and Sallnäs 2002; Peek and Mileti 2002; Stårdal, Lien, and Hardaker 2007). Participants minimally discussed physical proactive strategies to forests, but evidence for useful mitigation strategies is emerging, including strategic thinning, diversifying timber with storm resistant species like longleaf pine, and methods to harvest woody debris for bioenergy (Stanturf, Goodrick, and Outcalt 2007). Our findings were consistent with the functionality of coastal SES wherein landowners have high risk resilience and tolerance because they are well acquainted with responding to changes in the external social (policies, development, population, and markets) and environmental (natural hazards and stand recovery) structures (Adger et al. 2005; Morse et al. 2013). In most SES risk contexts, high levels of concern increase the likelihood of mitigation actions, but coastal systems are unique in that the landowners experience damage from hurricanes, over which they perceive little control, so future education and assistance programs should focus on proactive mitigation education as opposed to risk awareness outreach (A. P. Fischer 2018; A. P. Fischer and Charnley 2012; Weiner et al. 2021).

The main limitation of this study was the low participation. Private forest professionals have heterogenous roles, and we were not seeking a representative sample; however, we did not receive participation from several key informants who were identified as highly knowledgeable and influential in the region. Additionally, all our participants represented large corporate

landowning entities or widespread management groups, so more qualitative studies of large nonindustrial private forest landowners are necessary. Even with the small sample, we observed emergent themes in risk perceptions and identified some divisions, but more research is needed to assess how risk tolerance and perceived control may interact with risks to alter forest cover in the Southeast especially considering trends in fragmentation (Mehmood and Zhang 2001; Pan et al. 2009; Noori et al. 2016). Another noteworthy improvement to our content analysis is for future study to assess more details, such as quantifying anti-timber sentiments, and to quantify purposive omissions of specific risks (Gunderson, Stuart, and Petersen 2020). Our study provided important findings about broad perceptions and representations of risks for Southeastern private forests, but future research should expand upon the specific processes and sentiments surrounding different risks.

Conclusion

Media representation and forest professionals both portrayed investment value and policies related to capacity to earn profit as the most influential topics related to forest management. Between both aspects of the study, we identified major themes of private forest issues: Economic, socio-political, and natural hazards/environment related issues, but the media most frequently mentioned socio-political while participants emphasized economic. We found that large scale forest professionals described hurricane risk in the context of their perceived control and tolerance of risk, but most did not consider hurricanes a substantial risk due to their capacity to offset losses through recovery and self-insurance methods. Another risk to forest cover which was represented was the generational shift in ownership, and researchers should investigate the goals of younger inheritors and disseminate resources for forest cover maintenance to widowed inheritors. Our findings emphasize previous research which found that perceived control can

impact decision-making regardless of level of concern. Enriching landowner hurricane planning strategies through resource education may be necessary to build perceived control, risk tolerance, and discourage disposition of forests. Participants identified potential timber diversification strategies for damage mitigation, but most emphasized reliance on recovery strategies, so researchers, forest professionals, and outreach groups should further investigate the efficacy of such strategies and their implementation.

References

Adger, W. Neil, Terry P. Hughes, Carl Folke, Stephen R. Carpenter, and Johan Rockström. 2005. "Social-Ecological Resilience to Coastal Disasters." Science 309 (5737): 1036–39. https://doi.org/10.1126/SCIENCE.1112122.

Amos, Heather E. 2007. "Framing Energy and Forest Policy: A Content Analysis of Bioenergy in The Vancouver Sun." Vancouver: Acadia University.

Arvai, Joseph L., and Michael J. Mascarenhas. 2001. "Print Media Framing of the Environmental Movement in a Canadian Forestry Debate." Environmental Management 27 (5): 705–14. https://doi.org/10.1007/s002670010181.

Ban, Natalie C., Morena Mills, Jordan Tam, Christina C. Hicks, Sarah Klain, Natalie Stoeckl, Madeleine C. Bottrill, et al. 2013. "A Social-Ecological Approach to Conservation Planning: Embedding Social Considerations." Frontiers in Ecology and the Environment 11 (4): 194–202. https://doi.org/10.1890/110205.

Bebbington, Anthony. 1999. "Capitals and Capabilities: A Framework for Analyzing Peasant Viability, Rural Livelihoods and Poverty." World Development 27 (12): 2021–44. https://doi.org/10.1016/S0305-750X(99)00104-7.

Beck, John, and Michael F. D. Young. 2005. "The Assault on the Professions and the Restructuring of Academic and Professional Identities: A Bernsteinian Analysis." British Journal of Sociology of Education 26 (2): 183–97. https://doi.org/10.1080/0142569042000294165.

Bell, P A. 2001. Environmental Psychology. Annual Review of Psychology. 5th ed. Fort Worth: Harcourt College. https://doi.org/10.1146/annurev.ps.33.020182.003251.

Blake, Eric S. 2018. “Atlantic Hurricane Season: Catastrophic Losses and Costs” 71 (3): 28–37. https://doi.org/10.1080/00431672.2018.1448147.

Blennow, Kristina. 2008. “Risk Management in Swedish Forestry - Policy Formation and Fulfilment of Goals.” Journal of Risk Research 11 (1–2): 237–54. https://doi.org/10.1080/13669870801939415.

Blennow, Kristina. 2012. “Adaptation of Forest Management to Climate Change among Private Individual Forest Owners in Sweden.” Forest Policy and Economics 24 (November): 41–47. https://doi.org/10.1016/J.FORPOL.2011.04.005.

Blennow, Kristina, and Ola Sallnäs. 2002. “Risk Perception among Non-Industrial Private Forest Owners.” Scandinavian Journal of Forest Research 17 (5): 472–79. https://doi.org/10.1080/028275802320435487.

Boykoff, Maxwell T. 2007. “From Convergence to Contention: United States Mass Media Representations of Anthropogenic Climate Change Science.” Transactions of the Institute of British Geographers 32 (4): 477–89. https://doi.org/10.1111/j.1475-5661.2007.00270.x.

Boykoff, Maxwell T. 2009. “We Speak for the Trees: Media Reporting on the Environment.” Annual Review of Environment and Resources 34: 431–57. https://doi.org/10.1146/annurev.environ.051308.084254.

Brandeis, Thomas J, Andrew J Hartsell, James W Bentley, and Consuelo Brandeis. 2012. "Economic Dynamics of Forests and Forest Industries in the Southern United States." USDA Forest Service. www.srs.fs.usda.gov.

Butler, Brett J., Sarah M. Butler, Jesse Caputo, Jacqueline Dias, Amanda Robillard, and Emma M. Sass. 2021. "Family Forest Ownerships of the United States, 2018: Results from the USDA Forest Service, National Woodland Owner Survey." General Technical Report NRS-199. Madison, WI: U.S. Department of Agriculture, Forest Service, Northern Research Station. https://doi.org/10.2737/NRS.

Chinn, Sedona, P. Sol Hart, and Stuart Soroka. 2020. "Politicization and Polarization in Climate Change News Content, 1985-2017." Science Communication 42 (1): 112–29. https://doi.org/10.1177/1075547019900290/ASSET/IMAGES/LARGE/10.1177_1075547019900290-FIG3.JPEG.

Choi, Yoonhyeung, and Ying Hsuan Lin. 2008. "A Content Analysis of the Newspaper Coverage of the Three Major Hurricanes in 2005." Public Relations Review 34 (3): 294–96. https://doi.org/10.1016/J.PUBREV.2008.03.025.

Clarke, Mysha, Ajay Sharma, Taylor Stein, Jason Vogel, and Jarek Nowak. 2023. "Forest Disturbances and Nonindustrial Forest Landowners: Management of Invasive Plants, Fire Hazards and Wildlife Habitats after a Hurricane." Journal of Forestry fvad022 (June). https://doi.org/10.1093/jofore/fvad022.

Dale, Virginia H., Linda A. Joyce, Steve McNulty, and Ronald P. Neilson. 2000. "The Interplay between Climate Change, Forests, and Disturbances." Science of The Total Environment 262 (3): 201–4. https://doi.org/10.1016/S0048-9697(00)00522-2.

Dale, Virginia H, Ariel E Lugo, James A Macmahon, and Steward T A Pickett. 1998. "Ecosystem Management in the Context of Large, Infrequent Disturbances." Ecosystems 1: 546–57.

Deak, Alison, Heidi Huber-Stearns, Mindy Crandall, Kamana Poudel, Emily Jane Davis, Michael R Coughlan, and Carl Wilmsen. 2023. "Documenting Twenty Years of the Contracted Labor-Intensive Forestry Workforce on National Forest System Lands in the United States." Journal of Forestry fvad026 (June). https://doi.org/10.1093/jofore/fvad026.

Department for International Development (DFID). 2001. "Sustainable Livelihoods Guidance Sheets." www.dfid.gov.uk/.

Elomina, Jerbelle, and Helga Pülzl. 2021. "How Are Forests Framed? An Analysis of EU Forest Policy." Forest Policy and Economics 127 (June): 102448. https://doi.org/10.1016/J.FORPOL.2021.102448.

Emanuel, Kerry. 1987. "The Dependence of Hurricane Intensity on Climate." Nature 326 (6112): 483–85.

Emanuel, Kerry. 2005. "Increasing Destructiveness of Tropical Cyclones over the Past 30 Years." Nature 436 (7051): 686–88. https://doi.org/10.1038/nature03906.

Emanuel, Kerry, Sai Ravela, Emmanuel Vivant, and Camille Risi. 2006. "Supplement to A Statistical Deterministic Approach to Hurricane Risk Assessment." Bulletin of the American Meteorological Society 87 (3): S1–5. https://doi.org/10.1175/bams-87-3-emanuel.

Epanchin-Niell, Rebecca S., Matthew B. Hufford, Clare E. Asian, Jason P. Sexton, Jeffrey D. Port, and Timothy M. Waring. 2010. “Controlling Invasive Species in Complex Social Landscapes.” Frontiers in Ecology and the Environment 8 (4). https://doi.org/10.1890/090029.

Epanchin-Niell, Rebecca S., and James E. Wilen. 2010. “Cooperation, Spatial-Dynamic Externalities, and Invasive Species Management.” In Agricultural and Applied Economics Association.

Eriksson, Louise. 2014. “Risk Perception and Responses among Private Forest Owners in Sweden.” Small-Scale Forestry 13 (4): 483–500. https://doi.org/10.1007/s11842-014-9266-6.

Fischer, Alexandra P. 2011. “Reducing Hazardous Fuels on Nonindustrial Private Forests: Factors Influencing Landowner Decisions.” Journal of Forestry 109 (5).

Fischer, Alexandra P. 2018. “Forest Landscapes as Social-Ecological Systems and Implications for Management.” Landscape and Urban Planning 177 (September): 138–47. https://doi.org/10.1016/J.LANDURBPLAN.2018.05.001.

Fischer, Alexandra P., and Susan Charnley. 2012. “Private Forest Owners and Invasive Plants: Risk Perception and Management.” Invasive Plant Science and Management 5 (3): 375–89. https://doi.org/10.1614/ipsm-d-12-00005.1.

Fischer, Alexandra P., Andrew Klooster, and Lora Cirhigiri. 2019. “Cross-Boundary Cooperation for Landscape Management: Collective Action and Social Exchange among Individual Private Forest Landowners.” Landscape and Urban Planning 188. https://doi.org/10.1016/j.landurbplan.2018.02.004.

Fischer, Anton, Philip Marshall, and Ann Camp. 2013. “Disturbances in Deciduous Temperate Forest Ecosystems of the Northern Hemisphere: Their Effects on Both Recent and Future Forest Development.” Biodiversity and Conservation 22 (9): 1863–93. https://doi.org/10.1007/s10531-013-0525-1.

Geist, H.J., and E.F. Lambin. 2002. “Proximate Causes and Underlying Driving Forces of Tropical Deforestation.” BioScience 52 (2): 143–50.

Geng, Christina, Qing Chi, Zhe Ouyang, and Xun Xu. 2018. “Changing Perceptions and Reasoning Process: Comparison of Residents’ Pre-and Post-Event Attitudes.” Annals of Tourism Research, 39–53. https://doi.org/10.1016/j.annals.2018.02.010.

Gobster, Paul H., and Mark G. Rickenbach. 2004. “Private Forestland Parcelization and Development in Wisconsin’s Northwoods: Perceptions of Resource-Oriented Stakeholders.” Landscape and Urban Planning 69 (2–3): 165–82. https://doi.org/10.1016/J.LANDURBPLAN.2003.09.005.

Gruver, Joshua B., Alexander L. Metcalf, Allyson B. Muth, James C. Finley, and A. E. Luloff. 2017. “Making Decisions About Forestland Succession: Perspectives from Pennsylvania’s Private Forest Landowners.” Society and Natural Resources 30 (1): 47–62. https://doi.org/10.1080/08941920.2016.1180728.

Gunderson, Ryan, Diana Stuart, and Brian Petersen. 2020. “The Fossil Fuel Industry’s Framing of Carbon Capture and Storage: Faith in Innovation, Value Instrumentalization, and Status Quo Maintenance.” Journal of Cleaner Production 252. https://doi.org/10.1016/j.jclepro.2019.119767.

Halverson, Jeffrey B. 2018. “The Costliest Hurricane Season in U.S. History.” Weatherwise 71 (2): 20–27. https://doi.org/10.1080/00431672.2018.1416862.

Hannigan, J. A. 2014. Environmental Sociology. 3rd ed. London, UK: Routledge.

Hayhoe, Katharine, Donald J. Wuebbles, David R. Easterling, David W. Fahey, Sarah Doherty, James P. Kossin, William V. Sweet, Russell S. Vose, and Michael F. Wehner. 2018. “Our Changing Climate.” In Impacts, Risks, and Adaptation in the United States: The Fourth National Climate Assessment, Volume II, edited by DR Reidmiller, CW Avery, DR Easterling, KE Kunkel, KLM Lewis, TK Maycock, and BC Stewart, 72–144. Washington, DC, USA: U.S. Global Change Research Program. https://doi.org/10.7930/NCA4.2018.CH2.

Henderson, Jesse D., Robert C. Abt, Karen L. Abt, Justin Baker, and Ray Sheffield. 2022. “Impacts of Hurricanes on Forest Markets and Economic Welfare: The Case of Hurricane Michael.” Forest Policy and Economics 140 (July): 102735. https://doi.org/10.1016/J.FORPOL.2022.102735.

Hendrickx, Laurie, Charles Vlek, and Harmen Oppewal. 1989. “Relative Importance of Scenario Information and Frequency Information in the Judgement of Risk.” Acta Psychologica 72: 41.

Holsti, O. R. 1969. Content Analysis for the Social Sciences. Reading, MA: Addison-Wesley.

Johnson, Eric J, John Hershey, Jacqueline Meszaros, and Howard Kunreuther. 1993. “Framing, Probability Distortions, and Insurance Decisions.” Journal of Risk and Uncertainty 7: 35–51.

Karnatz, Caroline, Parag Kadam, Alexander Pfeuffer, and Puneet Dwivedi. 2021. “The Portrayal of Forest Certification in National and State Newspapers of the United States.” Forest Policy and Economics 130 (September): 102531. https://doi.org/10.1016/J.FORPOL.2021.102531.

Khanal, Puskar N, Donald L Grebner, Ian A Munn, Stephen C Grado, Robert K Grala, James E Henderson, and Marcus K Measells. 2016. “Nonindustrial Private Forest Landowner Beliefs toward Climate Change and Carbon Sequestration in the Southern United States.” Journal of Forestry 114 (5): 524–31. https://doi.org/10.5849/jof.15-033.

Kittredge, David B. 2005. “The Cooperation of Private Forest Owners on Scales Larger than One Individual Property: International Examples and Potential Application in the United States.” Forest Policy and Economics 7 (4). https://doi.org/10.1016/j.forpol.2003.12.004.

Knutson, Thomas R, Maya V Chung, Gabriel Vecchi, Jingru Sun, Tsung-Lin Hsieh, and Adam J P Smith. 2021. “Climate Change Is Probably Increasing the Intensity of Tropical Cyclones.” Critical Issues in Climate Change Science, ScienceBrief Review.

Lidskog, Rolf, and Daniel Sjödin. 2016. “Risk Governance through Professional Expertise. Forestry Consultants’ Handling of Uncertainties after a Storm Disaster.” Journal of Risk Research 19 (10): 1275–90. https://doi.org/10.1080/13669877.2015.1043570.

Logmani, Jacqueline, Max Krott, and Lukas Giessen. 2016. “Fragmented National Public Media Debate on International Forest Issues: A Case Study of Germany.” Canadian Journal of Forest Research 46 (9): 1081–91. https://doi.org/10.1139/cjfr-2015-0298.

Lugo, A. E. 2008. “Visible and Invisible Effects of Hurricanes on Forest Ecosystems: An International Review.” Austral Ecology. https://doi.org/10.1111/j.1442-9993.2008.01894.x.

Luxon, Emily Matthews. 2019. “Mobilizing Environmental Sentiment through the Media.” Environmental Politics 28 (4): 639–62. https://doi.org/10.1080/09644016.2018.1560743.

Marsooli, Reza, Ning Lin, Kerry Emanuel, and Kairui Feng. 2019. “Climate Change Exacerbates Hurricane Flood Hazards along US Atlantic and Gulf Coasts in Spatially Varying Patterns.” Nature Communications 10, 3785. https://doi.org/10.1038/s41467-019-11755-z.

Mehmood, Sayeed R., and Daowei Zhang. 2001. “Forest Parcelization in the United States.” Journal of Forestry 99 (4): 30–34. https://academic.oup.com/jof/article/99/4/30/4614372.

Miles, Brian, and Stephanie Morse. 2007. “The Role of News Media in Natural Disaster Risk and Recovery.” Ecological Economics 63 (2–3): 365–73. https://doi.org/10.1016/J.ECOLECON.2006.08.007.

Molder, Amanda L, and Mikhaila N Calice. 2023. “What Do Extreme Weather Events Say about Climate Change? Comparing Politicization and Climate Policy in U.S. Wildfire and Hurricane News Coverage.” Environmental Communication 17 (4): 370–85. https://doi.org/10.1080/17524032.2023.2190495.

Mook, Anne, and Puneet Dwivedi. 2023. “Shifting Forest Landownership Interests over the Life-Course of Female Forest Landowners in Rural Georgia, United States.” Journal of Rural Studies 100 (May). https://doi.org/10.1016/j.jrurstud.2023.103008.

Mook, Anne, Noah Goyke, and Puneet Dwivedi. 2022. “Conservation Intentions and Place Attachment among Male and Female Forest Landowners.” Rural Sociology 87 (3): 817–46. https://doi.org/10.1111/ruso.12434.

Morse, Wayde C, William J Mclaughlin, J D Wulfhorst, Celia Harvey, W C Morse, W J Mclaughlin, and C Harvey. 2013. “Social Ecological Complex Adaptive Systems: A Framework for Research on Payments for Ecosystem Services.” Urban Ecosystems 16: 53–77. https://doi.org/10.1007/s11252-011-0178-3.

Nagy, R. Chelsea, and B. Graeme Lockaby. 2011. “Urbanization in the Southeastern United States: Socioeconomic Forces and Ecological Responses along an Urban-Rural Gradient.” Urban Ecosystems 14 (1): 71–86. https://doi.org/10.1007/s11252-010-0143-6.

Noori, Navideh, Latif Kalin, Sumit Sen, Puneet Srivastava, and Charlene Lebleu. 2016. “Identifying Areas Sensitive to Land Use/Land Cover Change for Downstream Flooding in a Coastal Alabama Watershed.” Regional Environmental Change 16: 1833–45. https://doi.org/10.1007/s10113-016-0931-5.

Pan, Yi, Yaoqi Zhang, Indrajit Majumdar Pan, Y Zhang, and Y & Majumdar. 2009. “Population, Economic Welfare and Holding Size Distribution of Private Forestland in Alabama, USA.” Silva Fennica 43 (1): 161–71. http://www.metla.fi/silvafennica/full/sf43/sf431161pdf.

Park, Mi Sun, and Daniela Kleinschmit. 2016. “Framing Forest Conservation in the Global Media: An Interest-Based Approach.” Forest Policy and Economics 68 (July): 7–15. https://doi.org/10.1016/J.FORPOL.2016.03.010.

Peek, Lori A, and Dennis S Mileti. 2002. “The History and Future of Disaster Research.” Handbook of Environmental Psychology.

Pickett, S T A, Jianguo Wu, and M L Cadenasso. 1999. “Patch Dynamics and the Ecology of Disturbed Ground: A Framework for Synthesis.” In Ecosystems of Disturbed Ground, 707–22. Elsevier.

Prestemon, Jeffrey P., and Thomas P. Holmes. 2010. “Economic Impacts of Hurricanes on Forest Owners.” General Technical Report PNW-GTR-802. Vol. 2.

Reser, Joseph P., and Janet K. Swim. 2011. “Adapting to and Coping With the Threat and Impacts of Climate Change.” American Psychologist 66 (4): 277–89. https://doi.org/10.1037/a0023412.

Rickenbach, Mark G., and A. Scott Reed. 2002. “Cross-Boundary Cooperation in a Watershed Context: The Sentiments of Private Forest Landowners.” Environmental Management 30 (4). https://doi.org/10.1007/s00267-002-2688-5.

Rodríguez, Celia Tardío, Mark Snethlage, Aysegul Cil, and Sophie Condé. 2013. “Working Paper on an Overview of Activities to Assess Public Awareness on Biodiversity in Non-EU Countries: Towards an EEA Wide Public Awareness Indicator.” http://bd.eionet.europa.eu/.

Rowan, Katherine E. 1991. “Goals, Obstacles, and Strategies in Risk Communication: A Problem-Solving Approach to Improving Communication About Risks.” Journal of Applied Communication Research 19 (4). https://doi.org/10.1080/00909889109365311.

Rudiawarni, F A, I Made Narsa, and B Tjahjadi. 2020. “Are Emotions Exacerbating the Recency Bias?: An Experimental Study.” International Journal of Trade and Global Markets 13 (1): 61–70.

Sample, V. A. 1994. “Building Partnerships for Ecosystem Management on Mixed Ownership Landscapes.” Journal of Forestry 92 (8).

Sass, Emma M., Marla Markowski-Lindsay, Brett J. Butler, Jesse Caputo, Andrew Hartsell, Emily Huff, and Amanda Robillard. 2021. “Dynamics of Large Corporate Forestland Ownerships in the United States.” Journal of Forestry 119 (4): 363–75. https://doi.org/10.1093/jofore/fvab013.

Schelhas, John, and Robert Zabawa. 2009. “The Social Structure of Family and Farm Forestry in Alabama.” In Baumgartner, David M.; Ed. Proceedings of Human Dimensions of Family, Farm, and Community Forestry International Symposium, March 29 – April 1, 2004. Washington State University, Pullman, WA, USA. Washington State University Extension MISC0526.

Schelhas, John, Yaoqi Zhang, Robert Zabawa, and Bin Zheng. 2012. “Exploring Family Forest Landowner Diversity: Place, Race, and Gender in Alabama, Unites States.” International Journal of Social Forestry (IJSF) 5 (1): 1–21.

Soucy, Alyssa, Sandra De Urioste-Stone, Parinaz Rahimzadeh-Bajgiran, Aaron Weiskittel, and Bridie Mcgreavy. 2020. “Understanding Characteristics of Forest Professionals and Small Woodlot Owners for Communicating Climate Change Adaptation ☆.” Trees, Forests and People 2: 100036. https://doi.org/10.1016/j.tfp.2020.100036.

Spence, Alexa, Wouter Poortinga, and Nick Pidgeon. 2012. “The Psychological Distance of Climate Change.” Risk Analysis 32 (6): 957–72. https://doi.org/10.1111/J.1539-6924.2011.01695.X.

Stanturf, John A., Scott L. Goodrick, and Kenneth W. Outcalt. 2007. “Disturbance and Coastal Forests: A Strategic Approach to Forest Management in Hurricane Impact Zones.” Forest Ecology and Management 250 (1–2): 119–35. https://doi.org/10.1016/J.FORECO.2007.03.015.

Stårdal, Støle, Gudbrand Lien, and J. Brian Hardaker. 2007. “Perceived Risk Sources and Strategies to Cope with Risk among Forest Owners with and without Off-Property Work in Eastern Norway.” Scandinavian Journal of Forest Research 22 (5): 443–53. https://doi.org/10.1080/02827580701553701.

Stedman, Richard C. 2004. “Risk and Climate Change: Perceptions of Key Policy Actors in Canada.” Risk Analysis 24 (5): 1395–1406. https://doi.org/10.1111/j.0272-4332.2004.00534.x.

Sténs, Anna, and Erland Mårald. 2020. “‘Forest Property Rights under Attack’: Actors, Networks and Claims about Forest Ownership in the Swedish Press 2014–2017.” Forest Policy and Economics 111 (February). https://doi.org/10.1016/j.forpol.2019.102038.

Susaeta, Andres, Douglas R. Carter, and Damian C. Adams. 2014. “Impacts of Climate Change on Economics of Forestry and Adaptation Strategies in the Southern United States.” Journal of Agricultural and Applied Economics 46 (2). https://doi.org/10.1017/s1074070800000778.

Tran, Yenie L., Jacek P. Siry, Robert L. Izlar, and Thomas G. Harris. 2020. “Motivations, Business Structures, and Management Intentions of Large Family Forest Landowners: A Case Study in the U.S. South.” Forest Policy and Economics 118. https://doi.org/10.1016/j.forpol.2020.102244.

United States Department of Agriculture Farm Service Agency. 2019. “USDA Announces Block Grants for Three States as Part of Broader Disaster Relief Package. News Release, November 8, 2019. https://www.fsa.usda.gov/news-room/news-releases/2019/usda-announces-block-grants-for-three-states-as-part-of-broader-disaster-relief-package

Viinikainen, N.-E. 2021. “The Economic Cost of Climate Change in the United States of America.” Metropolia University of Applied Sciences. https://www.theseus.fi/bitstream/handle/10024/495300/Viinikainen_Noora-Emilia.pdf?sequence=2.

Weick, K, K M Sutcliffe, and D Obstfeld. 2009. “Organizing and the Process of Sensemaking.” In Handbook of Decision Making, 129–52. Chichester: Wiley.

Weiner, Roberta, Sarah P. Church, Junyu Lu, Laura A. Esman, Jackie M. Getson, Michelle Fleckenstein, Brennan Radulski, et al. 2021. “Climate Change Coverage in the United States Media during the 2017 Hurricane Season: Implications for Climate Change Communication.” Climatic Change 164 (3–4): 1–19. https://doi.org/10.1007/S10584-021-03032-0/TABLES/5.

Wenger, Etienne. 2000. “Communities of Practice and Social Learning Systems.” Organization 7 (2): 225–46. https://doi.org/10.1177/135050840072002.

Wiener, Sarah S., Nora L. Álvarez-Berríos, and Angela B. Lindsey. 2020. “Opportunities and Challenges for Hurricane Resilience on Agricultural and Forest Land in the U.S. Southeast and Caribbean.” Sustainability (Switzerland) 12 (4). https://doi.org/10.3390/su12041364.

Witte, K. 1992. “Putting the Fear Back into Fear Appeals: Reconciling the Literature.” Communication Monographs 59: 329–49.

Zwick, Michael M. 2005. “Risk as Perceived by the German Public: Pervasive Risks and ‘Switching’ Risks.” In Journal of Risk Research, 8:481–98. https://doi.org/10.1080/13669870500064150.

Chapter 3. Social valuation of biodiversity and ecosystem services by Southeastern coastal forest landowners

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Social valuation of biodiversity and ecosystem services by coastal Southeastern forest landowners

Abstract

Coastal and upland forests provide many services which sustain and fulfill human life. However, in the southeastern United States, most forest land is privately owned, so landowners are the primary decision-makers. The region is facing high risk of deforestation and land use conversion due to development and other structural factors. The purpose of this study was to assess Southeastern private forest owners' social valuation of forest ecosystem services, to assess their interest in receiving incentives for managing their land to conserve those services, and to explore which landowner characteristics may differentiate their values and conservation interest. We delivered a mail survey to private forest landowners with parcels of at least 50 acres across the Florida panhandle and coastal Alabama. We found that landowners valued biodiversity higher than all other services, followed by regulating services, then cultural services, and they valued provisioning services the least. Using multi-factor ANOVAs, we found differences in the social valuation of ecosystem services and biodiversity across landowner characteristics. Through a supplemental Principal Components Analysis, we found and discussed strengths and limitations of applying the adapted scale to any landowners who rely on natural resources for income. Additionally, we found that most landowners would be interested in incentives to manage for ecosystem services conservation. These results are useful for decision-makers trying to implement policies to conserve forest and watershed ecosystem services because they can appeal to values which landowners attach to the environment.

Key Words: Southeast, private forest, non-monetary valuation, landowner decision-making, payments for ecosystem services, social-ecological systems, coastal watersheds.

Introduction

Forest ecosystems provide services which sustain and fulfill human life in their surrounding communities (G. C. Daily 1997). In coastal watershed systems, forest landscapes maintain water quality and clarity, reduce agricultural nutrients and chemical pollutants, reduce flooding risk, and provide wildlife habitat, timber products, and recreation opportunities (Conmy and others 2017; Lehrter and Le 2017; Nagy and Lockaby 2011; Stednick 1996). Riparian buffers provide much of the watershed benefits of forests (Anbumozhi, Radhakrishnan, and Yamaji 2005; Alvarenga et al. 2017). In the southeast United States, humans are the dominant organism, and they benefit from all categories of ecosystem services: Provisioning, regulating, cultural, and supporting (Millennium Ecosystem Assessment (MEA) 2003). However, private landowners hold approximately 86% of the forest land in the southeast, so these riparian buffers and services primarily lie within individuals' land management decisions (B. J. Butler et al. 2021). Further, landowners in headwater regions do not perceive their influence on downstream systems and underestimate the conservation impacts of headwater streams; and in the southeast specifically, landowners may underestimate their forest stand's impacts on watershed services (Armstrong and Stedman 2020; Kreye et al. 2021). In social-ecological systems (SES), landowners operate within and across the surrounding natural and social systems which encompass their livelihood strategies and activities (Holland 1992; Morse, Hollenhorst, and Stoian 2007). Humans in these systems react and adapt to changes across the social and ecological systems within which they operate, and their adaptive actions, in turn, alter the systems (Adger et al. 2005; Giddens 1984; Stones 2005; Morse et al. 2013). Forests in private ownership support and provide watershed quality and benefits, but landowners in the southeast United States may be underestimating their properties' roles in the ecosystem.

Whether fiscal or social, landowners assign values to their forest land. The most frequently cited motivations for forest land ownership in this region are investment or income, recreation, and residential purposes (B. J. Butler et al. 2021; Bengston, Asah, and Butler 2011). These motivations are all driven by some level of capital or physical use; however, immaterial motivations, also known as non-use values (for example, beauty and scenery) are more difficult to quantify and can stem from broader cultural and regional values (Raymond and Kenter 2016; Kenter et al. 2015). Broader cultural and regional values, sometimes called "shared social values," are the values that groups or communities hold in common, and which reflect the social context of the region (e.g., faith-based communities, environmentalists) (Kenter et al. 2015). In the environmental management context, values include concepts like duty to future generations or responsibility to the ecosystem (Kenter et al. 2015). Regardless of the value structure, humans place values upon ecosystem services, and these values have often been studied in the economic context (Costanza 2000; Torres, Tiwari, and Atkinson 2021). Additionally, government policies and programs often fail to meet watershed populations' requirements for watershed ecosystem services (Kreye, Adams, and Escobedo 2014). The pressure production forestry places on an ecosystem can be compounded when surrounding forests are diminished through land conversion and deforestation, and in return these cycle changes affect the economic viability of forest landownership (Geist and Lambin 2002). One approach to conserving privately stewarded ecosystem services is through Payments for Ecosystem Services (PES) to landowners to promote actions to support ecosystem services or to reduce harmful actions (OECD 2000; Morse and others 2007; Wunder 2007). When landowners participate in PES programs, they receive incentives for executing a plan collaboratively designed with a forestry professional which outlines best management practices for supporting the ecosystem services provided by their

woodland. PES can contribute positively to forest retention and social norms play a role in re-enrollment over time (Morse et al. 2009; Chen et al. 2012).

In the southeast, forest landowners are requisite stewards for the watershed, but there may be a disconnect between landowner values and the priorities of policy decision-makers of the region. Conducting social valuation assessments for the ecosystem services provided by a resource or region can identify the local values to which policy makers can appeal. There are three primary categories of goals and preference for conducting social valuation: Efficiency (current individual preferences), fairness (community preferences), and sustainability (whole system preferences) (Costanza 2000). Researchers have not studied social valuation for the ecosystem services provided by private forests in the southeast.

Although timber production is a prominent land use for Southeastern forest owners, there is much to learn about future forest cover outside of the economic realm. A priority in conducting social valuations is to integrate diverse values to develop stakeholder inclusive, participatory, co-designed research which can improve the fairness, equity, and applicability of ecosystem services assessments (Bennett 2017; Boeraeve et al. 2018). Social valuation metrics co-designed with stakeholders are adaptable to different decision-making contexts and enhance persuasive communication within the realm of those decisions (Asah and Blahna 2020). By utilizing an adaptable social valuation scale, it is possible to elicit empirical estimations of respondents' ascribed values to specific aspects of nature (Asah and Blahna 2020). For example, in a co-designed scale developed to determine valuation for the biodiversity and ecosystem services of the Deschutes National Forest, Asah and Blahna (2020) developed more accessible terminology for questionnaires by labeling the assessments with the stakeholders' most frequently used language. For their questionnaire, they respectively labeled regulating, cultural,

and provisioning services as “functions,” “human benefits,” and “products” of the forest throughout the assessment (Asah and Blahna 2020). Applying instruments developed through co-designed methods improves the relevance and accuracy of the values assessed.

Social valuation studies tend to focus on analyzing group differences across socio-demographic traits, proximity to the resource (i.e., resident, visitor, urban, and rural), and environmental awareness (Zoderer et al. 2016; Walz, Grêt-Regamey, and Lavorel 2016; Schmidt et al. 2017). One such study of forest ecosystem services found that stakeholders lack knowledge about the concept of ecosystem services, but that socio-cultural valuation can target landowner priorities and preferences and improve planning for relevant outreach and education to promote management conducive to ecosystem services maintenance (Velasco-Muñoz et al. 2022). Other studies have focused on landscapes and land use preferences in the context of ecosystem services valuation, but do not tend to target forest landowners’ valuations of the services their private woodland provides (Velasco-Muñoz et al. 2022; Zoderer et al. 2016; Schmidt et al. 2017; Yang et al. 2019). A worldwide review identified the social valuation of forest ecosystem services as a relatively emerging topic compared to other valuation approaches and social valuations of other ecosystems (Velasco-Muñoz et al. 2022). The information gained from landowner valuation can bolster our understanding of how environmental values interplay with social systems and influence landowner management activities in a SES (Kline et al. 2017). There is a lack of knowledge about Southeastern forest owners’ perceptions of the services their forest lands provide.

The southeast United States is facing continued forest loss and land conversion due to development and other structural factors (Greene et al. 2020; Henderson et al. 2022; Khanal et al. 2016; Sharma et al. 2021; Nagy and Lockaby 2011). Researchers have identified urbanization as

the leading cause of deforestation in the United States, and a co-production mapping project indicated that 17.7 million acres of southern forest are at risk of deforestation by 2060 (Nagy and Lockaby 2011; Greene et al. 2020). Because the region's forests are primarily privately owned, it is urgent to study any factors contributing to land use decision-making. Therefore, it is necessary to understand and account for the social valuation of ecosystem services by private forest owners in the Southeast. Understanding landowners' implicit value perspectives towards their woodlands can provide insight into their motivations, priorities, and preferences which can inform policy and incentives to reduce deforestation. The purpose of this study was to (1) assess Southeastern private forest owners' social valuation of ecosystem services provided by their woodland by using an adapted assessment tool, (2) to assess their interest in receiving PES for managing their land to conserve those services, and (3) to explore which landowner characteristics may differentiate their values and conservation interest.

Methods

Study area

The study site spanned a portion of the northern Gulf of Mexico (GOM) commonly referred to as the "Emerald Coast" (Figure 1). This area is known for its clear waters, productive bays, and iconic beaches. We conducted this study across 11 counties, 10 of which were in Florida, 1 of which was in Alabama. The forest cover for these counties ranges from 40% to 90% of total land area, and all but Escambia County, FL host 50% or more forest cover (USDA Forest Service, Forest Inventory and Analysis Program 2022).The study site spanned ten Hydrologic Unit Code-8 (HUC-8) (a policy-relevant watershed unit in line with federal resource management agencies) watersheds which drain into the northern GOM. Forestry in the inland watershed and urbanization along the coast are both important socio-economic features in this region; however,

Florida counties receive 40% of the nation's hurricane landfalls and forest landowners face extensive damages which reduces the economic viability of their ownership (Etters 2019). This region displays stark transitions from the urban coastline to the rural upland forested area which is primarily privately owned.

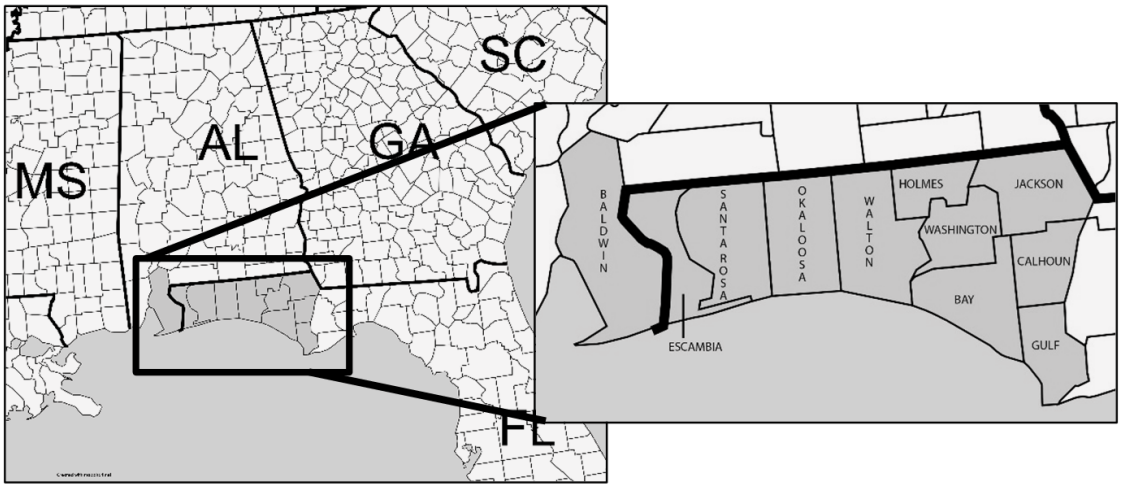


Figure 1. Florida and Alabama study site counties (N = 11). Baldwin county provided the sole Alabama sample.

Data collection

We conducted a mail survey using a modified Tailored Design Method (Dillman, Smyth, and Christian 2009). The survey distribution, data storage, and analysis were all approved by the Office of Human Research (Institutional Review Board) at Auburn University under Protocol 20-271 EX 2007. We delivered three total contacts: 1) A welcome letter with the survey booklet and a return envelope, 2) a reminder postcard, and 3) a final reminder letter including a web address to take the survey online (Appendix A). An online version of the survey (exact copy) was developed using Qualtrics software. The third mailing directed landowners to access the Qualtrics survey if they preferred. The only addition to the Qualtrics survey was Question 1

which asked for a code printed on the third mailing to allow the removal of duplicates in case a respondent returned a paper survey and completed an online survey. These unique codes were not associated with names and addresses during data analysis.

The study population included private woodland owners (i.e., family forests, corporations, and trusts) who owned at least one parcel of 50 acres or more of forest. These forest owners all owned parcels within the eleven-county study area (Figure 1). Forest owners were identified through two sources: The Florida Department of Revenue 2020 Tax Roll and the Baldwin County, AL Revenue Commission. There was no maximum parcel size for filtering the sample of landowners. We removed any duplicate addresses or landowner names from the individual county datasets. Upon compiling all county parcels into one sheet, the duplication removal process was repeated, and 708 landowners were deleted using random deletion to bring the total down to 3000. We followed this randomization with manual review and further duplicate deletion, and after shipping, we removed any failed deliveries from the recipient list. The final total of surveys delivered was 2885. The data collection took place in the from July to September 2022.

Social valuation and questionnaire design

We conducted the social valuation assessment via a questionnaire sent to a sub-population of forest landowners in the study area. The social valuation instrument was adapted from an existing co-designed scale tested for social valuation of ecosystem services in the Deschutes National Forest to allow for comparison (Asah and Blahna 2020). We adapted the scale for the context of Southeastern forest owners by collaborating for expert review with the forestry management and advising professionals. There were four sections representing three categories of ecosystem services: Provisioning, regulating, and cultural, but we assessed values

for “biodiversity” in lieu of supporting services, which was in line with our referenced co-designed scale and other studies (Millennium Ecosystem Assessment 2003; Asah and Blahna 2020; Velasco-Muñoz et al. 2022). We conducted this study utilizing the definitions of ecosystem services developed through the MEA (2003), as opposed to definitions and metrics developed by other efforts like The Economics of Ecosystems and Biodiversity or the Intergovernmental Platform on Biodiversity and Ecosystem Services to contribute to the growing body of social valuations literature which aims to improve assessments based on MEA definitions (The Economics of Ecosystems and Biodiversity (TEEB) 2010; Pascual et al. 2017). Across the four sections, there were 26 Likert scale questions for landowners to value individual indicators of ecosystem services by rating in the context of “how important to you are the following from your own woodland?” The scales were seven-point scales and ranged from 1 = not important at all to 7 = very important. The questionnaire also contained several questions about socio-demographic factors, landowner characteristics and past decision-making behaviors, and interest in PES. The full questionnaire is available in Appendix A.

Data analysis

We used some of the analytical methods from Asah and Blahna (2020) to allow for comparison of the co-produced scale and advance the discussion of its applicability. We conducted all statistical analyses in SPSS statistical software. The social valuation scale included four instruments (biodiversity, regulating services, provisioning services, and cultural services) aggregated from individual indicators. For example, timber products were an indicator for provisioning services. Asah and Blahna (2020) demonstrated exceptional Cronbach’s α reliability for all instruments for the co-designed scale. We conducted Cronbach’s α reliability testing for the instruments as well given our novel study population. Precision measures of 0.650

to 0.700, meaning error constitutes less than 30-35% of the valuation scale, are conventionally considered adequate in human dimensions research (Vaske 2008); given this and the original scale's reliability, we considered an α score greater than or equal to 0.800 to be a strong reliability score (Asah and Blahna 2020). Based on these conventions, we considered our valuation scales reliable if less than 35% of the valuation was constituted by error. To improve our recommendations, we also reviewed the valuation instruments by conducting a principal components analysis (PCA) for which we used the Kaiser criterion (eigenvalue > 1) to extract components loaded by based on the amount of variance they explain. Due to our Likert scale format, we applied the oblique rotation of factors and interpreted the pattern matrix for the component loadings of individual items across the instruments (Schreiber 2021).

Cronbach's alpha α tests assess the extent to which each of the individual items in a scale correspond to one another (i.e., when respondents indicate a high score for one item, they are likely to score other items in the same scale similarly high). While we may have improved our reliability for provisioning services by removing the item "timber products," we decided to retain the item due to its relevance to our study population. Other social valuation studies observed similar discrepancies in their scales for provisioning services: Valuations differed more on specific items than between instruments because respondents are prioritizing a few items at the expense of others (Zoderer et al. 2016; Burkhard et al. 2012).

While our dependent variables (the four instruments) violated the assumption of normality, as is common in Likert scale data, we proceeded with parametric means analysis tests due to their robust nature when testing a large sample which is representative of the population (Harpe 2015; Ghasemi and Zahediasl 2012). Further, we treated the Likert scales as continuous because it is appropriate to do so when applying an aggregated scale with more than five levels

on the scale (Harpe 2015; Vaske 2008). The aggregated scales ranged from acceptable to strong reliability and we aggregated them by the mean valuations across individual items which further justifies the use of mean valuations, as opposed to medians, for statistical comparison. When the assumption of normality is violated, it is more likely to inflate the *p*-value than to shrink it, so proceeding with the parametric tests can be more conservative than applying non-parametric statistics, which are less robust to violations, across a large population (Ghasemi and Zahediasl 2012).

Upon determining acceptable reliability, we compiled aggregate scores for all four instruments of the social valuation. To do so, we "scored" individual items by calculating the mean value of the item, then we calculated the mean value for the items designed to indicate each instrument as the instrument score. We computed aggregate scores for all four instruments. The aggregate instrument scores were necessary to conduct any further analysis with the respondent characteristics. Once we had aggregate scores for the items and instruments, we conducted mean comparison tests for the overall social valuation of each instrument. We ran pairwise *t* tests to compare the valuation of each instrument and computed mean scores to descriptively analyze the variation in valuation across individual items in each instrument. These tests provided insight into the specific aspects of each instrument which respondents perceived as the highest value facets of a category of the ecosystem.

Further analysis involved mean comparisons to investigate the role of landowner characteristics and past behaviors, self-stated interest in PES and involvement in conservation, and socio-demographics factors in respondents' social valuations of ecosystem services. We conducted a multi-factor analysis of variance (ANOVA) to assess whether mean valuations differed based on the factors analyzed. We chose multi-factor ANOVA as opposed to one-way

ANOVAs and independent samples *t* tests because the multi-factor ANOVA allowed us to control for all other predictor variables while interpreting the results, to test for interactions between predictor variables, and to reduce Type I Error risk by accounting for swamping (interpreting a non-significant as significant due to isolation other predictors). We analyzed four multi-factor ANOVAs: One for each valuation instrument. Figure 2 depicts the nine categorical factors in the ANOVAs and the descriptive information for each factor.

We interpreted the main effects by observing the *F*-statistic and the p-value to determine if there was a significant difference in mean valuation between groups for the categorical variables. For polychotomous variables with a statistically significant main effect, we conducted Tukey's post-hoc analysis of the estimated marginal means and applied a Bonferroni correction for multiple comparisons. We tested all main effects for 2x2 interactions listwise and removed any non-significant interactions. For significant interactions, we did not interpret the main effects of the factors interacting, but we interpreted the interaction term visually and descriptively through bar graphs, estimated marginal means, and 95% confidence intervals; we considered mean differences statistically significant if the confidence intervals had minimal (less than 25% of the interval length) or no overlap (Garofalo et al. 2022). For all statistical tests, we applied the alpha level of $p < 0.050$ to accept statistically significant mean differences. In addition to socio-economic factors, we tested the following landowner characteristics for differences in mean valuation: Estate planning, past experience with a stand damaging wind damage, interest in conservation incentives, and presence of streams on woodland. We included these factors because each of them is a contextual variable which can indicate the stability of forest ownership (Bell et al. 2019), the environmental sensitivity of parcels (Armstrong and Stedman 2020), and perspective of participatory conservation (Kelly and Crandall 2022). Tables 2-5 depict the full

Legend for polychotomous categories	
Income	A = Less than $50,000
	B = $50,000-$99,999
	C = $100,000-$150,000
	D = More than $150,000
Education	A = High school graduate or GED
	B = Associate's or technical degree
	C = Bachelor's degree
	D = Graduate/Advanced degree
Land use	A = Single-Use Forestry
	B = Multi-Use Forestry
	C = Single-Use Non-Forestry
	D = Multi-Use Non-Forestry
	E = Not Actively Used

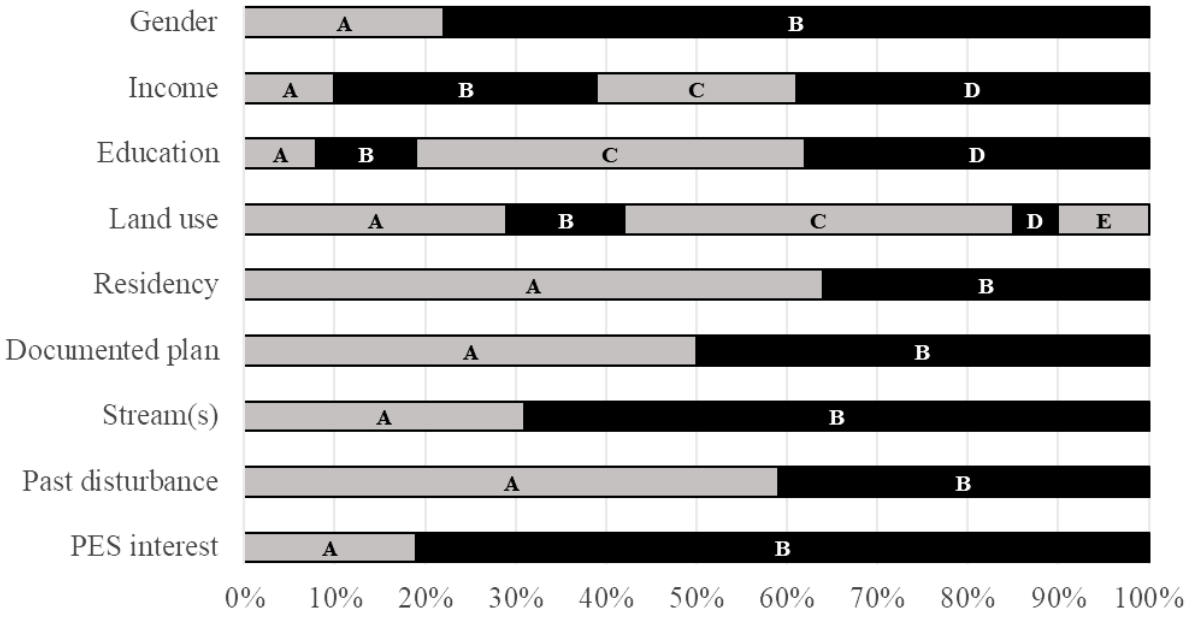


Figure 2. Proportion of respondents in each category of factors for social valuation assessments. Valid *N* = 345-349 depending on the social valuation instrument, however, rounded proportions were approximately static across instruments. Valid *N* is listed in Tables 1-4. For residency, documented plan, stream(s), past disturbance, and PES interest: A = No, B = Yes. For gender, A = Female, B = Male.

results of the factors included in the models. We additionally summarized and discussed respondent profiles related to hunting, fishing, and conservation goals.

Finally, we conducted a binary logistic regression to determine which factors predict landowner interest in PES. We asked landowners seven questions about their history with conservation decisions, their current land uses, and their perceptions of desired relative profit in a conservation incentive program. For our dependent variable, we asked landowners the following question on a seven-point scale: "If there were a conservation program that offered you a payment or tax benefit for maintaining the services and human benefits your woodland provides, how interested would you be in hearing more about the program?" The scale ranged from 1 = not interested to 7 = very interested with 4 = interested labeled as the midpoint. We transformed the scale to a binary variable by labeling values 1-3 as "not interested" and values 4-7 as "interested." All predictor variables were categorical, polychotomous predictors were dummy coded and analyzed across all possible reference categories, and there was no multicollinearity identified across predictors (for all, VIF < 2.00). We analyzed the results via the odds ratios relative to dummy coded reference categories for all variables.

Results

Reliability and Aggregated Scale Valuation

Three of the four sections of the scale displayed strong reliability. The Cronbach's α scores were 0.921, 0.949, and 0.811 for biodiversity, regulating, and cultural services, respectively. The Cronbach's α for the provisioning section was adequate at a value of 0.652.

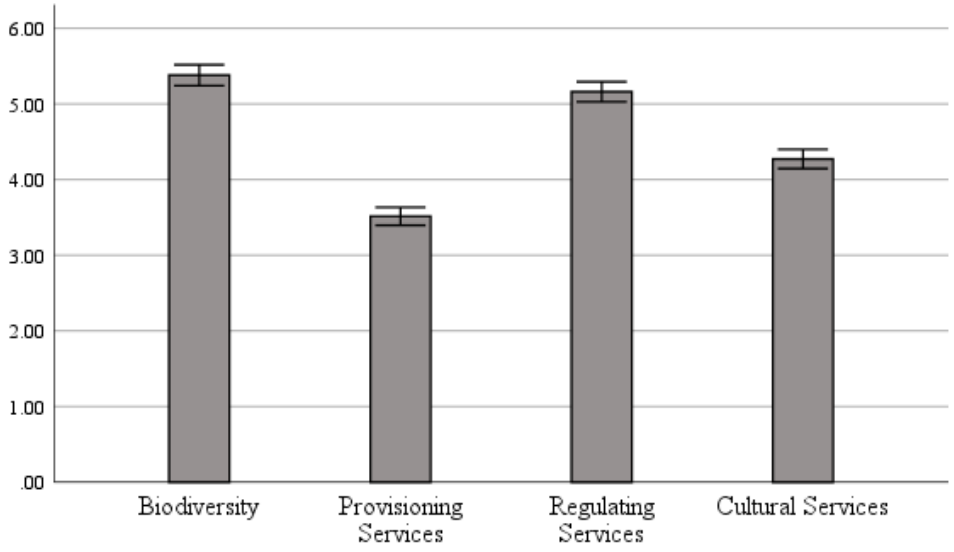


Figure 3. Mean (± 95% C.I.) of biodiversity and ecosystem services instruments on a seven-point scale (*N* = 519)

All pairwise *t* tests between the four valuation instruments resulted in statistically significant differences (for all tests, p<0.001; Figure 3). We observed that landowners valued biodiversity (*M* = 5.38; σ = 1.57) significantly higher than regulating (*M = 5.17*; σ = 1.52; +/- 0.051, +/- 95% C.I.), cultural (*M* = 4.27; σ = 1.44; +/- 0.069, +/- 95% C.I.), and provisioning (*M* = 3.52; σ = 1.37; +/- 0.073, +/- 95% C.I.) services. Landowners valued regulating services significantly higher than cultural (+/- 0.071, +/- 95% C.I.) and provisioning (+/- 0.075, +/- 95% C.I.) services. Finally, they valued cultural services significantly higher than provisioning (+/- 0.064, +/- 95% C.I.) services.

For the individual item scores, the mean valuations ranged from 2.33 to 5.75 on the seven-point scale (Figure 4). The lowest ranked items (*M* < 3.00) across all scales were non-.

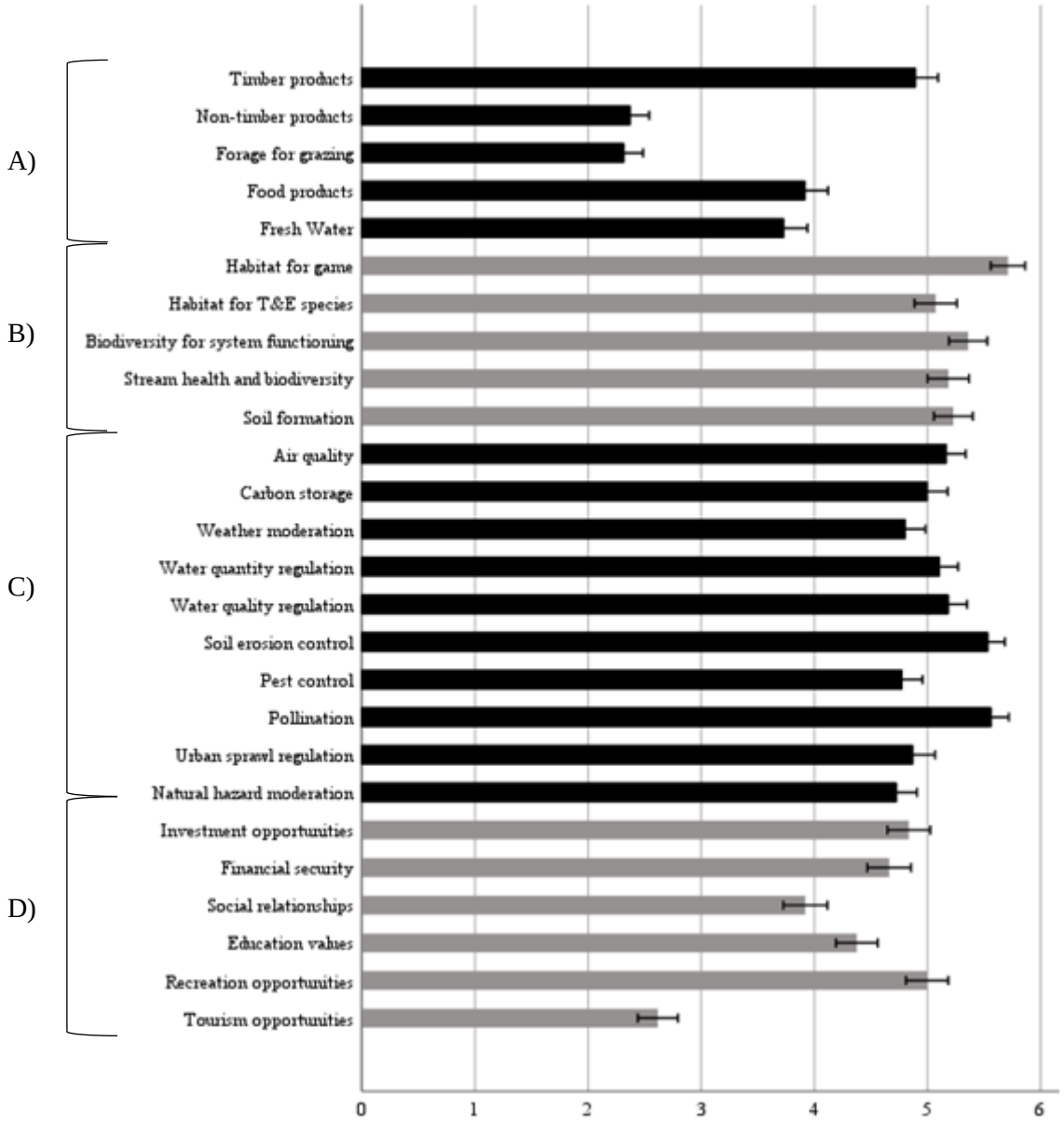


Figure 4. Mean valuation (± 2S.E.) of individual indicators of biodiversity and ecosystem services instruments on a seven-point Likert scale (*N* = 444). A = Provisioning, B = Biodiversity, C = Regulating, D = Cultural.

timber products (provisioning), forage for grazing (provisioning), and tourism opportunities (cultural). The highest valued item across all scales, and for the biodiversity instrument, was

habitat for game (M = 5.76; σ = 1.58). None of the mean valuations for indicators of biodiversity were below 5.00. Conversely, recreation opportunities were the highest valued item for cultural services, and it was the only item valued over 5.00. There were no items valued over 5.00 for provisioning services. Timber products, the highest valued provisioning item, were the only item valued above 4.00, and food products were the highest valued item otherwise. Respondents valued soil erosion control and pollination the highest of the regulating services and valued weather moderation, natural hazard moderation, urban sprawl regulation the lowest; however, these values were all higher than all provisioning services other than timber products.

The descriptive results for important considerations in forest management showed that 74% of respondents identified hunting and/or fishing as important, 88% identified forest conservation as important, and 91% of those who identified hunting and/or fishing as important also identified conservation as important. Of the hunting and/or fishing group, 85% selected that, in addition to themselves, they provided hunting and/or fishing access to their family and friends. Another 6% identified that they permit access to hunting clubs and the remaining 9% indicated other groups with permitted access, including the public, tenants, businesses, agencies, guides, or unspecified.

We supplemented the overall biodiversity and ecosystem services valuation analysis with a PCA for individual items across the four instruments. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy (KMO > 0.900) and the Bartlett's test of sphericity (p < 0.001) indicated that the items were appropriate for factor analysis. The results showed that there were five distinct components (Eigenvalue > 1; Table 1). The five factors explained 70.984% of the variance across the items list. Relative to the social valuation instrument we applied in this study, all items with high loadings (> 0.500) for Factor 1 described regulating services, for Factor 3 all

but one of the high loadings described biodiversity, for Factor 4 all high loadings described provisioning services, and for Factor 5 all high loadings described cultural services. Factor 2

Table 1. Principal components analysis pattern matrix for individual valuation items (N = 444)

Item	Component				
	1	2	3	4	5
Timber products	0.009	**0.792**	-0.024	0.132	0.165
Non-timber products	0.020	0.308	0.023	**0.542**	0.101
Forage for grazing	0.069	-0.075	0.116	**0.796**	0.010
Food products	-0.174	-0.071	-0.396	**0.610**	-0.135
Fresh water	0.149	-0.022	-0.097	**0.637**	-0.223
Habitat for game	0.036	0.041	**-0.826**	0.050	-0.028
Habitat for T&E species	0.354	-0.051	**-0.668**	0.050	0.078
Biodiversity for system functioning	0.385	0.003	**-0.683**	-0.006	0.058
Stream health and biodiversity	0.308	0.040	**-0.636**	0.047	-0.048
Soil formation	0.436	0.069	**-0.524**	0.011	-0.068
Air quality	**0.878**	0.040	-0.023	-0.005	0.045
Carbon storage	**0.927**	0.065	0.088	-0.023	0.063
Weather moderation	**0.951**	0.017	0.083	0.029	0.080
Water quantity regulation	**0.811**	-0.017	-0.035	0.026	-0.111
Water quality regulation	**0.848**	-0.025	-0.018	0.033	-0.054
Soil erosion control	**0.729**	0.042	-0.014	0.029	-0.082
Pest control	**0.727**	0.019	-0.035	0.100	-0.087
Pollination	**0.681**	-0.036	-0.239	0.064	0.002
Urban sprawl regulation	**0.575**	-0.133	-0.164	-0.066	-0.168
Natural hazard moderation	**0.807**	0.001	-0.042	-0.013	-0.049
Investment opportunities	-0.011	**0.881**	-0.007	-0.076	-0.153
Financial security	0.017	**0.863**	0.029	-0.074	-0.190
Social relationships	-0.004	0.254	-0.199	-0.076	**-0.700**
Education values	0.287	0.161	-0.172	0.037	**-0.548**
Recreation opportunities	-0.168	0.033	**-0.522**	0.098	**-0.539**
Tourism opportunities	0.158	-0.004	0.220	0.124	**-0.778**

Extraction method: Principal Component Analysis
Rotation method: Oblimin with Kaiser Normalization
Pattern matrix rotation converged on 11 iterations.

emerged as a separate category from the social valuation instruments applied and it included high loadings for timber products (provisioning), investment opportunities (cultural), and financial security (cultural). These three items did not have high loadings on any other factor. Recreation opportunities (cultural services) had a high loading on Factors 3 (biodiversity) and 5 (cultural services).

Multi-Factor ANOVAs

Biodiversity

The multi-factor ANOVA indicated statistically significant effects on biodiversity valuation for five main effects and two statistically significant interactions (Table 2). The results showed that there were statistically significant main effects for landowner experience with past wind disturbances to their forest (past disturbance) ($F(1, 329) = 5.127$, $p = 0.024$), whether landowners had a documented plan for what will happen to their woodland when they are no longer the owner (documented plan) ($F(1, 329) = 4.122$, $p = 0.043$), and a past disturbance by documented plan interaction ($F(1, 329) = 8.104$, $p = 0.005$). Figure 5A portrays the mean valuation differences across the past disturbance by documented plan interaction. Based on the 95% confidence intervals, the interaction term showed that landowners with both a documented plan and experience with a past disturbance ($M = 5.768$; ±0.354; ± 95% C.I.) valued biodiversity significantly higher than if they only had a documented plan without past disturbance experience ($M = 4.942$; ±0.367; ± 95% C.I.). Past disturbance also had a statistically significant interaction with residency ($F(1, 329) = 5.348$, $p = 0.021$; Figure 5B). Based on the 95% confidence intervals, landowners who were residents on their woodland and experienced a past disturbance ($M = 5.634$; ±0.483; ± 95% C.I.) valued biodiversity significantly higher than landowners who were residents but had not experienced a past disturbance ($M = 4.870$; ±0.375; ± 95% C.I.). Main effects analysis showed that there were differences in biodiversity values based on land use type ($F(4, 329) = 5.884$, $p < 0.001$), landowners with streams present on their woodland valued biodiversity higher than those without ($F(1, 329) = 20.409$, $p < 0.001$), and landowners interested in PES valued biodiversity higher than uninterested landowners ($F(1, 329) = 8.841$, $p = 0.003$). Tukey's Post-Hoc analysis indicated that multi-use forestry landowners valued biodiversity

services significantly higher than single-use non-forestry (p = 0.014; ± 0.781, ± 95% C.I.) and single-use forestry landowners (p < 0.001; ± 0.808, ± 95% C.I.; Figure 6A).

Table 2. Multi-factor analysis of variance of biodiversity social valuation (N = 348)

Item	Group	Mean	±SE	df	F	Sig.
Gender	Female	5.264	.202	1	.491	.484
	Male	5.125	.152			
Income	Less than $50,000	5.511	.263	3	1.330	.265
	$50,000-$99,999	5.255	.176			
	$100,000-$150,000	4.998	.225			
	More than $150,000	5.015	.191			
Education	High school graduate or GED	5.213	.299	3	1.695	.168
	Associate's or technical degree	5.515	.263			
	Bachelor's degree	4.935	.164			
	Graduate/Advanced degree	5.115	.162			
Residency	Not resident	5.137	.168	1	.479	.490
	Resident	5.252	.173			
Documented plan	No documented plan	5.034	.163	1	4.122	.043
	Documented plan	5.355	.174			
Land use	Single-use forestry	4.880	.183	4	5.884	<.001
	Single-use non-forestry	4.908	.244			
	Multi-use forestry	5.688	.173			
	Multi-use non-forestry	5.417	.355			
	Not actively used	5.079	.273			
Permanent stream(s) on woodland	No streams	4.814	.183	1	20.409	<.001
	Streams present	5.575	.158			
Past disturbance	No past disturbance	5.006	.154	1	5.127	.024
	Past disturbance experienced	5.383	.186			
Interest in ecosystem services incentives	Would not be interested	4.899	.210	1	8.841	.003
	Would be interested	5.490	.141			
Disturbance*Document plan	No*No	5.069	.180	1	8.104	.005
	No*Yes	4.942	.186			
	Yes*No	4.999	.217			
	Yes*Yes	5.768	.228			
Disturbance*Resident	No*No	5.141	.184	1	5.348	.021
	No*Yes	4.870	.191			
	Yes*No	5.133	.203			
	Yes*Yes	5.634	.246			

Based on estimated marginal means
R Squared = .222 (Adjusted R Squared = .179)

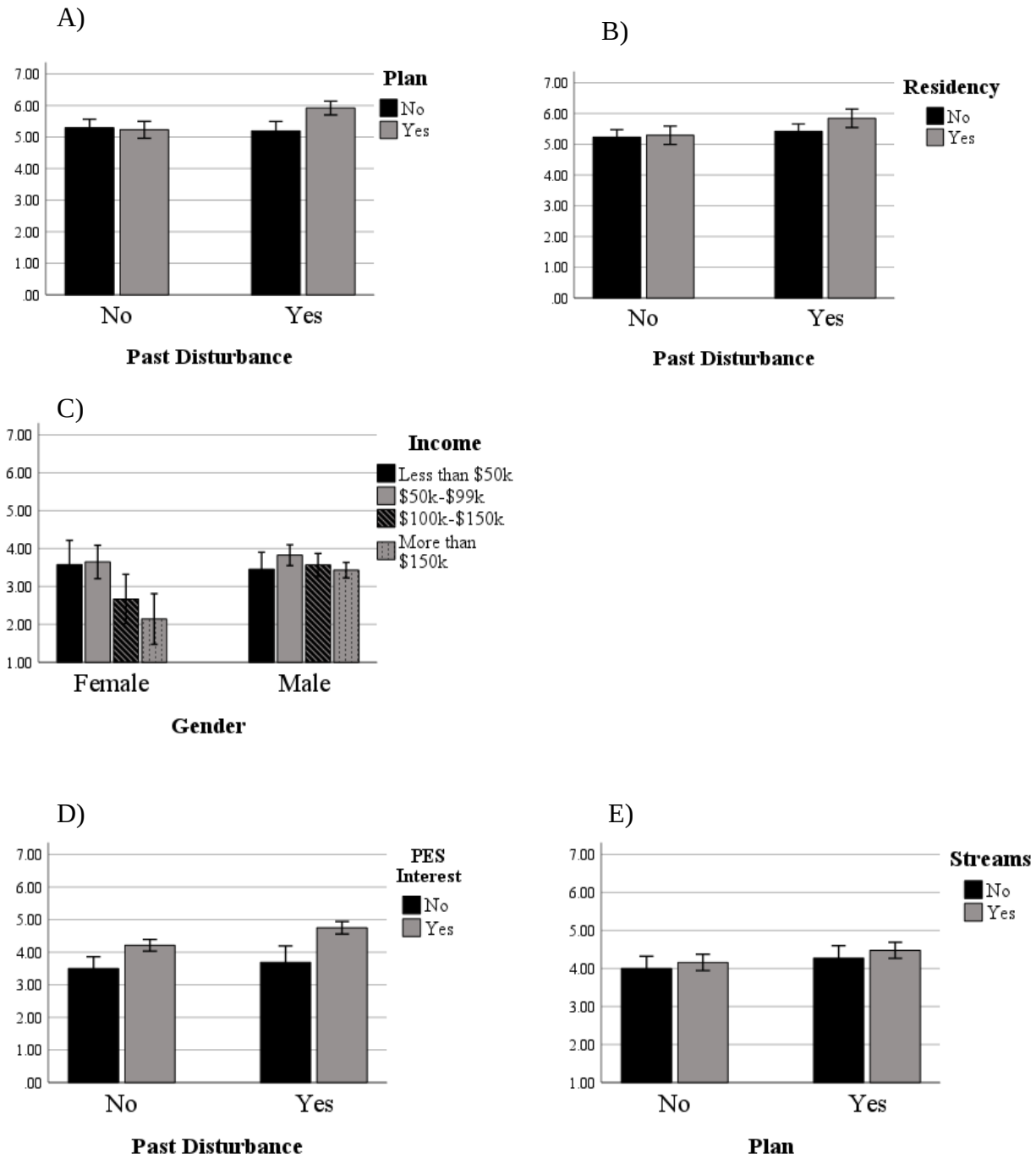
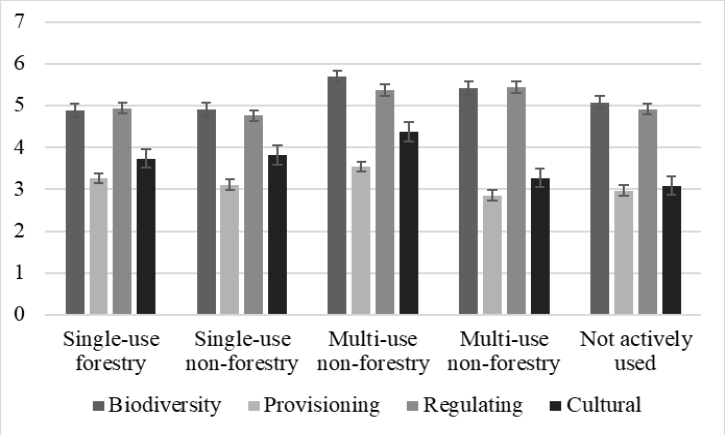
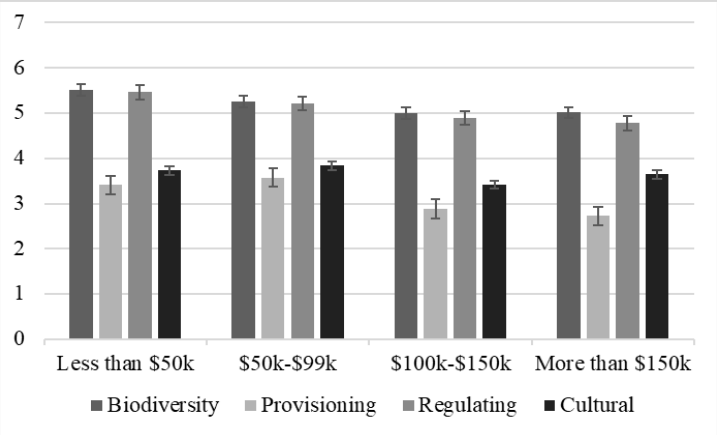


Figure 5. Significant interaction effects between factors in multi factor ANOVAs. All figures are based on estimated marginal means and error bars represent 95% confidence intervals. A-B = Biodiversity valuation interactions, C = Provisioning valuation interactions, D-E = Cultural

A)



B)



C)

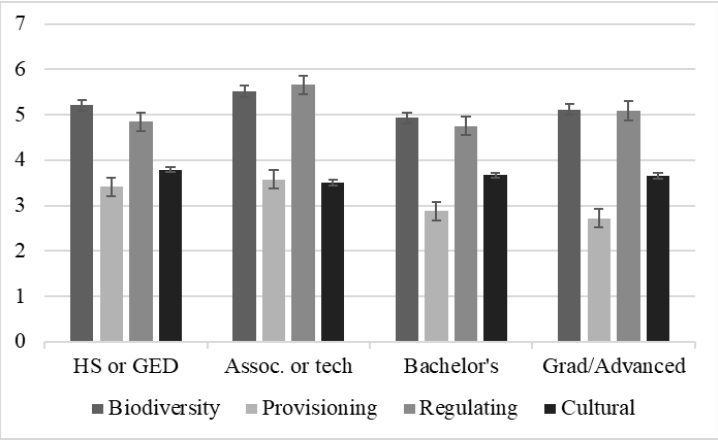


Figure 6. Tukey's Post-Hoc comparisons for main effects of polychotomous variables based on estimated marginal means (± 2S.E.). A = Land use, B = Income, C = Education. HS = high school graduate, Assoc. = associates, Tech = technical, Grad = graduate degree.

Provisioning services

The multi-factor ANOVA indicated statistically significant effects on provisioning services valuation for four main effects and one interaction (Table 3). There was a statistically significant interaction ($F(3, 329) = 3.833$, $p = 0.009$) between income ($F(3, 329) = 6.565$, $p < 0.001$) and gender ($F(1, 329) = 1.793$, $p = 0.181$), of which only income was statistically significant as a main effect. Figure 5C portrays the mean valuation differences across the gender by income

Table 3. Multi-factor analysis of variance of provisioning services social valuation ($N = 349$)

Item	Group		Mean	±SE	df	F	Sig.
Gender	Female		3.032	.172	1	1.793	.181
	Male		3.267	.130			
Income	Less than $50,000		3.415	.220	3	6.565	<.001
	$50,000-$99,999		3.577	.154			
	$100,000-$150,000		2.882	.213			
	More than $150,000		2.725	.197			
Gender*	Male	Less than $50,000	3.396	.275	3	3.883	.009
Income		$50,000-$99,999	3.351	.168			
		$100,000-$150,000	3.089	.195			
		More than $150,000	3.233	.154			
	Female	Less than $50,000	3.435	.326			
		$50,000-$99,999	3.802	.229			
		$100,000-$150,000	2.675	.334			
		More than $150,000	2.217	.348			
Education	High school graduate or GED		3.255	.249	3	1.641	.180
	Associate's or technical degree		3.394	.221			
	Bachelor's degree		3.031	.140			
	Graduate/Advanced degree		2.918	.138			
Residency	Not resident		3.110	.142	1	.337	.562
	Resident		3.190	.144			
Documented plan	No documented plan		3.193	.136	1	.432	.512
	Documented plan		3.106	.146			
Land use	Single-use forestry		3.268	.154	4	2.763	.028*
	Single-use non-forestry		3.113	.206			
	Multi-use forestry		3.538	.146			
	Multi-use non-forestry		2.857	.298			
	Not actively used		2.972	.228			
Permanent stream(s) on woodland	No streams		3.112	.155	1	.277	.599
	Streams present		3.187	.131			
Past disturbance	No past disturbance		2.967	.131	1	7.500	.007
	Past disturbance experienced		3.332	.152			
Interest in ecosystem services incentives	Would not be interested		2.867	.176	1	11.603	<.001
	Would be interested		3.432	.118			

Based on estimated marginal means
R Squared = .170 (Adjusted R Squared = .122)

interaction. Based on the 95% confidence intervals, the interaction term showed that female landowners whose annual income was over $150,000 ($M$ = 2.217; ±0.686; ± 95% C.I.) valued provisioning services lower than male landowners in the same income group (M = 3.233; ±0.303; ± 95% C.I.) and male landowners earning $50,000-$99,999 (M = 5.351; ±0.331; ± 95% C.I.). They also valued provisioning services lower than other female landowners earning $50,000-$99,999 (M = 3.802; ±0.450; ± 95% C.I.). Female landowners earning $100,000-$150,000 (M = 2.217; ±0.686; ± 95% C.I.) also valued provisioning services lower than female landowners earning $50,000-$99,000. The remaining statistically significant main effects showed that there were differences in provisioning values based on land use type ($F(4, 329) = 2.763$, $p = 0.028$), that landowners with past disturbance experience valued provisioning services higher than those without ($F(1, 329) = 7.500$, $p = 0.007$), and that landowners interested in PES valued provisioning services higher than those uninterested ($F(1, 329) = 11.603$, $p < 0.001$). The observed means showed that multi-use forestry landowners (M = 3.538; ± 0.146; ± 2S.E.) valued provisioning services higher than those landowners not actively using their woodland (M = 2.972; ± 0.146; ± 2S.E.); however, Tukey's Post-Hoc analysis for land use did not display a statistically significant difference between groups (Figure 6A).

Regulating services

The multi-factor ANOVA results for regulating services valuation showed five statistically significant main effects and no statistically significant interactions (Table 4). For the binary predictors, main effects analysis showed that landowners with a documented plan ($F(1, 329) = 4.494$, $p = 0.035$), a stream ($F(1, 329) = 8.873$, $p = 0.003$, or interest in PES ($F(1, 329) = 12.544$, $p < 0.001$) all valued regulating services higher than landowners without them. The results also showed that there were statistically significant differences between groups within education

Table 4. Multi-factor analysis of variance of regulating services social valuation (N = 345)

Item	Group	Mean	±SE	df	F	p
Gender	Female	5.273	.204	1	3.384	.067
	Male	4.904	.157			
Income	Less than $50,000	5.463	.267	3	2.609	.052
	$50,000-$99,999	5.217	.181			
	$100,000-$150,000	4.895	.229			
	More than $150,000	4.780	.193			
Education	High school graduate or GED	4.845	.304	3	4.091	.007
	Associate's or technical degree	5.663	.273			
	Bachelor's degree	4.757	.166			
	Graduate/Advanced degree	5.089	.165			
Residency	Not resident	4.947	.172	1	2.866	.091
	Resident	5.231	.175			
Documented plan	No documented plan	4.921	.167	1	4.494	.035
	Documented plan	5.256	.176			
Land use	Single-use forestry	4.943	.187	4	2.582	.037
	Single-use non-forestry	4.758	.248			
	Multi-use forestry	5.376	.175			
	Multi-use non-forestry	5.448	.369			
	Not actively used	4.918	.276			
Permanent stream(s) on woodland	No streams	4.832	.189	1	8.873	.003
	Streams present	5.345	.159			
Past disturbance	No past disturbance	5.053	.159	1	.194	.660
	Past disturbance experienced	5.124	.185			
Interest in ecosystem services incentives	Would not be interested	4.730	.214	1	12.544	<.001
	Would be interested	5.447	.145			

Based on estimated marginal means
R Squared = .181 (Adjusted R Squared = .141)

levels (F(3, 329) = 4.091, p = 0.007) and land use (F(4, 329) = 2.582, p = 0.037). Tukey's Post-Hoc results showed that landowners with an associate's or technical degree valued regulating services significantly higher than landowners with a bachelor's degree (p = 0.007; ± 0.732; ± 95% C.I.; Figure 6C). The observed means showed that multi-use forestry landowners (M = 5.376; ± 0.175; ± 2S.E.) valued regulating services higher than single-use non-forestry landowners (M =4.758 ; ± 0.248; ± 2S.E.); however, post-hoc testing did not display any statistically significant differences in regulating services valuation between land use groups.

Cultural services

There were two statistically significant main effects and two interactions for cultural services valuation ANOVAs (Table 5). The results showed that there was a statistically significant

interaction term ($F(1, 329) = 5.635$, $p = 0.018$; Figure 5D) between past disturbance ($F(1, 329) = 0.164$, $p = 0.686$) and PES interest ($F(1, 329) = 19.042$, $p > 0.001$). Based on the 95% confidence intervals for interaction population's estimated marginal means, landowners with PES interest, whether they did ($M = 4.244$; ±0.303; ± 95% C.I.) or did not ($M = 3.875$; ±0.281; ± 95% C.I.) have past disturbance experience, valued cultural services higher than landowners who had past disturbance experience and no PES interest ($M = 2.995$; ±0.594; ± 95% C.I.). If they had past

Table 5. Multi-factor analysis of variance of cultural services social valuation ($N = 345$)

Item	Group	Mean	±SE	df	F	p
Gender	Female	3.485	.181	1	3.873	.050
	Male	3.830	.142			
Income	Less than $50,000	3.728	.242	3	1.448	.229
	$50,000-$99,999	3.837	.160			
	$100,000-$150,000	3.422	.201			
	More than $150,000	3.643	.171			
Education	High school graduate or GED	3.794	.268	3	.270	.847
	Associate's or technical degree	3.508	.239			
	Bachelor's degree	3.670	.152			
	Graduate/Advanced degree	3.658	.149			
Residency	Not resident	3.632	.155	1	.117	.733
	Resident	3.683	.156			
Documented plan	No documented plan	3.580	.151	1	1.047	.307
	Documented plan	3.735	.161			
Land use	Single-use forestry	3.737	.163	4	9.554	<.001
	Single-use non-forestry	3.814	.218			
	Multi-use forestry	4.378	.155			
	Multi-use non-forestry	3.273	.333			
	Not actively used	3.086	.243			
Permanent stream(s) on woodland	No streams	3.638	.169	1	.070	.792
	Streams present	3.677	.143			
Past disturbance	No past disturbance	3.695	.141	1	.164	.686
	Past disturbance experienced	3.620	.188			
Interest in ecosystem services incentives	Would not be interested	3.256	.196	1	19.042	<.001
	Would be interested	4.059	.126			
Disturbance*Ecosystem services incentive interest	No*No	3.516	.210	1	5.635	.018
	No*Yes	3.875	.143			
	Yes*No	2.995	.302			
	Yes*Yes	4.244	.154			
Documented Plan*Stream(s)	No*No	3.724	.207	1	4.949	.027
	No*Yes	3.436	.163			
	Yes*No	3.551	.213			
	Yes*Yes	3.918	.166			

Based on estimated marginal means
R Squared = .221 (Adjusted R Squared = .178)

disturbance experience and PES interest, they also valued cultural services higher than landowners who had neither (M = 3.516; ±0.413; ± 95% C.I.). There was another statistically significant interaction term (F(1, 329) = 4.949, p = 0.027; Figure 5E) between streams (F(1, 329) = 0.070, p = 0.792) and documented plan (F(1, 329) = 1.047, p = 0.307). Based on the 95% confidence intervals for interaction population's estimated marginal means, landowners with a documented plan and a stream (M = 3.918; ±0.348; ± 95% C.I.) valued cultural services significantly higher than landowners with a stream and no documented plan (M = 3.436; ±0.320; ± 95% C.I.). The only statistically significant main effect for cultural services valuation independent of interaction was land use (F(4, 329) = 9.554, $p < 0.001$). Tukey's Post-Hoc results showed that multi-use forestry landowners valued cultural services significantly higher than single-use forestry landowners (p = 0.001; ± 0.462; ± 95% C.I.), multi-use non-forestry landowners (p = 0.016; ± 0.979; ± 95% C.I.), and those not actively using land ($p < 0.001$; ± 0.697; ± 95% C.I.; Figure 6A).

Interest in Payment for Ecosystem Services

The descriptive results of the binary logistic regression are depicted in Table 6. The results of the binary logistic regression used to investigate the relationship between woodland activities and characteristics and interest in PES found that five of the six factors in the model had a statistically significant effect on the odds of interest in PES (Table 7). The overall model was highly statistically significant ($p < 0.001$). We found that landowners who had designated some land in conservation in the previous decade (recent conservation) were 4.6 times as likely to indicate PES interest than those who did not (p = 0.023; ± 7.922 ± 95% C.I.) and that landowners who farm or ranch some acreage along with their woodland were 2.0 times as likely to indicate interest in PES than those with no farmed or ranched land (p = 0.040; ± 1.44 ± 95% C.I.).

Table 6. Descriptive information of valid respondents of logistic regression model analysis (N = 436)

Factor	Group	Incentive interest	
		No	Yes
Land farmed/ranched	No	66	250
	Yes	16	104
Recent conservation	No	79	300
	Yes	3	54
Past conservation incentives	No	56	161
	Yes	26	193
Relative profit	Less profit per acre	26	26
	Equal profit per acre	18	126
	More profit per acre	36	200
Land use	Single-Use Forestry	19	101
	Single-Use Non-Forestry	17	46
	Multi-Use Forestry	32	154
	Multi-Use Non-Forestry	8	19
	Not Actively Used	6	34
Acreage	Low	26	64
	MidLow	12	77
	Mid	16	70
	MidHigh	20	63
	High	8	80
Totals	Frequency of incentive interest	82	354

Acreage groups (quintiles of sample): Low = 0 - 88, Midlow = 89 - 151, Mid = 152 - 240, MidHigh = 241 - 534, High = 535+

Enrollment in conservation incentives or cost-share programs at any time (not just recent) in the past did not have a statistically significant effect on the odds of PES interest (p = 0.061; ± 1.156 ± 95% C.I.). Some acreage groups (split into 20 percentiles for respondent sample) were statistically significant factors for the odds of PES interest: Landowners in the High acreage group were 3.8 times as likely (p = 0.005; ± 4.265 ± 95% C.I.) and landowners in the MidLow group were 2.7 times as likely to indicate PES interest as landowners in the Low acreage group (p = 0.009; ± 2.511 ± 95% C.I.). High acreage landowners were also 3.2 times as likely to indicate PES interest as MidHigh acreage landowners (p = 0.019; ± 3.561 ± 95% C.I.). Landowners with no active use for their woodland were 3.6 times as likely to express interest in PES than single-use non-forestry landowners (p = 0.028; ± 6.355 ± 95% C.I.). Finally,

landowners indicated the relative profit per acre they would be willing to accept in an incentive program, and those who indicated equal profit per acre ($p < 0.001$; ± 6.403 ± 95% C.I.) or more profit per acre ($p < 0.001$; ± 4.488 ± 95% C.I.) were 7.3 and 5.9 times as likely, respectively, to indicate interest in PES.

Table 7. Results of logistic regression model analysis ($N = 436$)

Predictor	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I. for EXP(B)	
							Lower	Upper
Recent conservation	1.522	.671	5.139	1	.023	4.580	1.229	17.073
Past conservation incentives	.582	.310	3.514	1	.061	1.789	.974	3.286
Land farmed/ranched	.698	.340	4.208	1	.040	2.009	1.032	3.912
Low	-1.345	.489	7.579	1	.006	.260	.100	.679
MidLow	-.340	.517	.434	1	.510	.711	.258	1.958
Mid	-.755	.497	2.308	1	.129	.470	.178	1.245
MidHigh	-1.158	.493	5.523	1	.019	.314	.120	.825
High	-	-	-	-	-	-	-	-
Single-use forestry	-1.028	.584	3.104	1	.078	.358	.114	1.123
Single-use non-forestry	-1.292	.589	4.806	1	.028	.275	.086	.872
Multi-use forestry	-.829	.551	2.268	1	.132	.436	.148	1.284
Multi-use non-forestry	-.900	.688	1.712	1	.191	.406	.106	1.565
Not actively used	-	-	-	-	-	-	-	-
Equal profit per acre	1.982	.406	23.864	1	<.001	7.260	3.277	16.083
More profit per acre	1.780	.357	24.915	1	<.001	5.928	2.947	11.923
Constant	1.107	.676	2.682	1	.101	3.025		

Model summary:
-2 Log likelihood: 351.383
Cox & Snell R Square: .149, Nagelkerke R Square: .240

Discussion

Social Valuations of Biodiversity and Ecosystem Services

Several early social valuation studies found that respondents value provisioning services the highest (Hartter 2010; Iftekhar and Takama 2008; Agbenyega et al. 2009). Our findings that biodiversity and regulating services were valued the highest, followed by cultural then provisioning services, were consistent with more recent work (Martín-López et al. 2012; Asah and Blahna 2020; Zoderer et al. 2016). We expected to find higher values for provisioning services than we observed given that we were studying a population primarily engaged in

forestry, and people reliant on resources often value them differently than the trends in the general population (Castillo et al. 2005). In the case of our respondents, the importance of timber products was the main driver of the overall valuation of provisioning.

Landowners valued soil erosion control and pollination the highest of individual indicators of regulating services which deviates from other literature in which people tend to value water-related (i.e., water quality) services highly (Castro et al. 2016; Asah and Blahna 2020). These studies also recorded fresh water for drinking as the highest valued provisioning service; however, we found that timber and food products were the highest valued. The highest valued item across all scales was habitat for game species and given the high proportion of hunters/fishers in the study population, there is a possible discrepancy between hunting/fishing values related to provisioning and biodiversity. The PCA analysis showed that habitat for game species was explaining the variance in the same concept as all other biodiversity indicators and the hunters/fishers also prioritized forest conservation, but future studies should consider designing indicators for hunting in the provisioning scale. Further, managing habitat for game species may not necessarily imply support of the natural biodiversity of the ecosystem, so researchers should consider the popular methods for game management in their study region. Soil, pollination, and timber ranking higher than other forest watershed services aligns with the known land uses for our study population, but it does introduce doubt that landowner values align with the services most ecologically impactful in a given watershed (Armstrong and Stedman 2020; Kreye, Adams, and Escobedo 2014).

Our multi-factor ANOVA results showed several landowner and woodland characteristics which were significant as main effects in the valuations. For regulating services, landowners with a documented plan, a permanent stream on property, and an interest in PES all

had higher mean values. Streams present and PES interest had the same effect on biodiversity valuation, and landowners with disturbance experience valued provisioning services higher than those without. An interaction term indicated that landowners with streams and a documented plan valued cultural services higher than those with a stream but no plan. Higher regulating and biodiversity services valuations from landowners with streams present are noteworthy because these parcels are potentially critical for watershed support (Anbumozhi, Radhakrishnan, and Yamaji 2005; Kreye, Adams, and Escobedo 2014). It's unclear whether landowners with permanent streams are more conscious of the importance of their parcels' impacts on watershed functions, but their values could indicate potential awareness.

Another interaction term showed that those with PES interest (regardless of disturbance history) valued cultural services higher than those without PES interest who had past disturbance experience. The highest valued items in the cultural services instrument were investment opportunities, financial security, and recreation opportunities, and both PES and past disturbances could impact the feasibility of return on forest investment. It's possible that there is a division in the disturbance experience group between minor disturbance and severe disturbance, but we did not investigate the perceived severity of past disturbances. The PES interest by past disturbance interaction could be valuable information for policymakers interested in conserving forest cover through incentives in disaster-prone areas considering social norms can influence enrollment in PES programs (Chen et al. 2012; Henderson et al. 2022).

There are often discrepancies in which services are valued the highest depending on respondent proximity to and reliance on the resource, and this can create conflict between the beneficiaries and the stewards of ecosystem services; however, we did not find that a landowners residency, our indicator of proximity, played a major role in their valuations (Zoderer et al. 2016;

Martín-López et al. 2012; Castro et al. 2016). The only statistically significant effect we found for resident woodland owners was through analysis of an interaction term showing that residents who had experienced a past disturbance valued biodiversity higher than residents who had not experienced such a past disturbance. Similarly, landowners with past disturbance experience and a documented plan for their forest's future had relatively higher valuation of biodiversity. The coastal nature of the region means disturbances are frequent, so given the capacity for adaptation in SES, residents with past disaster experience and documented plans for their woodland may be more resilient and active in their management and attribute more value to the capacity of ecosystems and their support in SES (Adger et al. 2005).

Forest owners, including those who use their land for timber production, often list multiple reasons for ownership (i.e., recreation investment, residence, forestry). They tend not to identify a sole or leading land-use, so while we asked respondents to select all uses that applied, we condensed them into single or multi use and forestry or non-forestry categories (Bengston, Asah, and Butler 2011). We found that landowners identifying multiple uses including forestry valued biodiversity more than any landowners marking single-use (forestry or otherwise) and valued cultural services higher than any landowners marking non-forestry use (single or multiple) or no active use. While we also observed significant main effects of land use on the valuation of provisioning and regulating services, we did not observe statistically significant differences between groups. For both provisioning and regulating services, the observed means showed that multi-use landowners had higher valuation than single-use or inactive landowners. Studies on people's perceptions of land use and ecosystem services have showed that distinctions between multi-use and single-use land are the primary land use distinctions which affect valuations of cultural, regulating, and provisioning services (García-Llorente et al. 2012;

Harrison et al. 2010; Martín-López et al. 2012). While these studies compared how people perceived the services provided by different landscapes, we observed a similar trend in that multi-use forestry landowners valued their woodland's biodiversity and cultural services higher than single-use landowners, and that there is a possible effect for both regulating and provisioning services.

Regarding demographic factors, the results showed that education was the only factor which had a significant, independent main effect on landowner valuation of ecosystem services. Respondents with an associate's or technical degree valued regulating services higher than those with a bachelor's degree which contradicts previous studies which indicate that people's formal education is an important driver of their valuations (Martín-López et al. 2012; Scholte, van Teeffelen, and Verburg 2015). However, another study suggested that focusing on socio-demographic characteristics alone may lead to misidentification of significant predictors, and they found that individuals valued regulating services higher when they reported high environmental knowledge, regardless of education level (Zoderer et al. 2016). Our respondents' deviation from the literature in this regard suggests evidence for the need to further modify the predictors assessed when studying natural resource stakeholders.

While income was a statistically significant main effect on provisioning services valuation, there was a gender by income interaction where we observed that higher income female landowners valued provisioning services lower than male landowners earning the same or less than them and female landowners earning less. While gender was not a statistically significant main effect, this finding is inconsistent with previous research which tends to find that females are more likely to perceive ecosystem services as important than males (Martín-López et al. 2012; Zoderer et al. 2016). Consistent with previous research, the researchers who

developed the original scale applied in this study found that females valued biodiversity, regulating, and cultural services higher than males, but there were no statistically significant differences in valuation based on gender for forest provisioning services specifically (Asah and Blahna 2020). Our study is the first to identify an interaction across demographic variables. Southeastern female landowners often value conservation and family legacy attached to their forests more than male landowners, but they may lack the resources to maintain forest cover (Mook, Goyke, and Dwivedi 2022; Schelhas et al. 2012). However, forests subdivided and fragmented when inherited by younger generations (Gruver et al. 2017; Pan et al. 2009). While we only investigated the role of gender in valuation, it will be important for future studies to investigate the values of younger landowners. The majority (> 70%) of primary private forest landowners in the study region are male and are aging (> 60 years), so this topic is worth further study considering that both gender and age trends in land ownership are shifting due to generational turnover (B. J. Butler et al. 2021; Zhang et al. 2009; B. J. Butler and Wear 2013).

Interest in Payments for Ecosystem Services

In the Southeast, private forest landowners prioritize their rights to control their management and land use decisions (Siry et al. 2010). Additionally, most Southeastern private forest policy discourse emphasizes landowner and expert (licensed professional forester) authority over forest management decisions, as opposed to strict state-enforced rules and regulations (Kelly and Crandall 2022; Goldstein, Crandall, and Kelly 2023). States with popular participatory conservation programs emphasize incentives conducive to market-based forestry and allow the forest landowners to collaborate with experts to design the plan for exceeding minimal standards for management practices (Kelly and Crandall 2022). Given the emphasis on property and usage rights in the Southeast, any approach to incentivizing ecosystem services stewardship must

appeal to individual landowner goals. By assessing both social values of ecosystem services and landowner characteristics influencing likelihood of PES interest, we sought to bolster the relevance of this study for policymakers.

We found several factors of land use history which significantly affected the odds of landowner interest in PES. Given our results, landowners with high acreage, parcels in other agricultural use, recent conservation activities, and parcels without active use may be the ideal candidates for a PES program. Ecologically speaking, the most effective candidates for PES are parcel owners with moderate land impacts (i.e., some agricultural land, some forested land, and/or forest in active production) and these results indicate that there may be demand for PES on eligible parcels in the Southeast (Wunder 2007). In previous PES schemes, smaller landowner participation has been minimal even though their participation could prevent forest fragmentation across patches (Leary et al. 2021; Morse et al. 2009). We found that smaller landowners were less likely to indicate interest in PES than most other groups, so outreach with smaller landowners may be necessary to bolster participation and the valuations in this study can enrich the outreach efforts.

Reliability considerations

While the reliability for the biodiversity, regulating services, and cultural services instruments were all strong, we deemed the reliability for provisioning services as merely acceptable. We conducted the PCA following the study to provide recommendations for improving reliability for future studies. The results indicated that our respondents' valuations for financial capital related items timber products (provisioning), investment opportunities (cultural), and financial security (cultural) loaded together and separated from their respective assigned scale's other items. PCA essentially indicated that there was a fifth scale emerging based on landowners conducting a

financial valuation within the scales. This variation in valuation differs from social valuation of forest ecosystem services by people who are not necessarily financially reliant on or responsible for forest resources (Asah and Blahna 2020; Schmidt et al. 2017; Velasco-Muñoz et al. 2022). When assessing communities dependent on a natural resource, the provisioning results seem to be skewed towards those one or two individual items attached to the resource (Zoderer et al. 2016; Burkhard et al. 2012). The three items loaded into the component separate from the valuation categories were either provisioning or cultural services items and these were the two lowest ranked of the instruments, so it is unlikely that respondents were only valuing from a financial perspective across the whole scale. The reliability discrepancy due to these livelihood related items is a limitation of this study and researchers should focus on modifying cultural and provisioning services to consider how potential resource dependence may skew valuations.

Conservation decision-making

Forest landowners may have unique social values regarding the ecosystem services provided by their private forests relative to study populations who do not hold private woodland. When trying to implement policy to conserve private forest and watershed ecosystem services, there may be conflicting values between those managing for the services and those receiving the benefits (Castro et al. 2016). This is especially true in regions like the Southeast where policies prioritize landowner and forester autonomy over management practices (Goldstein, Crandall, and Kelly 2023; Kelly and Crandall 2022). Social valuation studies allow decision-makers to evaluate tradeoffs given a population's value perceptions of the ecosystem surrounding them. Forestry networks and extension programs, for example, can apply our results for the valuation of individual items (i.e., soil formation, pollination) to inform how to frame their outreach materials to align with landowner values (Asah and Blahna 2020). Our results indicated that a majority

forest landowners were interested in receiving PES; however, landowners were also less likely to indicate interest in a potential program if it offers less relative profit per acre than they currently earn. Decision-makers and forestry professionals should prioritize activities which support landowner objectives and in turn increase their likelihood to participate in conservation incentives (Adhikari et al. 2021). Dismissing rural landowner and resident values in policy can result in accrued resentment and perceptions of imposition, regardless of whether people understand the benefits of ecosystem services (Castillo et al. 2005).

The benefit of presenting a social valuation with an assessment of PES interest is that we identified regional trends in the values of forest owners which enriches knowledge about the SES and informs policymakers on what and how to garner support for decisions (Kenter et al. 2015). When it comes to altering management behaviors, natural resource professionals may find more success by conducting outreach with landowners who understand biodiversity and ecosystem service value, but who practice management strategies which are not identical with recommendations made by the professionals (Davis, Asah, and Fly 2015). These landowners may have the capacity to accept changes in management practices but may require support to do so. This is especially true for landowners who need more support in the economic and logistic operations of forest ownership because understanding and valuing an ecosystem is not sufficient preparation or capacity for actively managing it (Ewel 2001). Our results depicted the social valuation of ecosystem services for Southeastern landowners, and we found that there is some deviation from the previous research on valuation in other ecosystems and for other populations, so our findings are relevant to adjusting approaches towards conservation in the region's private forests.

Conclusion

Our aim for this study was to adapt a co-designed instrument to assess the forest ecosystem services social valuation of Southeastern private woodland owners, to investigate the factors affecting the values, and to determine the role of their land use history in predicting their interest in theoretical incentives for conserving ecosystem services. The results of this study contained valuable information about the unique values of private forest landowners relative to the public. We found that a few individual indicators of provisioning and cultural services related to landowner financial returns created some limitation in the reliability of the valuation instruments. We also found contradictory results about formal education as a predictor of values of regulating services and suggest that future studies assess or inquire about ecosystem knowledge as opposed to formal education in the context of forest landowners. The results also showed that most respondents would be interested in PES, and we identified that large landowners with some agricultural land and experience with conservation programs may be the most likely participants. While we were not conducting a monetary valuation of ecosystem services, these results supplemented the social valuation and indicated that landowners expressed financial motivations for conservation along with the personal values they indicated for the tangible and intangible values of ecosystem services. Researchers can apply our findings about the reliability discrepancies in social valuation contexts to adapt their own scales to localized landowner populations, especially if the populations are resource dependent.

References

Adger, W. Neil, Terry P. Hughes, Carl Folke, Stephen R. Carpenter, and Johan Rockström. 2005. 'Social-Ecological Resilience to Coastal Disasters'. Science 309 (5737): 1036–39. https://doi.org/10.1126/SCIENCE.1112122.

Adhikari, Ram K., Robert K. Grala, Stephen C. Grado, Donald L. Grebner, and Daniel R. Petrolia. 2021. 'Landowner Concerns Related to Availability of Ecosystem Services and Environmental Issues in the Southern United States'. Ecosystem Services 49 (June): 101283. https://doi.org/10.1016/J.ECOSER.2021.101283.

Agbenyega, O, P J Burgess, M Cook, and J Morris. 2009. 'Application of an Ecosystem Function Framework to Perceptions of Community Woodlands'. Land Use Policy 26: 551–57.

Alvarenga, Lívia Alves, Carlos Rogério de Mello, Alberto Colombo, and Luz Adriana Cuartas. 2017. 'Hydrologic Impacts Due to the Changes in Riparian Buffer in a Headwater Watershed'. CERNE 23 (1): 95–102. https://doi.org/10.1590/01047760201723012205.

Anbumozhi, Venkatachalam, Jay Radhakrishnan, and Eiji Yamaji. 2005. 'Impact of Riparian Buffer Zones on Water Quality and Associated Management Considerations'. Ecological Engineering 24 (5 SPEC. ISS.): 517–23. https://doi.org/10.1016/J.ECOLENG.2004.01.007.

Armstrong, Andrea, and Richard C. Stedman. 2020. 'Thinking Upstream: How Do Landowner Attitudes Affect Forested Riparian Buffer Coverage?' Environmental Management 65 (5): 689–701. https://doi.org/10.1007/S00267-020-01271-Y/TABLES/3.

Asah, Stanley T., and Dale J. Blahna. 2020. 'Involving Stakeholders' Knowledge in Co-Designing Social Valuations of Biodiversity and Ecosystem Services: Implications for

Decision-Making'. Ecosystems 23 (2): 324–37. https://doi.org/10.1007/s10021-019-00405-6.

Bell, Kathleen P., Marla Markowski-Lindsay, Paul Catanzaro, and Jessica Leahy. 2019. 'Family-Forest Owner Decisions, Landscape Context, and Landscape Change'. Landscape and Urban Planning 188 (August): 118–31. https://doi.org/10.1016/j.landurbplan.2018.08.023.

Bengston, David N, Stanley T Asah, Brett J Butler. 2011. 'The Diverse Values and Motivations of Family Forest Owners in the United States: An Analysis of an Open-Ended Question in the National Woodland Owner Survey'. Small-Scale Forestry 10: 339–55. https://doi.org/10.1007/s11842-010-9152-9.

Bennett, Elena M. 2017. 'Research Frontiers in Ecosystem Service Science'. Ecosystems 20 (1): 31–37. https://doi.org/10.1007/s10021-016-0049-0.

Boeraeve, Fanny, Marc Dufrene, Rik De Vreese, Sander Jacobs, Nathalie Pipart, Francis Turkelboom, Wim Verheyden, and Nicolas Dendoncker. 2018. 'Participatory Identification and Selection of Ecosystem Services: Building on Field Experiences'. Ecology and Society 23 (2). https://doi.org/10.5751/ES-10087-230227.

Burkhard, Benjamin, Franziska Kroll, Stoyan Nedkov, and Felix Müller. 2012. 'Mapping Ecosystem Service Supply, Demand and Budgets'. Ecological Indicators 21 (October): 17–29. https://doi.org/10.1016/j.ecolind.2011.06.019.

Butler, Brett J., and David N. Wear. 2013. 'Forest Ownership Dynamics of Southern Forests'. Southern Forest Futures Project. In The Southern Forest Futures project: technical report. General Technical Report SRS-GTR-178. Asheville, NC: USDA-Forest Service, Southern Research Station.

Butler, Brett J., Sarah M. Butler, Jesse Caputo, Jacqueline Dias, Amanda Robillard, and Emma M Sass. 2021. 'Family Forest Ownerships of the United States, 2018: Results from the USDA Forest Service, National Woodland Owner Survey'. General Technical Report NRS-199. Madison, WI: U.S. Department of Agriculture, Forest Service, Northern Research Station. https://doi.org/10.2737/NRS.

Castillo, Alicia, Antonieta Magañ, Anna Pujadas, Lucía Martínez, and Carmen Godínez. 2005. 'Understanding the Interaction of Rural People with Ecosystems: A Case Study in a Tropical Dry Forest of Mexico'. Ecosystems 8: 630–43. https://doi.org/10.1007/s10021-005-0127-1.

Castro, Antonio J., Caryn C. Vaughn, Jason P. Julian, and Marina García-Llorente. 2016. 'Social Demand for Ecosystem Services and Implications for Watershed Management'. Journal of the American Water Resources Association 52 (1): 209–21. https://doi.org/10.1111/1752-1688.12379.

Chen, Xiaodong, Frank Lupi, Li An, Ryan Sheely, Andrés Viña, and Jianguo Liu. 2012. 'Agent-Based Modeling of the Effects of Social Norms on Enrollment in Payments for Ecosystem Services'. Ecological Modelling 229 (March): 16–24. https://doi.org/10.1016/j.ecolmodel.2011.06.007.

Conmy, Robyn N., Blake A. Schaeffer, Joseph Schubauer-Berigan, Jessica Aukamp, Allyn Duffy, John C. Lehrter, and Richard M. Greene. 2017. 'Characterizing Light Attenuation within Northwest Florida Estuaries: Implications for RESTORE Act Water Quality Monitoring'. Marine Pollution Bulletin 114 (2): 995–1006. https://doi.org/10.1016/J.MARPOLBUL.2016.11.030.

Costanza, Robert. 2000. ‘Social Goals and the Valuation of Ecosystem Services’. Ecosystems 3 (1): 4–10.

Daily, Gretchen C. 1997. ‘Introduction: What Are Ecosystem Services?’ In Nature’s Services: Societal Dependence on Natural Ecosystems, edited by GC Daily. New Haven, CT: Yale University Press.

Davis, Miriam L E Steiner, Stanley T Asah, and J Mark Fly. 2015. ‘Family Forest Owners’ Forest Management Understandings: Identifying Opportunities and Audiences for Effective Outreach and Education’. Forest Science 61 (1): 105–13. https://doi.org/10.5849/forsci.13-014.

Dillman, Don A., Jolene D. Smyth, and Leah M. Christian. 2009. Internet, Phone, Mail, and Mixed-Mode Surveys: The Tailored Design Method. 4th ed. Hoboken, NJ: Wiley & Sons.

Etters, Karl. 2019. ‘Timber Farms in Florida, Georgia Suffering After Hurricane Michael’. Insurance Journal. 2019.

Ewel, Katherine C. 2001. ‘Natural Resource Management: The Need for Interdisciplinary Collaboration’. Ecosystems 4: 716–22. https://doi.org/10.1007/s10021-001-0040-1.

García-Llorente, Marina, Berta Martín-López, Irene Iniesta-Arandia, César A. López-Santiago, Pedro A. Aguilera, and Carlos Montes. 2012. ‘The Role of Multi-Functionality in Social Preferences toward Semi-Arid Rural Landscapes: An Ecosystem Service Approach’. Environmental Science and Policy 19–20 (May): 136–46. https://doi.org/10.1016/j.envsci.2012.01.006.

Garofalo, Sara, Sara Giovagnoli, Matteo Orsoni, Francesca Starita, and Mariagrazia Benassi. 2022. 'Interaction Effect: Are You Doing the Right Thing?' PLoS ONE 17 (7 July). https://doi.org/10.1371/journal.pone.0271668.

Geist, Helmut J., and Eric F. Lambin. 2002. 'Proximate Causes and Underlying Driving Forces of Tropical Deforestation'. BioScience 52 (2): 143–50.

Ghasemi, Asghar, and Saleh Zahediasl. 2012. 'Normality Tests for Statistical Analysis: A Guide for Non-Statisticians'. International Journal of Endocrinology and Metabolism 10 (2): 486–89. https://doi.org/10.5812/ijem.3505.

Giddens, Anthony. 1984. The Constitution of Society: Outline of the Theory of Structuration. Cambridge: Polity Press.

Goldstein, Brita, Mindy S. Crandall, and Erin Clover Kelly. 2023. '"The Cost of Doing Business": Private Rights, Public Resources, and the Resulting Diversity of State-Level Forestry Policies in the U.S.' Land Use Policy 132 (September): 106792. https://doi.org/10.1016/J.LANDUSEPOL.2023.106792.

Greene, Rachel E., Kristine O. Evans, Michael T. Gray, D. Todd Jones-Farrand, and William G. Wathen. 2020. 'Using a Coproduction Approach to Map Future Forest Retention Likelihood in the Southeastern United States'. Journal of Forestry 118 (1): 28–43. https://doi.org/10.1093/JOFORE/FVZ063.

Gruver, Joshua B., Alexander L. Metcalf, Allyson B. Muth, James C. Finley, and A. E. Luloff. 2017. 'Making Decisions About Forestland Succession: Perspectives from Pennsylvania's Private Forest Landowners'. Society and Natural Resources 30 (1): 47–62. https://doi.org/10.1080/08941920.2016.1180728.

Harpe, Spencer E. 2015. ‘How to Analyze Likert and Other Rating Scale Data’. Currents in Pharmacy Teaching and Learning. Elsevier Inc. https://doi.org/10.1016/j.cptl.2015.08.001.

Harrison, Paula A, Marie Vandewalle, Martin T Sykes, Pam M Berry, Rob Bugter, Francesco De Bello, Christian K Feld, et al. 2010. ‘Identifying and Prioritising Services in European Terrestrial and Freshwater Ecosystems’. Biodiversity Conservation 19: 2791–2821. https://doi.org/10.1007/s10531-010-9789-x.

Hartter, Joel. 2010. ‘Resource Use and Ecosystem Services in a Forest Park Landscape’. Society and Natural Resources 23 (3): 207–23. https://doi.org/10.1080/08941920903360372.

Henderson, Jesse D., Robert C. Abt, Karen L. Abt, Justin Baker, and Ray Sheffield. 2022. ‘Impacts of Hurricanes on Forest Markets and Economic Welfare: The Case of Hurricane Michael’. Forest Policy and Economics 140 (July): 102735. https://doi.org/10.1016/J.FORPOL.2022.102735.

Holland, John. 1992. ‘Complex Adaptive Systems’. Daedalus 121 (1).

Iftekhar, M. S., and T. Takama. 2008. ‘Perceptions of Biodiversity, Environmental Services, and Conservation of Planted Mangroves: A Case Study on Nijhum Dwip Island, Bangladesh’. Wetlands Ecology and Management 16 (2): 119–37. https://doi.org/10.1007/s11273-007-9060-8.

Kelly, Erin Clover, and Mindy S. Crandall. 2022. ‘State-Level Forestry Policies across the US: Discourses Reflecting the Tension between Private Property Rights and Public Trust Resources’. Forest Policy and Economics 141 (August): 102757. https://doi.org/10.1016/J.FORPOL.2022.102757.

Kenter, Jasper O., Liz O'Brien, Neal Hockley, Neil Ravenscroft, Ioan Fazey, Katherine N. Irvine, Mark S. Reed, et al. 2015. 'What Are Shared and Social Values of Ecosystems?' Ecological Economics 111 (March): 86–99. https://doi.org/10.1016/J.ECOLECON.2015.01.006.

Khanal, Puskar N, Donald L Grebner, Ian A Munn, Stephen C Grado, Robert K Grala, James E Henderson, and Marcus K Measells. 2016. 'Nonindustrial Private Forest Landowner Beliefs toward Climate Change and Carbon Sequestration in the Southern United States'. Journal of Forestry 114 (5): 524–31. https://doi.org/10.5849/jof.15-033.

Kline, Jeffrey D., Eric M. White, A. P. Fischer, Michelle M. Steen-Adams, Susan Charnley, Christine S. Olsen, Thomas A. Spies, and John D. Bailey. 2017. 'Integrating Social Science into Empirical Models of Coupled Human and Natural Systems'. Ecology and Society 22 (3). https://doi.org/10.5751/ES-09329-220325.

Kreye, Melissa M., Damian C. Adams, and Francisco J. Escobedo. 2014. 'The Value of Forest Conservation for Water Quality Protection'. Forests 5 (5): 862–84. https://doi.org/10.3390/f5050862.

Kreye, Melissa M, Damian C Adams, José R Soto, Sophia Tanner, and Renata Rimsaite. 2021. 'Economic and Ethical Motivations for Forest Restoration and Incentive Payments'. Society and Natural Resources 34 (8): 1093–1110. https://doi.org/10.1080/08941920.2021.1938320.

Leary, John, Kerry Grimm, Clare Aslan, Melissa Mark, Sarah Frey, and Robyn Bath-Rosenfeld. 2021. 'Landowners' Socio-Cultural Valuation of Ecosystem Services Provided by Trees in Costa Rican Agricultural Landscapes'. Environmental Management 67 (5): 974–87. https://doi.org/10.1007/s00267-021-01442-5.

Lehrter, John C., and Chengfeng Le. 2017. ‘Satellite Derived Water Quality Observations Are Related to River Discharge and Nitrogen Loads in Pensacola Bay, Florida’. Frontiers in Marine Science 4 (SEP): 274. https://doi.org/10.3389/FMARS.2017.00274/BIBTEX.

Martín-López, Berta, Irene Iniesta-Arandia, Marina García-Llorente, Ignacio Palomo, Izaskun Casado-Arzuaga, David García Del Amo, Erik Gómez-Baggethun, et al. 2012. ‘Uncovering Ecosystem Service Bundles through Social Preferences’. PLoS ONE 7 (6). https://doi.org/10.1371/journal.pone.0038970.

Millennium Ecosystem Assessment. 2003. Ecosystems and Human Well-Being: A Framework for Assessment. Washington, D. C.: Island Press.

Mook, Anne, Noah Goyke, and Puneet Dwivedi. 2022. ‘Conservation Intentions and Place Attachment among Male and Female Forest Landowners’. Rural Sociology 87 (3): 817–46. https://doi.org/10.1111/ruso.12434.

Morse, Wayde C, Steven Hollenhorst, and Dietmar Stoian. 2007. ‘Payments for Environmental Services in Costa Rica: Conservation and Production Decisions within Social Ecological Structuration: Developing a Linked Human-Environment Model with a Case Example of Costa Rica’s Program of Payments for Environmental Services’.

Morse, Wayde C, William J Mclaughlin, J D Wulfhorst, Celia Harvey, W C Morse, W J Mclaughlin, and C Harvey. 2013. ‘Social Ecological Complex Adaptive Systems: A Framework for Research on Payments for Ecosystem Services’. Urban Ecosystems 16: 53–77. https://doi.org/10.1007/s11252-011-0178-3.

Morse, Wayde C, Jessica L Schedlbauer, Steven E Sesnie, Bryan Finegan, Celia A Harvey, Steven J Hollenhorst, Kathleen L Kavanagh, Dietmar Stoian, and J D Wulfhorst. 2009.

‘Consequences of Environmental Service Payments for Forest Retention and Recruitment in a Costa Rican Biological Corridor’. Ecology and Society 14 (1).

Nagy, R. Chelsea, and B. Graeme Lockaby. 2011. ‘Urbanization in the Southeastern United States: Socioeconomic Forces and Ecological Responses along an Urban-Rural Gradient’. Urban Ecosystems 14 (1): 71–86. https://doi.org/10.1007/s11252-010-0143-6.

Organization for Economic Co-Operation and Development (OECD). 2001. ‘Environmental Indicators for Agriculture Methods and Results’. Executive Summary Report. Paris, France: Policies and Environment Division, OECD.

Pan, Yi, Yaoqi Zhang, Indrajit Majumdar Pan, Y Zhang, and Y & Majumdar. 2009. ‘Population, Economic Welfare and Holding Size Distribution of Private Forestland in Alabama, USA’. Silva Fennica 43 (1): 161–71. http://www.metla.fi/silvafennica/full/sf43/sf431161pdf.

Pascual, Unai, Patricia Balvanera, Sandra Díaz, György Pataki, Eva Roth, Marie Stenseke, Robert T. Watson, et al. 2017. ‘Valuing Nature’s Contributions to People: The IPBES Approach’. Current Opinion in Environmental Sustainability 26 (June): 7–16. https://doi.org/10.1016/j.cosust.2016.12.006.

Raymond, Christopher M., and Jasper O. Kenter. 2016. ‘Transcendental Values and the Valuation and Management of Ecosystem Services’. Ecosystem Services 21 (October): 241–57. https://doi.org/10.1016/J.ECOSER.2016.07.018.

Schelhas, John, Yaoqi Zhang, Robert Zabawa, and Bin Zheng. 2012. ‘Exploring Family Forest Landowner Diversity: Place, Race, and Gender in Alabama, Unites States’. International Journal of Social Forestry (IJSF) 5 (1): 1–21.

Schmidt, Katja, Ariane Walz, Berta Martín-López, and René Sachse. 2017. 'Testing Socio-Cultural Valuation Methods of Ecosystem Services to Explain Land Use Preferences'. Ecosystem Services 26 (August): 270–88. https://doi.org/10.1016/J.ECOSER.2017.07.001.

Scholte, Samantha S.K., Astrid J.A. van Teeffelen, and Peter H. Verburg. 2015. 'Integrating Socio-Cultural Perspectives into Ecosystem Service Valuation: A Review of Concepts and Methods'. Ecological Economics. Elsevier. https://doi.org/10.1016/j.ecolecon.2015.03.007.

Schreiber, James B. 2021. 'Issues and Recommendations for Exploratory Factor Analysis and Principal Component Analysis'. Research in Social and Administrative Pharmacy. Elsevier Inc. https://doi.org/10.1016/j.sapharm.2020.07.027.

Sharma, Ajay, Santosh K. Ojha, Luben D. Dimov, Jason G. Vogel, and Jarek Nowak. 2021. 'Long-Term Effects of Catastrophic Wind on Southern US Coastal Forests: Lessons from a Major Hurricane'. PLOS ONE 16 (1): e0243362. https://doi.org/10.1371/journal.pone.0243362.

Siry, J, F Cubbage, D Newman, and R Izlar. 2010. 'Forest Ownership and Management Outcomes in the U.S., in Global Context'. International Forestry Review 12 (1).

Stednick, John D. 1996. 'Monitoring the Effects of Timber Harvest on Annual Water Yield'. Journal of Hydrology 176 (1–4): 79–95. https://doi.org/10.1016/0022-1694(95)02780-7.

Stones, Rob. 2005. Structuration Theory. London, ENG: Red Globe Press.

The Economics of Ecosystems and Biodiversity (TEEB). 2010. 'Mainstreaming the Economics of Nature: A Synthesis of the Approach, Conclusions and Recommendations of TEEB'. London, UK.

Torres, Angélica Valencia, Chetan Tiwari, and Samuel F. Atkinson. 2021. 'Progress in Ecosystem Services Research: A Guide for Scholars and Practitioners'. Ecosystem Services 49 (June). https://doi.org/10.1016/j.ecoser.2021.101267.

United States Department of Agriculture Forest Service, Forest Inventory and Analysis Program. 2022. 'Forest Inventory FIADB-API Web-Application Version 2.0.3'. St. Paul, MN: U.S. Department of Agriculture, Forest Service, Northern Research Station. 2022. [Available only on internet: http://apps.fs.usda.gov/fiadb-api/evalidator].

Vaske, Jerry J. 2008. Survey Research and Analysis: Applications in Parks, Recreation, and Human Dimensions. State College, PA: Venture Publishing.

Velasco-Muñoz, Juan F., José A. Aznar-Sánchez, Marina Schoenemann, and Belén López-Felices. 2022. 'An Analysis of the Worldwide Research on the Socio-Cultural Valuation of Forest Ecosystem Services'. Sustainability (Switzerland) 14 (4). https://doi.org/10.3390/su14042089.

Walz, Ariane, Adrienne Grêt-Regamey, and Sandra Lavorel. 2016. 'Social Valuation of Ecosystem Services in Mountain Regions'. Regional Environmental Change 16: 1985–87. https://doi.org/10.1007/s10113-016-1028-x.

Wunder, Sven. 2007. 'The Efficiency of Payments for Environmental Services in Tropical Conservation: Essays'. Conservation Biology 21 (1): 48–58. https://doi.org/10.1111/j.1523-1739.2006.00559.x.

Yang, Siqi, Wenwu Zhao, Paulo Pereira, and Yanxu Liu. 2019. 'Socio-Cultural Valuation of Rural and Urban Perception on Ecosystem Services and Human Well-Being in Yanhe Watershed of China'. Journal of Environmental Management 251 (December). https://doi.org/10.1016/j.jenvman.2019.109615.

Zhang, Y, X Liao, Brett J. Butler, and John Schelhas. 2009. 'The Increasing Importance of Small-Scale Forestry: Evidence from Family Forest Ownership Patterns in the United States'. Small-Scale Forestry 8: 1–14. https://doi.org/10.1007/s11842-008-9050-6.

Zoderer, Brenda Maria, Paola Sabina, Lupo Stanghellini, Erich Tasser, Janette Walde, Harald Wieser, and Ulrike Tappeiner. 2016. 'Exploring Socio-Cultural Values of Ecosystem Service Categories in the Central Alps: The Influence of Socio-Demographic Factors and Landscape Type'. Regional Environmental Change 16: 2033–44. https://doi.org/10.1007/s10113-015-0922-y.

Appendix A

Forest Landowner Survey

2022 Gulf Coast Forest Owner Survey

Understanding forest landowner production and conservation futures

A Study By:
The College of Forestry, Wildlife and Environment
Auburn University
In collaboration with the
Florida Forestry Association

AUBURN
UNIVERSITY
College of Forestry,
Wildlife and Environment

Greetings!

Auburn University College of Forestry, Wildlife and Environment (CFWE) is working in collaboration with the Florida Forestry Association to gather information regarding forest landowner production and conservation futures in the Gulf Coast Region. A traditional powerhouse of the forestry industry, this region has undergone land use change and has faced the brunt of hurricane impacts. These changes influence the forest industry and all the subsequent ecosystem services that forests provide such as watershed value, biodiversity habitat, carbon sequestration, forest recreation, and even the aesthetics of the region.

The best way we have of learning about forest production and conservation related issues is by asking the most relevant population to share their thoughts and opinions. You are one of a small number of randomly selected Gulf Coast forest owners who we are asking to complete this survey. The questions should take about 10-15 minutes to complete. We appreciate and value your input and look forward to receiving the completed survey. The information you share with us will be used to inform forest and conservation associations and consultants, agency personnel and policy makers, and individual forest owners. It is designed to enhance future forest production and conservation decisions. The results of this study will also be made directly available to any survey participant.

Sincerely,

Wayde Morse
Conservation Social Scientist
College of Forestry, Wildlife and Environment
Auburn University

Your Property Along the Gulf Coast

Our goal is to gather information regarding forest landowner production and conservation futures in the Gulf Coast Region. These changes influence the forest industry and all the subsequent benefits and services your forests provide. The best way we have of learning about forest production and conservation is to ask the most relevant people: Landowners like you. To begin, we need to understand a little about your land.

As a reminder, all of your responses will be kept confidential, and your answers will never be associated with your mailing address or your name.

For this survey we <u>define woodland</u> as land that includes:

- Woods, woodlots, timberland, and non-working forests
  - Land at least 50 acres
- Where trees were removed, and trees will grow again
  - Land at least 50 acres
- Woodland **does not include:**
  - Christmas tree farms, orchards, or nurseries
  - Land that is mowed for lawn

1. How many total acres of land (of any type) do you own along the Gulf Coast?

_____acres

2. Approximately, how many acres of the property you own is <u>woodland?</u>

_____acres

3. Approximately, how many acres of woodland do you own in each of the following counties?

(*Check all that apply*)

Figure 1. Florida coastal counties.

Figure 2. Alabama coastal counties.

☐Escambia _____acres
☐Santa Rosa _____acres
☐Okaloosa _____acres
☐Walton _____acres
☐Holmes _____acres
☐Washington _____acres
☐Bay _____acres
☐Jackson _____acres
☐Calhoun _____acres
☐Gulf _____acres
☐Baldwin (AL) _____acres
☐Other _____acres

4. Do you own any land that is farmed or ranched?

For the purpose of this survey, a farm or ranch is a place where, on average, $1,000 or more is earned from the sale of crops (other than forest products) or animals.

- ☐ Yes
- ☐ No (skip to #5)

a. If yes, how many acres is for crops (farming)

_____acres

b. If yes, how many acres is pasture for livestock (ranching)

_____acres

5. Which of the following categories BEST describes your ownership?
(*Check one*)

- Individual
- Joint, with family and /or friends
- Family partnership or family LLC or LLP
- Family trust or estate
- Corporation or business
- Other (please specify) _____

a. How many people are a part of this ownership, including yourself?
_____people

6. For how many years have you, your family, or your organization owned this property?

- Less than 10 years
- 10-19 years
- 20-29 years
- 30-39 years
- 40-49 years
- More than 50 years of ownership

7. What is the primary use of your woodland?
(*Check all that apply*)

☐ Recreational ☐ Investment ☐ Woodland not actively used
☐ Forestry ☐ Residential ☐ Other (please specify)
_____

8. Is your home (primary residence) on or within a mile of any of your woodland?

- Yes
- No

9. Do you have any permanent streams on your woodlands?

- Yes
- No

a. If yes, do you maintain any trees, shrubs, or bushes along the stream bank (buffer)?

- Yes
- No

10. Please rank your agreement with the following statements about yourself and your forest network.

	1	2	3	4	5	6	7
	Strongly disagree						Strongly agree
Being a forester is a part of who I am	○	○	○	○	○	○	○
I am personally capable of adapting my woodland to extreme weather impacts	○	○	○	○	○	○	○
I am a part of a forestry association	○	○	○	○	○	○	○
I have peers/mentors to whom I can speak and ask questions about my woodland	○	○	○	○	○	○	○
I am connected with professional forest advisors (i.e., extension/consultants)	○	○	○	○	○	○	○
My network's forest cover decisions influence my own	○	○	○	○	○	○	○
I have access to management groups for my woodland	○	○	○	○	○	○	○

11. How important are the following items within your management goals for your woodland?

	1	2	3	4	5	6	7
	No Importance			Important			Very Important
To earn financial returns	○	○	○	○	○	○	○
To maintain the land to pass on to my heirs	○	○	○	○	○	○	○
To maintain a place of residence	○	○	○	○	○	○	○
Forest conservation	○	○	○	○	○	○	○
Being a forester is one of my responsibilities to my family	○	○	○	○	○	○	○
Being a forester is one of my responsibilities to my surrounding community	○	○	○	○	○	○	○
Hunting and/or fishing	○	○	○	○	○	○	○
Recreation, other than hunting or fishing	○	○	○	○	○	○	○
Beauty and scenery	○	○	○	○	○	○	○

a) If hunting and/or fishing are part of your woodland management goals, who are the groups you allow to access to the land?
(*Check all that apply*)

☐Myself
☐My family members
☐Friends
☐The public
☐Hunting clubs
☐Tenants
☐A business
☐A government agency
☐Guides
☐Hunting and/or fishing are not a part of my management goals

History of Your Woodland

To understand your production and conservation plans in the future, it is helpful for us to understand your recent activity within your woodland. Additionally, there have been a number of extreme storms and other weather events in the last 10 years, so we are interested in learning about salvage, harvests, or other activities that occurred following a disturbance.

Land Use History

12. In the LAST 10 years,

a. Did you convert any non-woodland (i.e., pasture/crop) into woodland?

- ☐ Yes, _____acres
- ☐ No

b. Did you sell any portion of your woodland?

- ☐ Yes, _____acres
- ☐ No

c. Did you convert any portion of your woodland into non-woodland?

- ☐ Yes
- ☐ No (*skip to d.*)

If yes, for what use did you convert?

- ☐ Farming _____acres
- ☐ Ranching _____acres
- ☐ Residential _____acres
- ☐ Other (please include use and acreage) _____

d. Did you designate any portion of your woodland in a conservation program?

- ☐ Yes, _____acres
- ☐ No

Planned Harvests

Please answer the following questions related to decisions about your land in the LAST 10 years.

13. Approximately, how much woodland did you <u>plan and harvest</u> for timber?

_____acres

a. Did you replant on your harvested woodland?

- ☐ Yes, _____acres
- ☐ No

b. Did you leave any of your harvested woodland area to allow for natural regeneration?

- ☐ Yes _____acres
- ☐ No

Salvage/Disturbance Harvests

14. Please answer the following questions related to decisions about your land in the LAST 10 years.

Was any of your woodland impacted by a <u>wind disturbance</u> that left it requiring replacement?

- ☐ Yes, _____acres
- ☐ No (*skip to #15*)

If yes, please answer the following:

a. Did you conduct salvage logging on any of the damaged land?

- ☐ Yes, _____acres
- ☐ No (*skip to b.*)

If yes, did you replant after salvage logging?

- ☐ Yes, _____acres
- ☐ No

b. Was your any of your damaged land left to allow for natural regeneration?

- ☐ Yes, _____acres
- ☐ No

c. Did you convert any of the damaged land (salvaged or otherwise) to uses other than woodland?

- ☐ Yes, _____acres
- ☐ No (*skip to d.*)

If yes, for what use did you convert?

- ☐ Farming
- ☐ Ranching
- ☐ Residential
- ☐ Other (please specify) _____

d. Did you sell any of the damaged land (salvaged or otherwise)?

- ☐ Yes, _____acres
- ☐ No

Extreme Weather Scenarios

Since 1960, 41 severe coastal storms have made landfall between Dauphin Island, AL and Panama City, FL. There have been 6 severe coastal storms in the past 3 years. 9 of the top 10 costliest storms in the United States have occurred since the year 2000. In 2020 alone, there were 30 named storms and 13 of those became hurricanes.

This table depicts severe coastal storm landings between Dauphin Island, AL and Panama City, FL since 1960. The final 2 rows show 2 potential increases (25% and 50%) in severe storms based on the previous 20 years.

Years	Tropical Storms	Category 1-2 Hurricanes	Category 3+ Hurricanes	Total Severe Storms
1961-1980	5	4	3	12
1981-2000	6	7	1	14
2001-2020 Scenario 1	12	4	3	18
2021-2040 Scenario 2 with 25% increase	15	5	4	23
2021-2040 Scenario 3 with 50% increase	18	6	5	28

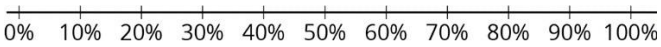
We are interested in understanding how your woodland management may change given the following three scenarios. Please answer the following three sets of questions given the 3 different proposed storm conditions.

Years	Tropical Storms	Category 1-2 Hurricanes	Category 3+ Hurricanes	Total Severe Storms
2021-2040 Scenario 1	12	4	3	18

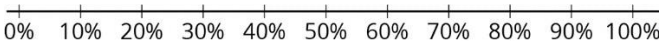
Scenario 1: Tropical storm and hurricane rate <u>remains the same as 2000-2020 levels</u>.

If the storm conditions of Scenario 1 were to occur:
(*For the following questions: If yes, please mark an approximate percentage on the line with an X. If your answer is "none," please mark the X at 0%.)*

15. I would likely sell a portion of my woodland in the next 10 years.

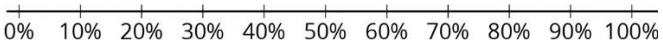


16. I would likely convert a portion of my woodland for another use in the next 10 years.



a. If you were to convert some woodland, to what use would you convert it?
(*Check all that apply*)
☐Farming ☐Ranching ☐Residential
☐Unsure ☐Other _____

17. I would likely designate a portion of my woodland in a conservation program in the next 10 years.



18. My responses to this scenario are similar to how I currently plan to manage my land in the next 10 years.

1	2	3	4	5	6	7
Strongly disagree						Strongly agree
○	○	○	○	○	○	○

Scenario 2: Tropical storm and hurricane rates <u>increase 25% from 2000-2020 levels.</u>

Years	Tropical Storms	Category 1-2 Hurricanes	Category 3+ Hurricanes	Total Severe Storms
2021-2040 Scenario 2 with 25% increase	15	5	4	23

If the storm conditions of Scenario 2 were to occur:

(*For the following questions: If yes, please mark an approximate percentage on the line with an X. If your answer is "none," please mark the X at 0%.)*

19. I would likely sell a portion of my woodland in the next 10 years.

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

20. I would likely convert a portion of my woodland for another use in the next 10 years.

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

a. If you were to convert some woodland, what would you convert it to?

(*Check all that apply*)

☐Farming ☐Ranching ☐Residential

☐Unsure ☐Other _____

21. I would likely designate a portion of my woodland in a conservation program in the next 10 years.

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

22. My responses to this scenario are similar to how I currently plan to manage my land in the next 10 years.

1	2	3	4	5	6	7
Strongly disagree						Strongly agree
○	○	○	○	○	○	○

Scenario 3: Tropical storm and hurricane rates <u>increase 50% from 2000-2020 levels.</u>

Years	Tropical Storms	Category 1-2 Hurricanes	Category 3+ Hurricanes	Total Severe Storms
2021-2040 Scenario 3 with 50% increase	18	6	5	28

If the storm conditions of Scenario 3 were to occur:

(*For the following questions: If yes, please mark an approximate percentage on the line with an X. If your answer is "none," please mark the X at 0%.)*

23. I would likely sell a portion of my woodland in the next 10 years.

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

24. I would likely convert a portion of my woodland for another use in the next 10 years.

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

a. If you were to convert some woodland, what would you convert it to?
(*Check all that apply*)
☐Farming ☐Ranching ☐Residential
☐Unsure ☐Other _____

25. I would likely designate a portion of my woodland in a conservation program in the next 10 years.

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

26. My responses to this scenario are similar to how I currently plan to manage my land in the next 10 years.

1	2	3	4	5	6	7
Strongly disagree						Strongly agree
○	○	○	○	○	○	○

Extreme Weather Perceptions

For questions 27-30, please consider your past experience with hurricanes.

27. Consider which named storms have impacted the northern Gulf of Mexico in the past. Please list the storms you believe had the greatest impact on your woodland(s).

_____

_____

_____

_____

28. To what extent to you believe that hurricanes are influential in altering land use along the northern Gulf of Mexico?

1	2	3	4	5	6	7
No influence						Very high influence
○	○	○	○	○	○	○

29. What is your level of concern for future hurricanes and their potential damage to <u>your</u> woodland?

1	2	3	4	5	6	7
No concern						Very high concern
○	○	○	○	○	○	○

30. How do you feel your concern level about hurricane risk to your forest investments compares to your neighbors?

1	2	3	4	5	6	7
I am far less concerned			About the same concern			I am far more concerned
○	○	○	○	○	○	○

Future of Your Woodland

Please indicate your agreement or disagreement with the following statements regarding factors that might <u>influence your decision to SELL OR CONVERT some or all of your woodland in the future.</u>

	1	2	3	4	5	6	7
	Strongly Disagree			Agree			Strongly Agree
A change in forest product market prices	○	○	○	○	○	○	○
A change in U.S. forest certification requirements	○	○	○	○	○	○	○
A change in environmental regulations	○	○	○	○	○	○	○
A change in stumpage prices	○	○	○	○	○	○	○
A change in woodland tax incentives	○	○	○	○	○	○	○
Prices in other agricultural markets	○	○	○	○	○	○	○
Subsidies for land uses other than forestry	○	○	○	○	○	○	○
Other forest owners selling their land	○	○	○	○	○	○	○
I would sell my forest land if I was offered a reasonable price	○	○	○	○	○	○	○
Inability to find a management group to operate my woodland	○	○	○	○	○	○	○
An increased number of hurricanes	○	○	○	○	○	○	○
An increased strength/intensity of hurricanes	○	○	○	○	○	○	○
An increase in wind damage to my forest	○	○	○	○	○	○	○
Retirement	○	○	○	○	○	○	○
Availability of *affordable* insurance	○	○	○	○	○	○	○

31. Do you have a documented plan for what will happen to your land when you are no longer the owner?

- o Yes
- o No (*skip to #32*)

a. If yes, please indicate all plans that apply to your woodland
(Check all that apply)

- □ I have a **will** that includes wishes for how I want my land used in the future.
- □ I have a **trust** that includes wishes for how I want my land used in the future.
- □ A **conservation easement or restriction** has been placed on all or some of my property by myself or a previous owner.
- □ I have a documented **exit strategy** specifying how I want my land to be used in the future.
- □ I have a documented plan to **sell or liquidate** my land in the future.
- □ I have some **other documentation** that includes wishes for how I want my land used in the future.
  Please specify _____

32. If you were to sell or pass on your forest land, who would you be likely to sell or pass it on to?
(Check all that apply)

- □ My children
- □ Other family member(s)
- □ A business
- □ A government agency
- □ A conservation group
- □ Other (please specify): _____

Benefits of Your Woodland

For Questions 33-36, please rate the extent to which the following benefits from your woodland are important to you. Please fill one answer for each item.

33. How important to you are the following products from <u>your own woodland</u>?

	1	2	3	4	5	6	7
	Not important at all						Very important
Timber Products	○	○	○	○	○	○	○
Non-timber products such as pine straw	○	○	○	○	○	○	○
Forage for grazing	○	○	○	○	○	○	○
Food products including wild game, fish, or vegetation	○	○	○	○	○	○	○
Fresh water for drinking, energy, irrigation, or other uses	○	○	○	○	○	○	○

34. Please rate the extent to which you feel these aspects of the natural system are important to manage on your land.

	1	2	3	4	5	6	7
	Not important at all						Very Important
To provide habitat for game animals	○	○	○	○	○	○	○
To provide potential habitat for threatened and endangered species	○	○	○	○	○	○	○
To help maintain biodiversity that helps support forest system functioning	○	○	○	○	○	○	○
To help protect stream health and biodiversity (i.e., abundance/diversity of aquatic life)	○	○	○	○	○	○	○
To maintain and promote soil formation	○	○	○	○	○	○	○

35. How important to you are the following functional benefits <u>of your woodland</u>?

	1	2	3	4	5	6	7
	Not important at all						Very Important
Air quality regulation/ provision of clean air	○	○	○	○	○	○	○
Carbon storage: in trees, plants, and soils	○	○	○	○	○	○	○

Weather moderation: of temperature and precipitation	○	○	○	○	○	○	○
Water regulation: runoff and flood control	○	○	○	○	○	○	○
Water regulation: groundwater recharge and purification	○	○	○	○	○	○	○
Soil erosion: control by trees and other plants	○	○	○	○	○	○	○
Blocking passage of pests: mosquitos, germs, and diseases that may affect people or crops	○	○	○	○	○	○	○
Pollination: bees that pollinate crops, flowers, and other plants	○	○	○	○	○	○	○
Urban sprawl regulation: control the way the city grows	○	○	○	○	○	○	○
Moderating natural hazards: winds & storms	○	○	○	○	○	○	○

36. How important to you are the following direct human benefits <u>of your woodland</u>?

	1	**2**	**3**	**4**	**5**	**6**	**7**
	Not important at all						Very Important
The investment opportunities the forest provides to my household	○	○	○	○	○	○	○
The financial security the forest provides to my household	○	○	○	○	○	○	○
The social relationships that I have with others because of the forest	○	○	○	○	○	○	○
The educational values of the forest	○	○	○	○	○	○	○
Recreation opportunities	○	○	○	○	○	○	○
Tourism opportunities that that having forests provides to the region	○	○	○	○	○	○	○

Conservation on Your Woodland

37. Have you ever had your forest land enrolled in any type of conservation program that provided you with financial benefits such as tax relief, paid incentives, cost-share, or other financial incentives?

- ☐ Yes
- ☐ No (*skip to #38*)

a. Have you ever had your forest land enrolled in any of the following cost-share programs:

(Check all that apply)

- ☐ Conservation Reserve Program
- ☐ Environmental Quality Incentives Program
- ☐ Wildlife Incentives Program
- ☐ Wetland Reserve Program/Wetland mitigation
- ☐ Private market enrollment for the capture of Carbon Sequestration
- ☐ Conservation Easement
- ☐ Other state-funded conservation programs
- ☐ Other federally funded conservation program
- ☐ Other privately funded conservation program

38. If there were a conservation program that offered you a payment or tax benefit for maintaining the services and human benefits your woodland provides, how interested would you be in hearing more about the program?

	1	2	3	4	5	6	7
	Not Interested			Interested			Very Interested
Participation in a conservation program	○	○	○	○	○	○	○

39. If a conservation program offered an annual payment for conserving for woodland, at what price would you be willing to enroll your land?

	1	2	3	4	5	6	7
	Less profit per acre			Equal profit per acre			More profit per acre
Relative profits per acre	○	○	○	○	○	○	○

Demographics

40. What is your sex?

- Female
- Male
- Prefer not to say

41. In what year were you born?

42. In which county and state do you currently live?

_____, _____

a. For how many years have you lived here?

_____year(s)

43. What is the highest level of education you have completed?
(*Check one*)

- ☐ Less than 12th grade
- ☐ High school graduate or GED
- ☐ Some college, but no degree
- ☐ Associate's or technical degree
- ☐ Bachelor's degree (4 year)
- ☐ Graduate/Advanced degree

44. Are you retired?

- o Yes
- o No

45. What is your ethnicity?
(*Check all that apply*)

- ☐ Native American
- ☐ Black/African American
- ☐ Hispanic or Latino
- ☐ Hawaiian or Pacific Islander
- ☐ White/Caucasian
- ☐ Asian
- ☐ Other _____
- ☐ Prefer not to answer

46. Approximately, what percentage of your household's income is generated from your woodland?

_____%

47. Approximately, what percentage of your income is generated from other aspects of your property (agriculture, livestock, leasing, etc.)

_____%

48. Which of these options best describes your 2021 income?

This data will only be used to categorize and analyze the distribution of income among forested landowners and how it may relate to their land use decisions for this research project, and as a reminder, all of your answers are confidential and will never be associated with your name or mailing address.

- Less than $14,999
- $15,000-$24,999
- $25,000-$34,999
- $35,000-$49,999
- $50,000-$74,999
- $75,000-$99,999
- $100,000-$149,999
- More than $150,000

We grant you our sincerest thanks for completing this survey and helping us understand the future of our Gulf Coast region forests. The valuable information you shared will be used to enhance the future of forest production and conservation decisions.

If you have any additional comments, questions, concerns, or anything else you would like to share about your woodland, please write them in the space below.

Appendix B

Forest Landowner Survey Letters

Dear Forest Owner,

Auburn University College of Forestry, Wildlife and Environment (CFWE) is collaborating with the Florida Forestry Association to gather information regarding forest landowner production and conservation futures in the Gulf Coast Region. A traditional powerhouse of the forestry industry, this region has undergone land use change and has faced the brunt of hurricane impacts.These changes influence the forest industry and all the subsequent ecosystem services that forest land provides such as watershed value, biodiversity habitat, carbon sequestration, forest recreation, and even the aesthetics of the region.

The best way we have of learning about forest production and conservation related issues is by asking the most relevant population to share their thoughts and opinions. You are one of a small number of randomly selected Gulf Coast forest owners who we are asking to participate by completing a survey questionnaire. This questionnaire is only available to Alabama and Florida property owners age 19 or older. The questions should take about 10-15 minutes to complete. Your responses will be kept confidential. Your answers will never be associated with your mailing address or your name. There is no cost to you for your participation. Your participation is completely voluntary and your decision about whether or not to participate will not jeopardize your future relations with Auburn University or the College of Forestry, Wildlife and Environment. Any data obtained in connection with this study will remain anonymous.

The information you share with us will be used to inform forest and conservation associations and consultants, agency personnel and policy makers, and individual forest owners. It is designed to enhancefuture forest production and conservation decisions. The results of this study will also be made directly available to any survey participant.

We appreciate and value your input and look forward to receiving the completed survey.

By taking a few moments to share your views and experiences, you will be helping to develop a better understanding of the future of forest production and conservation along the Gulf Coast. If you have any questions about this survey, please contact PhD student Annamarie Brown by email at aeb0159@auburn.edu or by telephone at 334-844-8043.

Sincerely,

Wayde Morse

Dr. Wayde Morse

Professor, College of Forestry, Wildlife and Environment

Auburn University

Having read the following information provided in this packet, you must decide if you want to participate in this research project. If you decide to participate, the data you provide will serve as your agreement todo so. If you have any questions about your rights as a research participant, you may contact the AuburnUniversity Office of Human Subjects Research of the Institutional Review Board by telephone at 334- 844-5966 or by email at IRBadmin@auburn.edu or IRBChair@auburn.edu.

The Auburn University Institutional Review Board has approved this document for use from March 18, 2022, onward.
Protocol #20-271 EX 2007

Greetings!

Recently, you received a questionnaire related to forest production and conservation futures along the Gulf Coast. If you have already completed and returned this questionnaire, please accept our sincerest thanks. If not, please complete the questionnaire as soon as possible. We appreciate that you are taking the time to help us with this study!

If you have any other questions, or if you did not receive a questionnaire, please contact Annamarie Brown at 334-844-8043 or email us at aeb0159@auburn.edu. Thank you for your time and assistance with this research.

Sincerely,

Wayde Morse

Dr. Wayde Morse

Professor, College of Forestry, Wildlife and Environment

Auburn University

Dear Forest Owner,

A few weeks ago, you were sent a packet containing a survey about forest landowner production and

conservation futures in the Gulf Coast Region. If you have already completed and returned this questionnaire, please accept our sincerest thanks. If not, please consider filling it out and returning it as soon as possible. This is our final request and reminder to you to help us out by completing the questionnaire!

If you have misplaced your survey, please complete it at the following URL:

https://bit.ly/gulfsurvey
ID:

The College of Forestry, Wildlife and Environment at Auburn University is working with the Florida Forestry Association to gather this information. The information you share with us will be used to inform forest and conservation associations and consultants, agency personnel and policy makers, and individual forest owners. It is designed to enhance future forest production and conservation decisions.

You are one of a small number of randomly selected Gulf Coast forest owners who we are asking to participate by completing a survey questionnaire. This questionnaire is only available to Alabama and Florida property owners aged 19 or older. The questionnaire should take approximately 10-15 minutes to complete. Your responses will be kept confidential. Your answers will never be associated with your mailing address or your name. There is no cost to you for your participation. Your participation is completely voluntary and your decision about whether or not to participate will not jeopardize your future relations with Auburn University or the College of Forestry, Wildlife and Environment. Any data obtained in connection with this study will remain anonymous.

We appreciate and value your input and look forward to receiving your responses. If you have any questions about the survey, please contact Annamarie Brown by telephone at 334-844-8043 or by email at aeb0159@auburn.edu.

Sincerely,

Wayde Morse

Dr. Wayde Morse

Professor, College of Forestry, Wildlife and Environment

Auburn University

Having read the following information provided in this packet, you must decide if you want to participate in this research project. If you decide to participate, the data you provide will serve as your agreement to do so. If you have any questions about your rights as a research participant, you may contact the Auburn University Office of Human Subjects Research of the Institutional Review Board by telephone at 334-844-5966 or by email at IRBadmin@auburn.edu or IRBChair@auburn.edu. The Auburn University Institutional Review Board has approved this document for use from March 18, 2022, onward. Protocol #20-271 EX 2007

Appendix C

Forest Stakeholder Interview Questionnaire

Property Questions

1. How many acres of woodland do you/your company own or manage in the Florida panhandle and coastal Alabama?
2. What is the composition of timber within your woodland? (Loblolly, slashpine, longleaf, etc.)
3. For how many years have you, your family, or your organization owned or managed woodland in this region?
4. How many acres of these collective properties are used farming or ranching?
5. What is the primary use of these woodland properties?
6. Type of ownership? (Individual, joint, corporation, LLC, etc.)

Content Questions

1. How do you factor hurricanes or wind damage into your forest management plans?
    a. What is your level of concern for future hurricanes and potential damage to your woodland?
    b. If hurricanes get stronger or increase in number, to what extent do you think this will influence your management?
    c. Do you believe extreme hurricanes like hurricane Michael change your or others' perceptions about managing lands for timber?
2. Do you plan to sell or convert any portion of your woodland in the next 10 years?
    a. Approximate percentage converted to farming, ranching, solar, or residential?
3. Have you done any salvage logging on the property(ies) you manage due to storm damage?\
    a. Do you have any insurance that covers hazards like storm damage? (Does such insurance exist?)
    b. What strategies do you/your company use to deal with storm recovery?
4. Are there industry issues, government programs, or other factors that may influence your future forest management (Potential prompt: For example, mill closures, tax polies, or environmental regulation changes)
    a. How will these issues impact your management?
5. To what extent are you interested in conservation programs with your timber?
6. What role are solar farms playing in changing land cover in the region?
7. What do you think are some of the major things driving forest management/land cover in the region?