



Forest Landowners' Engagement in Communication Networks and Educational Activities: Insights from the Southern United States

Prabin Bhusal^{a,b}, Rajan Parajuli^a, Sonia R. Bruck^c, Sabhyata Lamichhane^d, Ana Cubas-Baez^a, and Erin O. Sills^a

^aDepartment of Forestry and Environmental Resources, North Carolina State University, Raleigh, NC 27695, USA; ^bInstitute of Forestry, Tribhuvan University, Pokhara Campus, Hariyokharka-15, Nepal; ^cUnited States Department of Agriculture Forest Service, Southern Research Station, Forest Economics and Policy Unit, Durham, NC, USA; ^dDepartment of Forestry, Mississippi State University, 105 Thompson Hall, Mississippi State, MS 39762, USA

ABSTRACT

We employed the Multiple Indicator-Multiple Causes (MIMIC) model to explore whether the pattern of landowners' engagement in various information sources and educational activities was influenced by the COVID-19 pandemic, making it harder and unsafe to attend mass gatherings. Using data from a 2023 survey of forest landowners in the Southern United States, we found that 51% of respondents were likely to engage in communication networks and educational activities over the next decade. Landowners with larger forest holdings, purchased properties, and the ownership motivation for enjoying scenery are more likely to engage in communication and educational activities. Increased use of online resources and delays in receiving forestry and land management assistance during the pandemic were also positively associated with engagement, highlighting the pandemic's role in reshaping educational outreach and communication efforts. Our findings offer nuanced insights for developing and revising forest landowner communication networks and educational programs in the post-pandemic era.

ARTICLE HISTORY

Received 20 March 2025
Accepted 10 December 2025

KEYWORDS

COVID-19 pandemics; educational activities; forest landowners; forest management; Multiple Indicator-Multiple Causes model

Introduction

In the United States (U.S.), about 60% of forestland is privately owned, with family forest owners (FFOs) holding roughly 39% throughout the country (Butler et al. 2021). The majority of FFOs own and manage small- to medium tracts that are infrequently harvested or replanted (Butler, Schelhas, and Butler 2019; Snyder, Butler, and Markowski-Lindsay 2019) and often have limited forestry knowledge or training compared to large corporate and industrial owners (Measells et al. 2006). Many FFOs are unfamiliar with federal or state programs that can support and advance forest management objectives related to timber quantity and quality, wildlife habitat, or legacy planning (Ma et al. 2012). To promote sustainable land management, government

agencies and nonprofit organizations have invested heavily in education and outreach, including technical assistance, peer learning, and Cooperative Extension (Sagor et al. 2014). Cooperative Extension Services offer education and technical assistance on various cost-share programs, forest certification systems, and other context-specific forest management techniques (Ednie and Leahy 2007; Kueper et al. 2014). Yet, a large share of landowners remains disengaged from these opportunities (Ma et al. 2012), highlighting persistent gaps between outreach efforts and landowner participation in various government supports and incentive programs (Balasubramanian et al. 2024; Chizmar et al. 2021; Zobrist and Rozance 2015).

The COVID-19 pandemic, the period between March 2020 and February 2022, drastically altered how landowners access information through various information sources and networks. Lockdowns and social distancing measures forced Cooperative Extension and other sources of education and outreach to pivot to remote delivery (Fawcett et al. 2020). This shift accelerated digital competency among both educators and landowners (Bardon et al. 2023), potentially increasing long-term reliance on online resources. Remote learning also improved access for certain groups, such as older people, working adults and young parents (Bruck et al. 2024). However, pandemic-related “virtual fatigue” (Epstein 2020) and persistent digital divides may lead to limited engagement for others. Understanding how these changes reshaped landowner communication and education preferences is therefore critical for designing adaptive outreach strategies in this changing context. Theoretically, landowners’ behaviors and perceptions are shaped by their attitudes, social norms, and perceived control over actions, as described by the Theory of Planned Behavior (Ajzen 1991). Access to peer networks and social interactions further influence these behaviors through social capital and learning processes (Bodin, Crona, and Ernstson 2006; Lin 2001), particularly under external shocks such as COVID-19 that disrupted conventional engagement and communication patterns.

Past studies consistently reported limited awareness and varying landowner preferences for educational formats. Kuhns, Brunson, and Roberts (1998), for example, reported that nonindustrial private forest landowners preferred simple educational materials such as newsletters and personal assistance over workshops and high-tech methods, whereas Measells et al. (2006) found that 60% of landowners in the U.S. South had never received forestry information. Unaware of programs is found the consistent reason for not meeting educational needs by landowners in North Carolina (Bardon et al. 2023). Similarly, Khanal, Straka, and Guynn (2019) reported that field tours and short workshops were the preferred formats, but Bardon et al. (2023) revealed that mailing the materials is the preferred information delivery method among forest landowners. Results from the National Woodland Owner Survey similarly show that more than half of FFOs have never engaged with agencies or associations for forestry education (U.S. Department of Agriculture Forest Service 2025).

Previous studies suggest that landowners’ objectives and demographics strongly influence preferred communication channels. In North Carolina, Bardon et al. (2023) found that “legacy” and “conservation-oriented” owners favored online and mail resources, while “timber” and “investment” owners preferred traditional mail and less online interaction. Age also influences landowner preferences on education tools and delivery methods: younger owners often favor online tools, whereas older cohorts rely more on conventional

outreach (Butler, Butler, and Markowski-Lindsay 2017), though studies are unclear on how age relates to program participation (Langpap 2004; Ma et al. 2012).

Trust in information sources further affects landowner interest and participation in various education programs and communication networks. Landowners tend to view associations and peer networks as more credible than government agencies (Kilgore et al. 2007; Kueper, Sagor, and Becker 2013). In Minnesota, skepticism toward certification programs arose partly from confusion with state agencies’ branding, illustrating how perceived government control can discourage participation (Ednie and Leahy 2007). More broadly, low familiarity with certification (Kilgore et al. 2005) and concerns about documentation burdens have kept landowner participation in cost-share, certification, and conservation easement programs lower nationally (Ma et al. 2012; Rubino, Tian, and Pelkki 2022).

Thus, in this evolving outreach context, this study examines whether and how landowners’ engagement in various information sources and educational activities changed following the COVID-19 pandemic in the Southern United States. These findings provide nuanced insights for educators, policymakers, and forestry stakeholders to develop and implement forestry education programs and foster communication networks among FFOs.

Methods

Regional Landowner Survey and the Data

For this study, we utilized the data collected from a survey of forest landowners in 13 Southern States of the U.S. (Figure 1). The survey instrument was developed with input from four focus groups of forest landowners and other forestry stakeholders

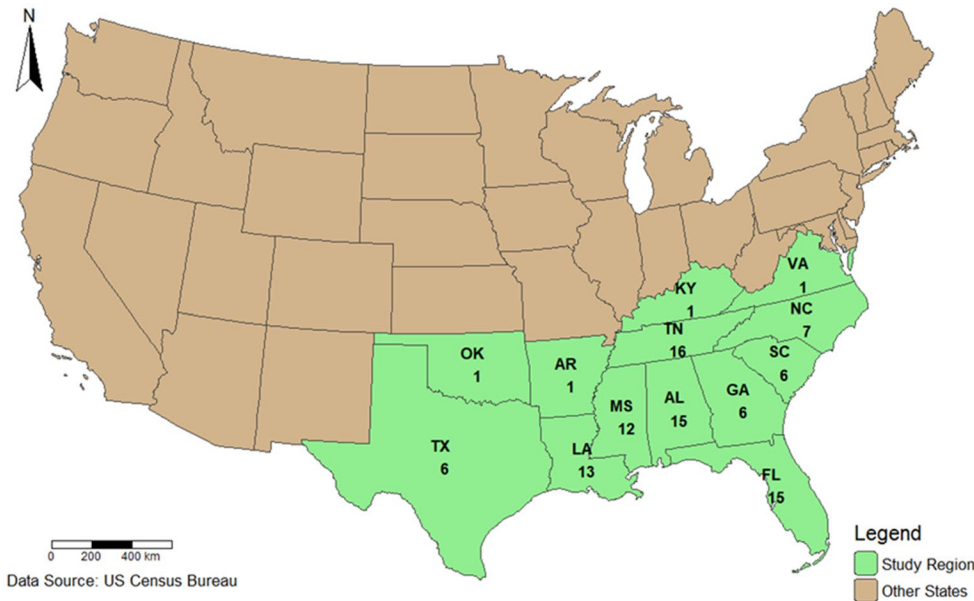


Figure 1. The study region with percentages of total responses from each state.

conducted in the fall of 2022 (Bruck et al. 2024), as well as related literature (e.g., Bardon et al. 2023; Butler et al. 2021; Ma et al. 2012). We also explored the preferred methods of external assistance stated by FFOs in NWOS to guide our survey instrument.

The survey instrument included several questions to assess not only the pandemic's impacts on forest landowners, markets, and forest management but also the emerging opportunities and challenges in forest management, estate planning, and communication networks during and after the pandemic. The instrument was pre-tested with a small group of forest landowners in North Carolina and Alabama and then revised for clarity before fielding it in the study area. The Institutional Review Board of North Carolina State University (IRB Protocol # 25008) approved as exempt the entire survey protocol.

Due to increasing survey non-response rates (Williams and Brick 2018), we employed various methods of questionnaire dissemination. We purchased the contact information of forest landowners from Giant Partners Marketing Agency ($n=8,016$), with the main inclusion criteria of private landowners having at least 20 acres with 10% forest cover in 13 southeastern states. In particular, we asked Giant Partners to prepare a contact list of forest landowners with both email and mailing addresses in their dataset with a plan to utilize various survey modes. An acreage threshold of 20 acres was applied, consistent with findings that small-scale landowners are generally less engaged in forest management and public assistance programs (Butler, Schelhas, and Butler 2019; Snyder, Butler, and Markowski-Lindsay 2019). Additionally, several state preferential property tax programs have 20 acres as a minimum acreage requirement for forestland programs (Chizmar et al. 2025).

We began with an online questionnaire using Qualtrics in the summer and fall of 2023, with three follow-up reminders sent between these periods (Dillman, Smyth, and Christian 2014). We also requested several forestry associations and state tree farm groups in 13 Southern States to share our Qualtrics link to their email listserv. Since the number of valid responses was quite low even after all these efforts, we sought to increase the representativeness of our sample by deploying three survey modes (web-only, mail, and push-to-web postcards) with and without incentives in our last round of survey dissemination. The incentive strategies were a \$2 bill inserted into mail surveys and a raffle draw of \$100 gift cards for all modes. The details of the survey dissemination and incentive schemes are explained in Cubas-Baez, Parajuli, and Sills (2025).

Of the original 8,016 landowner contacts from Giant Partners, 126 emails were undeliverable. We are unsure how many individuals received email from forestry associations, but it is possible that many of those were already included in our list from Giant Partners. To reduce the risk of duplicate responses, the emails distributed through state tree farms and associations asked landowners to disregard the invitation if they had already completed the survey. Additionally, we screened the dataset for duplicate entries and high response overlaps, with particular attention to the demographic section. The relatively low response rate, despite our efforts, could be due to outdated contact information obtained from Giant Partners. It is also possible that emails were directed into spam folders, preventing the recipient from seeing the request. Additionally, some survey recipients might have been disinterested in discussing COVID-19, since the survey was sent in 2023, three years after the start of the pandemic. We received 364 valid responses from forest landowners across 13 Southern States, all of whom own at least 20 acres of forestland in one or more states. Table 1

Table 1. Description and summary statistics of the dependent and explanatory variables included in the MIMIC model explaining the forest landowner’s engagement in communication networks and education activities in the Southern United States.

Variables	Descriptions	#Obs.	Mean from our survey	NWOS mean ^a
Dependent variable for MIMIC model: A latent construct derived from the four indicator variables: How likely are you to engage in the following communication networks and education activities in the next ten years?				
Consultation	To get land management assistance and consultation activities: <i>Extremely Likely (5), Somewhat Likely (4), Neutral (3), Somewhat unlikely (2), Extremely Unlikely (1)</i>	316	3.46	
Education	To get forestry or land management education: <i>Extremely Likely (5), Somewhat Likely (4), Neutral (3), Somewhat unlikely (2), Extremely Unlikely (1)</i>	316	3.33	
Involvement	To get involved with forest landowner associations or cooperatives: <i>Extremely Likely (5), Somewhat Likely (4), Neutral (3), Somewhat unlikely (2), Extremely Unlikely (1)</i>	316	3.03	
Neighbors	To communicate with neighbors about forest management: <i>Extremely Likely (5), Somewhat Likely (4), Neutral (3), Somewhat unlikely (2), Extremely Unlikely (1)</i>	315	3.18	
Explanatory Variables				
<i>Forestland ownership characteristics</i>				
Acres forestland	Binary: Total acres of forestland owned by landowners (≥ 100 acres [≥ 40.5 ha] = 1, 20–99 acres [8.1–40.1 ha] = 0).	364	0.53	0.48 ^b
Resident landowner	Binary: Forest landowners’ primary residence or vacation home on or within a mile of forestland tracts (Yes = 1, No = 0)	360	0.50	0.64
Acquisition purchased	Binary: Forestland acquisition: Purchased (Yes = 1, No = 0)	360	0.70	0.70
Ownership individual	Binary: Forestland ownership: Individual (Yes = 1, No = 0)	357	0.40	0.26
Reason beauty	Binary: Reason for owning forestland: Beauty (Yes = 1, No = 0)	353	0.69	0.75
Revenue land	Binary: Earned revenue from land-use Leases, such as hunting, camping, and other recreational leases (Yes = 1, No = 0)	349	0.23	

(Continued)

Table 1. Continued.

Variables	Descriptions	#Obs.	Mean from our survey	NWOS mean ^a
<i>COVID-19 related characteristics</i>				
Financial impact	Binary: During the pandemic, forest landowner's household experienced a significant decrease in total income (Yes= 1, No= 0)	350	0.17	
Education networks	Binary: use of online forestry webinars, social media, or conversations with neighbors during the pandemic (More = 1, Otherwise = 0)	318	0.14	
Delay assistance	Binary: Forest landowners faced delays of six months or more to get forestry and land management assistance, in-person or virtual, during the pandemic. (Yes= 1, Otherwise = 0)	327	0.11	
COVID disruption	Binary: After the pandemic, did life return "back to normal" or a "new normal" by the end of 2023 for your household? (Back to normal or new normal = 1, Otherwise = 0)	306	0.74	
<i>Demographic characteristics</i>				
Education	Categorical: Forest landowner's level of education (Less than 12 th grade =1, High school diploma or GED = 2, Some college = 3, Associate degree = 4, Bachelor's degree = 5, Master's degree or higher education = 6, Doctorate =7)	314	4.64	0.47 ^c
Income	Binary: Total annual household income in 2022 (Less than \$25,000 = 1, \$25,000–\$49,999 = 2, \$50,000–\$74,999 = 3, \$75,000 to \$99,999 = 4, \$100,000–\$149,999 = 5, \$150,000–\$199,999 = 6, \$200,000 or greater = 7)	294	4.83	
Race: white	Binary: Race of the respondent (White or European American = 1, Otherwise = 0)	312	0.95	0.97

^aSomewhat equivalent average values obtained from the USDA National Woodland Owner Survey Dashboard for the landowners in the Southeastern United States from the 2018 survey cycle. Note that these are not apple-to-apple comparisons as most of the questions were framed differently in NWOS from our survey and the timeframe of these two surveys is quite different.

^bExcluding the acreages less than 20 acres.

^cThis proportion indicates the bachelor or higher degree.

illustrates the total number of observations used for the analysis after accounting for partial and missing responses.

Empirical Model and Estimation Method

To evaluate how external shocks such as COVID-19 affected forest landowners' behavior and perceptions, we developed an empirical model grounded in the Theory of Planned Behavior (TPB) (Ajzen 1991). According to TPB, behavioral intentions are shaped by attitudes, subjective norms, and perceived behavioral control—all relevant to landowners' decisions to participate in forestry education or communication networks. During COVID-19, these determinants likely shifted due to disruptions in in-person engagement and the rapid adoption of online learning platforms in the absence of regular social activities due to lockdowns and other pandemic policies (Fawcett et al. 2020). In addition, access to knowledgeable peer networks can be viewed as a form of social capital within the social network theory of social capital (Lin 2001). It suggests that individuals can access resources and knowledge through their immediate groups and the broader network surrounding it. Strong, diverse networks can improve community adaptive capacity (Bodin, Crona, and Ernstson 2006). Therefore, through a combination of social learning and social capital, engagement in peer networks enables landowners to build relationships, acquire knowledge, and promote collaborations, including active engagement in communication networks and educational activities.

Our survey elicited forest landowners' likelihood of engaging in communication networks and educational activities using four indicator variables: (i) seeking land management assistance and consultation, (ii) obtaining forestry or land management education, (iii) involvement with forest landowner associations or cooperatives, and (iv) communication with neighbors about forest management (Table 1). We hypothesized that these four indicators measured landowners' propensity to engage in communication networks and education activities in the next 10 years as a single latent variable. We adopted a ten-year horizon to assess landowners' intentions to engage in educational and communication activities, reflecting the typical timeframe of forest management cycles such as thinning, cost-share contracts, and revision of management plans during which landowners commonly reassess their objectives and management strategies.

These four indicators represented distinct but interrelated dimensions of landowners' engagement in forestry educational programs and communication networks. Modeling them as a latent variable allows for correction of measurement error and captures the shared underlying dimension of engagement behavior (Woods, Oltmanns, and Turkheimer 2009). This approach accounts for the fact that each observed indicator may have random errors due to response biases or inconsistency in reporting. By extracting shared underlying constructs, the MIMIC model reduced the influence of these errors (Woods, Oltmanns, and Turkheimer 2009). The significant and high factor loading results substantiated that these factors strongly reflect the underlying construct, justifying their aggregation. Similarly, the direct effect on indicators helped identify the nuanced relationship (e.g., covariates may enhance education but not communication with neighbors), thus providing an analysis of the heterogeneous effects of covariates. From a practical perspective, analyzing the four indicators as a latent

construct provided both an overall approach and method-specific engagement strategies (what kind of landowners need to target which method of engagement).

For this analysis, we used the MIMIC model, which simultaneously examines the effects of covariates on both the latent construct and its individual indicators (Chen and Jiang 2019; Proitsi et al. 2011). Unlike other regression approaches, MIMIC combines subject characteristics directly into a structural equation model to provide a more comprehensive understanding of covariate influences (Skrondal and Rabe-Hesketh 2004). This approach improves parameter estimation and clarifies relationships between variables, ultimately leading to more accurate insights into landowners' engagement behaviors (Woods, Oltmanns, and Turkheimer 2009; Chen and Jiang 2019). The MIMIC approach is widely used to analyze unobservable constructs measured by multiple indicators and influenced by observed causes in the various fields, including natural resources (Adhikari et al. 2024; Hassan and Schneider 2016; Holley et al. 2020; Rose and Spiegel 2011).

Following the analytical procedure for the MIMIC model outlined by Proitsi et al. (2011), Chen and Jiang (2019), and Holley et al. (2020), we first conducted the confirmatory factor analysis (CFA) on the four indicators of a latent construct to validate the factor structure of the four indicators. Then, we transformed the structural equation model into the MIMIC model by incorporating covariates to assess their impact on the factor structure of the forest landowner's likelihood of engagement in communication networks and educational activities.

The MIMIC model comprises the following two components: The first component delineates the relationship between the latent variable and the four indicators constituting the latent constructs estimating its suitability. The measurement model quantified the likelihood of forest landowners' engagement in communication networks and educational activities as a single latent variable based on indicators of the communication and educational activities that forest landowners expect to engage with. The degree of respondents' agreement with the four main indicators (Table 1) was measured using a five-point Likert scale ranging from extremely likely to extremely unlikely.

The second component models the structural relationship between the covariates and latent factor. This component aims to examine whether the covariates influence the structural relationship of forest landowners' likelihood of engagement in communication networks and educational activities in the Southern U.S. Forest landowner characteristics, including demographics, forest ownership, forest management motivation, and the impact of the COVID-19 pandemic, serve as covariates for the MIMIC model.

The measurement model is represented as (Rose and Spiegel 2011):

$$Y = \Lambda\eta + \varepsilon \quad (1)$$

Where Y is a vector of observed indicator variables representing different communication and educational engagement activities, Λ is a vector of factor loadings that defines how strongly each indicator is associated with the latent construct, η is the latent variable characterized by engagement in communication networks and education activities, and ε is a vector of measurement errors for the indicators.

The structural model is represented as:

$$\eta_i = Z_j\Gamma + \zeta_i \quad (2)$$

Where η_i is the latent construct representing a single latent variable, Γ is $j \times 1$ column vector of coefficients corresponding to each explanatory variable, Z_i is a $1 \times j$ row vector of observed explanatory variables (covariates), where j represents the number of covariates, and ζ_i is the error term for the latent variable.

We evaluated the robustness of the model's fit by using multiple criteria. The non-significant result of the Chi-square (χ^2) test indicates that the theoretical model can reproduce the variance-covariance relationships observed in the sample. However, it is important to note that this test is sensitive to large sample sizes. The root mean square error of approximation (RMSEA) assesses how well the model fits the population covariance matrix. The standardized root mean square residual (SRMR) measures the extent to which the models fit the data. A value below 0.05 suggests a very good model fit (Jöreskog and Sörbom 1996). The Comparative Fit Index (CFI) and Tucker-Lewis Index (TLI) compare the fit of the target model with that of an independent or null model. A value above 0.90 indicates a very good model fit. These diverse measures of fit provide balanced sensitivity to sample size and model complexity. Our model demonstrated a good fit, with $\chi^2 = 63.42$ ($p = 0.02$), RMSEA = 0.04, SRMR = 0.04, CFI = 0.949, and TLI = 0.994. We analyzed the odds ratio and percentage changes in the log odds of each covariate (Adhikari et al. 2024; Lambert, Paudel, and Larson 2015) associated with the latent variable. This analysis elucidates how the respondents' likelihood of engagement in communication networks and educational activities changes when a covariate increases or changes by a corresponding unit while holding all other variables constant. Finally, we analyzed the direct association between the covariates and each indicator of the latent variable representing landowners' preference for engaging in educational and networking activities. The analysis was conducted using R version 4.4.1 (2024) and the lavaan package (Rosseel 2012).

Results

Descriptive Analysis

Table 1 provides details on four indicators, which are utilized to estimate a latent construct that represents forest landowners' likelihood of engagement in communication networks and educational activities in the next 10 years. The explanatory covariates for these constructs are respondent characteristics, including demographics, forest ownership, ownership objectives, and the impact of the COVID-19 pandemic on their educational and outreach activities.

The descriptive statistics from our survey show that the average respondent was 66 years old and the average household income falls in the \$100,000–\$149,999 range. About 20% of the respondents were female, and 95% were white or of European race. Approximately 50% of the respondents owned more than 100 acres of forestland within a mile of their primary residence, and the majority (70%) had acquired their forestland through purchase. Furthermore, 40% of the respondents held individual ownership. Respondents who owned land for aesthetic purposes accounted for 69% of the sample; however, reasons for ownership were not mutually exclusive. The COVID-19 pandemic had an impact on the ability of forest landowners to manage or seek Extension, with

74% of respondents experiencing its effects and reporting a return to normalcy after the pandemic, whereas the remaining 26% reported no disruption. To test for non-response bias, we compared the mean values of key explanatory variables with the NWOS averages from the Southeastern United States (Table 1). The close correspondence between the two sets of means indicates that non-response bias is unlikely to affect the results.

The four indicator variables for the latent construct that forms the overall engagement in communication networks and educational activities include the likelihood of engagement in forest management assistance and consultation activities, forestry or land management education, forest landowner associations or cooperatives, and communication with neighbors about forest management. We found that about 51% of respondents are likely to participate in various communication networks and educational activities seeking management assistance, education, and involvement with associations and cooperatives in the next 10 years (Table 2). About 58% of the respondents indicated that they were somewhat or extremely likely to seek consultation and assistance for forestry and land management. Similarly, approximately 55% of forest landowners indicated that they were likely to obtain forestry or land management education in the next 10 years. Over 40% of the respondents in each category reported that they were likely to engage with landowner associations or cooperatives and communicate with neighbors for their communication networks. On average, 30% of the respondents were unlikely to participate in all activities, while 20% reported a neutral response (Table 2).

Changes in Communication Networks and Landowner Education Activities During the COVID-19 Pandemic Compared to Pre-Pandemic

While the majority of respondents (59%) reported that they never utilized most of the education networks for their communication and education activities, we found that approximately 14% of respondents increased their use of online forestry webinars, social

Table 2. Landowner’s likelihood to engage in communication networks and education activities in the next 10 years.

Landowners likelihood of engagement in communication networks and education activities in the next 10 years	Responses in percentages				
	Extremely Unlikely	Somewhat unlikely	Neutral	Somewhat Likely	Extremely Likely
Get forestry and land management assistance and consultations (consultation)	19	7	17	25	33
Get forestry or land management education (education)	20	8	17	29	26
Get involved with forest landowner associations or cooperatives (involvement)	26	9	22	22	21
Communicate with neighbors about forest management (neighbors)	23	9	20	25	23

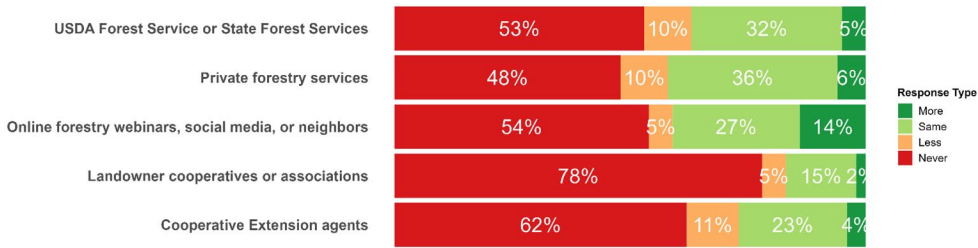


Figure 2. Changes in use of different education networks during the pandemic compared to the pre-pandemic period, as reported by Forest landowners.

Table 3. Percentage of respondents reporting delays of six months or more in education and communication activities during the pandemic.

Activity	Did not attempt	Completed without delays	Faced delays
To get forestry and land management assistance	67	22	11
To get forestry or land management education, in person or virtual	71	19	10
To attend a meeting or seminar for a forestry or landowner association or cooperative	73	14	13
To work with and communicate with my neighbors regarding forestry and land management	65	26	9

media, or conversation with neighbors during the pandemic compared to the pre-pandemic period (Figure 2). Among approximately half of respondents (47%) who reported using federal and state forestry agencies as an information source, most (60%) said that their reliance on that information source had not changed during the pandemic.

The study revealed that a small proportion of respondents (11%) experienced delays of six months or more in educational and communication activities during the pandemic, and the majority of respondents reported that they did not attempt to engage in any educational or communication activities during the pandemic (Table 3). Similarly, 26% of the respondents stated that they communicated with neighbors regarding forestry and land management without delays.

Among those who reported facing delays, 13% cited social distancing, stay-at-home, or quarantine requirements, and 10% identified lack of access to forestry or land management personnel as the major cause of delays in education and communication activities during the pandemic (Figure 3). For each specific cause, the remaining respondents indicated that cause was not applicable (“No”).

The MIMIC Model: The Effects of Covariates on Latent Construct Representing Landowners’ Intent to Engage in Communication Networks and Education Activities

The results of the measurement model show that all four indicators have factor loadings over 0.75 and are significant at $p < .01$ (Table 4), demonstrating the validity of the latent

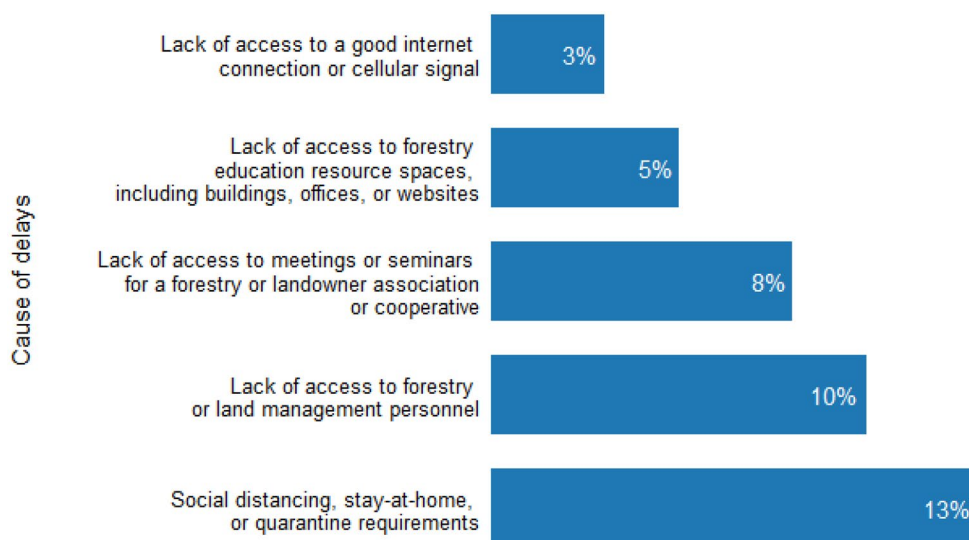


Figure 3. Causes of delays in education and communication activities during the pandemic. The bars show the proportion of the respondents who answered “yes” for each cause. The remaining respondents within this subgroup answered “No” for each specific cause.

Table 4. Measurement model for Landowner’s likelihood to engage in communication networks and education activities.

Indicators	Factor loadings	Threshold 1	Threshold 2	Threshold 3	Threshold 4
Consultation	0.78***	−0.89***	−0.66***	−0.19**	0.45***
Education	0.94***	−0.85***	−0.60***	−0.13*	0.66***
Involvement	0.88***	−0.65***	−0.38***	0.17**	0.80***
Neighbors	0.75***	−0.76***	−0.49***	0.03	0.72***

Significance at * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

construct. The thresholds represent the cutoff points on the latent continuum of landowners’ likelihood of engagement in communication networks and education activities, where respondents are likely to transition from one response category to the next. Most of the thresholds were significant, indicating a clear distinction between response categories.

The MIMIC model was designed to examine which types of landowners (as characterized by various covariates) are more likely to engage in communication networks and educational activities, represented by a latent construct capturing the likelihood of four distinct methods of engagement over the next decade, and to assess how these relationships vary across each engagement method. Of the 13 covariates analyzed, nine characteristics were significantly associated with the likelihood of being engaged landowners and proactive learners (Table 5), and 10 covariates showed significant associations with different methods of engagement compared with the overall likelihood of engagement (Table 6).

The MIMIC Model Results

The results suggest that forest land acreage ($\beta = 0.39$, $p < 0.01$) and land acquisition through purchases ($\beta = 0.15$, $p < 0.1$) were positively associated with the likelihood

Table 5. MIMIC estimates for landowner's likelihood to engage in communication networks and education activities and percentage change in propensity odds.

Covariates	Coefficient	Z value	Percent Change in log odds
Forestland ownership characteristics			
Acres forestland	0.39 (0.11)***	3.65	25.5
Resident landowner	−0.12 (0.10)	−1.18	−6.8
Acquisition purchased	0.15 (0.11)*	1.33	7.8
Ownership individual	−0.09 (0.10)	−0.93	−5.0
Reason beauty	0.41 (0.10)***	3.91	24.3
Revenue land	0.35 (0.11)**	2.96	18.1
COVID-19 related characteristics			
Financial impact	−0.13 (0.13)	−1.02	−5.4
Education networks	0.65 (0.15)***	4.44	30.1
Delay assistance	0.35 (0.15)**	2.34	12.8
Covid disruption	0.28 (0.11)**	2.62	15.6
Demographic characteristics			
Education	0.03 (0.03)	1.02	6.2
Income	−0.04(0.02)	−1.17	−7.1
Race white	−0.68 (0.22)**	−3.14	−15.6

Notes: $\chi^2=63.42$ ($p=0.02$), RMSEA = 0.04, SRMR = 0.04, CFI = 0.979, and TLI = 0.997.

Significance at * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$, Standard errors are in parentheses.

Table 6. Direct effect of covariates on each method of engagements (construct indicators).

Covariates	Consultation	Education	Involvement	Neighbors
	Coefficient	Coefficient	Coefficient	Coefficient
Forestland ownership characteristics				
Acres forestland	0.45 (0.17)**	0.50 (0.15)***	0.55(0.16)***	0.35(0.15)*
Resident landowner	−0.26 (0.16)	−0.06 (0.16)	−0.29 (0.16)*	0.06(0.16)
Acquisition purchased	−0.10 (0.16)	0.23 (0.15)*	0.32 (0.17)**	0.22 (0.16)
Ownership individual	−0.16 (0.14)	−0.02 (0.14)	−0.15 (0.15)	−0.17 (0.14)
Reason beauty	0.34 (0.15)**	0.64 (0.15)***	0.56 (0.16)***	0.32 (0.15)*
Revenue land	0.34 (0.18)*	0.47 (0.18)*	0.52 (0.16)**	0.23 (0.17)
COVID-19 related characteristics				
Financial impact	−0.05 (0.20)	−0.31 (0.18)**	−0.04 (0.18)	−0.18(0.19)
Education networks	0.41 (0.24)	1.19 (0.27)***	0.73 (0.21)***	0.70 (0.23)***
Delay assistance	0.44 (0.22)*	0.33 (0.24)	0.48 (0.25)	0.41 (0.25)
Covid disruption	0.22 (0.16)	0.43 (0.17)**	0.26 (0.17)	0.40 (0.16)**
Demographic characteristics				
Education	0.05 (0.04)	0.022 (0.04)	0.02 (0.04)	0.06 (0.05)
Income	−0.02 (0.04)	−0.10 (0.04)	−0.004 (0.04)	−0.02 (0.04)
Race white	−0.91 (0.36)**	−1.10 (0.31)***	−0.60 (0.28)*	−0.69 (0.29)**

Significance at * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$, Standard errors are in parentheses.

of engagement, indicating that landowners with larger forest holdings and those who have purchased forest land tracts are more likely to engage in communication networks and educational activities than those with smaller forest tracts and those who have inherited their forest land tracts, respectively. The land management objectives were also found to be significant covariates. Landowners managing forestland for scenery and beauty ($\beta=0.41$, $p<0.01$) demonstrated a strong positive association with the likelihood of seeking education, communication, and management assistance in the future. Furthermore, forest landowners deriving revenue from land use leases, such as hunting, camping, and other recreational leases, exhibit a significant positive association with their likelihood of engaging in education and communication networks.

COVID-19-related covariates showed a significant positive association with engagement likelihood, suggesting that the pandemic had a greater influence on outreach compared to pre-pandemic. The landowners who engaged in education networks ($\beta=0.65$, $p<0.01$) during COVID-19, such as online forestry webinars, social media, or conversations with neighbors exhibited a strong positive association with the likelihood of engagement in education and communication networks in the subsequent 10 years. Similarly, landowners who faced delays of six months or more to get forestry and land management assistance during the pandemic ($\beta=0.35$, $p<0.05$) and who faced COVID-19 disruption and returned to normal ($\beta=0.28$, $p<0.05$) are more likely to engage in education and communication networks in the subsequent 10 years. Although the majority of respondents (95%) were White and European American, we found race to be a significant covariate, with a negative association of White and European American landowners ($\beta = -0.68$, $p<0.05$) with their engagement in educational activities. This indicates that white landowners are less likely to engage in education and communication networks than landowners from other ethnic backgrounds. The odds ratio results (Table 5) demonstrate that landowners who own forest land over 100 acres, who are managing forestland for scenery and beauty, who are managing for timber production, and who engaged in more education networks during COVID-19 are strong predictors of the likelihood of engagement in communication networks and education activities. For instance, landowners' engagement in online forestry webinars, social media, or conversations with neighbors during COVID-19 is associated with a 30% increase in the log odds of the likelihood of engagement in communication networks and educational activities in the next 10 years.

Direct Effect of Covariates on Each Method of Engagement and Networks

For the covariates that describe forest ownership characteristics, the direct effect results (Table 6) indicate specific relationships between different engagement methods. For instance, forest owners who acquired land through purchase showed insignificant associations with consultation and neighbors' engagement. Resident landowners demonstrate a significant negative correlation with engagement, suggesting a lower likelihood of engagement in landowner associations or cooperatives. Furthermore, landowners owning forestland for revenue exhibited no significant association with neighbors' engagement.

We found a specific effect of COVID-19-related covariates on different methods of engagement compared with the overall likelihood of engagement. The direct effect indicates that landowners who engaged in education networks during the pandemic were more likely to engage in educational activities, involvement in associations or cooperatives, and communication with neighbors in the future. While no significant engagement with consultation activities Landowners who experienced a significant decrease in total income during the pandemic were less likely to engage in educational activities in the future. Similarly, landowners disrupted by COVID-19 were more likely to engage in education and neighbors' communication, suggesting that pandemic uncertainties might have encouraged more active engagement in peer networks and knowledge-sharing activities. The delay in assistance is significantly associated only with the engagement in consultation, suggesting that landowners who experienced delays of six months or more to get forestry and land management assistance during

the pandemic are more likely to seek land management assistance and consultancy services. Regarding demographic covariates, no distinct engagement pattern is found across different methods of engagement.

Discussion

The COVID-19 pandemic profoundly reshaped the delivery of forestry education and outreach, driving a rapid transition from in-person meetings to remote learning platforms. Landowners were compelled to adapt to virtual environments for forest management assistance and education—an unfamiliar experience for many landowners (Fawcett et al. 2020; Bruck et al. 2023). This study examined forest landowners' intentions to engage in communication networks and educational activities in the post-pandemic period. This study explores the key factors influencing landowners' likelihood of participating in consultations, education programs, forestry associations, and communication with neighbors—both as individual engagement methods and as a broader construct of communication and educational participation over the next decade. By incorporating socioeconomic, ownership, and COVID-19-related variables, this study provides insights into how the pandemic reshaped landowners' engagement patterns and preferences.

Consistent with the pre-pandemic literature (e.g., Blatner, Baumgartner, and Quackenbush 1991; Ma et al. 2012), our results indicate that landowners with larger forest holdings are significantly more likely to participate in communication networks and educational activities. Forest size remains a critical determinant of engagement because it correlates with both access to resources and awareness of programs (Butler et al. 2021; Floress et al. 2019). Similarly, larger acreage owners are found to have larger and more diverse personal networks that significantly influence the adoption of sustainable forest management practices (Sagor et al. 2014). Large landowners usually invest more capital and resources to acquire and manage their properties for economic returns. These findings suggest that outreach efforts should be tailored to accommodate both large and small landowners, given that smaller landholders, despite being the majority of family forest owners, often face structural and informational barriers to participation (Downing and Finley 2005). Forest ownership motivation also emerged as important predictors of the likelihood of engagement in educational and communication activities. Landowners who prioritize aesthetic enjoyment (“to enjoy beauty and scenery”) as their primary reasons for owning forestland were more likely to participate in communication networks and educational activities. This finding aligns with prior work showing that management objectives often drive landowners' decisions in participation and engagement in forestry activities (Catanzaro et al. 2007; Measells et al. 2006), suggesting that personalized outreach messages tailored to specific ownership goals could more effectively address landowners' key needs on education and communication networks. For instance, outreach for aesthetic-oriented landowners might emphasize biodiversity and conservation compared to other ownership objectives.

Furthermore, landowners who acquired their properties through purchases were more likely to engage in communication networks and educational activities than those who inherited or obtained land through other means. This distinction may reflect differences in management goals or familiarity with forestry resources. Landowners

who purchase their properties may have an immediate interest in maximizing the economic and ecological values of their land, potentially making them more receptive to outreach efforts. Despite living near their forestland, primary landowners were less likely to engage with forest landowner associations or cooperatives (Table 6). This pattern aligns with the general trend of limited engagement among FFOs with forestry associations and programs (Butler, Butler, and Markowski-Lindsay 2017) highlighting a potential gap in Extension and outreach programs targeted at forest landowners. Additionally, this may be because landowners remain under representation in educational programs, particularly for the small landowners (Mitani and Lindhjem 2022).

The pandemic also accelerated the adoption of online educational resources (Fawcett et al. 2020), and our results indicate that landowners who adopted virtual learning platforms during this period are more likely to continue utilizing them. The use of online information sources was relatively higher than other educational networks during the pandemic among the reported cases (Figure 2). This finding aligns with Bardon et al. (2023) and Pratama et al. (2020), suggesting that the pandemic expanded digital literacy and created enduring opportunities for hybrid engagement. Integrating virtual tools with in-person activities can help Cooperative Extension and similar organizations reach a broader audience, particularly absentee owners, while maintaining opportunities for peer learning and community building (Fawcett et al. 2020; Parajuli et al. 2020). However, nearly 60% of respondents reported never using educational networks, echoing results from the National Woodland Owner Survey (NWOS) and highlighting the persistent challenge of outreach to disengaged landowners.

The distinct direct effects of COVID-19–related covariates on different engagement types suggest that preferences evolved during the pandemic. Landowners who experienced disruptions due to COVID-19 were more likely to engage in forest education and neighbor communication, but less so in formal consultation or association activities. This may indicate that pandemic-related uncertainty fostered greater reliance on peer networks and informal information exchange (Bardon et al. 2023; Penn, Gutierrez-Castillo, and Blazier 2024). Moreover, the expansion of virtual learning during the pandemic likely increased long-term interest in forest management and conservation among previously unengaged landowners. With approximately 50% of FFOs owned by absentee landowners (Butler et al. 2021), online engagement preferences provide a potential avenue to reach these landowners for outreach.

Landowners who experienced a significant decrease in total income during the pandemic were less likely to engage in land management assistance, consultation, and educational activities in the future. This resonates with earlier studies indicating that financial constraints influence landowners' decision-making (Hilsenroth et al. 2021). These results underscore the need to design outreach and cost-sharing programs that engage financially constrained landowners (Chizmar et al. 2021). Encouraging participation through financial or technical assistance could help sustain engagement despite economic setbacks in forest landownerships.

Overall, this study finding along with the comparison to prior literature revealed that many patterns of engagement remained consistent across the pre- and post-pandemic periods, including the influence of landholding size and ownership motivations. However, increased technological adoption and the demand for flexible delivery

methods highlight the need for adaptive outreach strategies that accommodate diverse landowner preferences in the post-pandemic era.

This study has several limitations that warrant consideration when interpreting the findings. First, the data relied on self-reported responses from forest landowners, which may have been subject to hypothetical bias, as we attempted to capture the future intentions of landowners. Second, the MIMIC model assumes linear relationships between covariates and latent constructs, potentially simplifying complex interactions. Third, the cross-sectional design limits the ability to capture changes in engagement behavior over time. Future research would benefit from longitudinal studies to better understand how these engagement patterns evolve and how virtual learning and hybrid outreach models influence long-term landowner behavior.

Conclusion

The COVID-19 pandemic presented unique challenges and opportunities in various landowners' engagement in educational activities and communication methods. The findings highlight the critical role of landholding size, ownership motivations, and prior engagement with educational networks and financial incentive programs in determining the likelihood of engagement in educational activities and communication networks in the future along with its direct association with different engagement methods.

While landowners holding large acreage and those owning forests for aesthetic purposes demonstrated a higher propensity to engage with Extension services, small-acreage landholders and those with limited access to resources remained under-represented. This may highlight the need for targeted and inclusive educational and outreach strategies. The increased reliance on virtual platforms during the pandemic presents both opportunities and challenges highlighting the importance of hybrid approaches that combine the accessibility of online resources with the benefits of in-person programs. The MIMIC findings on the association of landowners' characteristics with outreach engagement are broadly consistent with previous studies while COVID-19 related characteristics suggest that the pandemic may have changed a pattern of landowners' learning and communication approaches.

The findings of this study offer several actionable insights for forestry education, outreach, and communication networks. First, Cooperative Extension and forestry educational agencies should adopt flexible, hybrid engagement strategies that combine virtual platforms with in-person activities to broaden accessibility, particularly for absentee and small landowners. Second, outreach materials and programs should be customized to reflect ownership motivations, landholding size, and management goals, thereby increasing relevance and engagement of diverse forest landowners. Third, enhancing financial and technical support for economically constrained landowners could help mitigate engagement barriers intensified by the pandemic. Finally, investing in digital infrastructure and capacity-building initiatives will be essential to sustain the momentum of virtual learning and ensure equitable access to forestry education and communication networks in the post-pandemic era. In the post-pandemic era, balancing traditional outreach methods with innovative tools and approaches will be

crucial to continue supporting forest landowners in achieving their long-term management and conservation goals.

Acknowledgement

We would like to sincerely acknowledge all the forest landowners from thirteen southern states who agreed to participate in the survey and provided valuable information.

Author contributions

CRedit: **Prabin Bhusal**: Formal analysis, Methodology, Writing – original draft, Writing – review & editing; **Rajan Parajuli**: Conceptualization, Funding acquisition, Methodology, Resources, Supervision, Validation, Writing – original draft, Writing – review & editing; **Sonia Bruck**: Writing – original draft, Writing – review & editing; **Sabhyata Lamichhane**: Writing – original draft, Writing – review & editing; **Ana Cubas-Baez**: Data curation, Writing – original draft, Writing – review & editing; **Erin Sills**: Supervision, Validation, Writing – review & editing.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This study is funded by the United States Department of Agriculture, National Institute of Food and Agriculture (USDA NIFA), grant no. [2022-68006-36430].

References

- Adhikari, S., B. Thapa, S. D. Fuhlendorf, and O. Joshi. 2024. “Landowner Perceptions toward Adopting Patch-Burn and Mixed-Species Grazing for Rangelands in the U.S. Southern Great Plains.” *Journal of Agricultural and Applied Economics* 56: 389–404. <https://doi.org/10.1017/aae.2024.16>.
- Ajzen, Icek. 1991. “The Theory of Planned Behavior.” *Organizational Behavior and Human Decision Processes* 50 (2): 179–211. [https://doi.org/10.1016/0749-5978\(91\)90020-T](https://doi.org/10.1016/0749-5978(91)90020-T).
- Balasubramanian, K., A. Mook, P. Kadam, and P. Dwivedi. 2024. “Do Male and Female Family Forest Landowners Have Different Training Needs? A Case Study from Georgia, United States.” *Forest Policy and Economics* 163: 103205. <https://doi.org/10.1016/j.forpol.2024.103205>.
- Bardon, R. E., K. Peters, R. Parajuli, and K. S. U. Jayaratne. 2023. “Educational Needs of North Carolina Non-Industrial Private Forest Landowners and Barriers to Meeting These Needs.” *Journal of Extension* 61 (1): 1. <https://doi.org/10.34068/joe.61.01.01>.
- Blatner, K. A., D. M. Baumgartner, and L. R. Quackenbush. 1991. “NIPF Use of Landowner Assistance and Education Programs in Washington State.” *Western Journal of Applied Forestry* 6 (4): 90–94. <https://doi.org/10.1093/wjaf/6.4.90>.
- Bodin, Ö., B. Crona, and H. Ernstson. 2006. “Social Networks in Natural Resource Management: What Is There to Learn from a Structural Perspective?” *Ecology and Society* 11 (2): r2. <https://www.ecologyandsociety.org/vol11/iss2/resp2/>. <https://doi.org/10.5751/ES-01808-1102r02>.
- Bruck, S. R., R. Parajuli, S. Chizmar, and E. O. Sills. 2023. “Impacts of COVID-19 Pandemic Policies on Timber Markets in the Southern United States.” *Journal of Forest Business Research* 2 (1): 130–167. <https://doi.org/10.62320/jfbr.v2i1.25>.

- Bruck, S. R., S. Chizmar, R. Parajuli, G. E. Frey, A. Lamica, and E. O. Sills. 2024. "A Qualitative Assessment of Interrelated Impacts of the Coronavirus Disease 2019 Pandemic on the Timber Supply Chain in the Southern United States." *Society & Natural Resources* 37 (10): 1491–1507. <https://doi.org/10.1080/08941920.2024.2380451>.
- Butler, B. J., J. Caputo, A. L. Robillard, E. M. Sass, and C. Sutherland. 2021. "One Size Does Not Fit All: Relationships between Size of Family Forest Holdings and Owner Attitudes and Behaviors." *Journal of Forestry* 119 (1): 28–44. <https://doi.org/10.1093/jofore/fvaa045>.
- Butler, S. M., B. J. Butler, and M. Markowski-Lindsay. 2017. "Family Forest Owner Characteristics Shaped by Life Cycle, Cohort, and Period Effects." *Small-Scale Forestry* 16: 1–18. <https://doi.org/10.1007/s11842-016-9333-2>.
- Butler, S. M., J. Schelhas, and B. J. Butler. 2019. "Minority Family Forest Owners in the United States." *Journal of Forestry* 118 (1): 70–85. <https://doi.org/10.1093/jofore/fvz060>.
- Catanzaro, P., D. T. Damery, A. D'Amato, and K. Ferrare. 2007. *Economic Viability of Ownerships in the Deerfield River Watershed*. Amherst, MA: University of Massachusetts Amherst, Department of Environmental Conservation.
- Chen, Y., and K. Jiang. 2019. "A Multiple Indicators Multiple Causes (MIMIC) Model of the Behavioral Consequences of Hotel Guests." *Tourism Management Perspectives* 30: 197–207. <https://doi.org/10.1016/j.tmp.2019.02.014>.
- Chizmar, S. J., R. Parajuli, R. Bardon, and F. Cubbage. 2021. "State Cost-Share Programs for Forest Landowners in the Southern United States: A Review." *Journal of Forestry* 119 (2): 177–195. <https://doi.org/10.1093/jofore/fvaa054>.
- Chizmar, S., R. Parajuli, S. Lamichhane, G. E. Frey, K. MacFarland, M. Pinyan, and S. Teague. 2025. "A National Review of State Preferential Property Tax Programs: challenges and Opportunities for Agroforestry Practices in the United States." Gen. Tech. Rep. WO-106, 40. Washington, DC: U.S. Department of Agriculture, Forest Service, Washington Office.
- Cubas-Baez, A., R. Parajuli, and E. O. Sills. 2025. "Field Note: What Motivates Forest Landowners to Participate in Surveys? Lessons from a Methodological Experiment in the Southern United States." *Journal of Forestry*. 0123456789, P 1-12. <https://doi.org/10.1007/s44392-025-00061-w>.
- Dillman, D. A., J. D. Smyth, and L. M. Christian. 2014. *Internet, Phone, Mail, and Mixed-Mode Surveys: The Tailored Design Method*. San Francisco: John Wiley & Sons.
- Downing, A. K., and J. C. Finley. 2005. "Private Forest Landowners: What They Want in an Educational Program." *The Journal of Extension* 43 (1): 14. <https://open.clemson.edu/joe/vol43/iss1/14>.
- Ednie, A. J., and J. E. Leahy. 2007. "Forest Certification for Northern Minnesota's Family Forest Landowners: Knowledge, Interest, and Preferences for Education." In Proceedings of the 2006 Northeastern Recreation Research Symposium, 532–538. Gen. Tech. Rep. NRS-P-14. Newtown Square, PA: U.S. Department of Agriculture, Forest Service.
- Epstein, H. A. B. 2020. "Virtual Meeting Fatigue." *Journal of Hospital Librarianship* 20 (4): 356–360. <https://doi.org/10.1080/15323269.2020.1819758>.
- Fawcett, J. E., R. Parajuli, R. E. Bardon, L. Boby, L. Kays, and R. Strnad. 2020. "Tools for Quickly Adapting during Pandemics, Disasters, and Other Unique Events." *Journal of Extension* 58 (2): 5. <https://doi.org/10.34068/joe.58.02.05>.
- Floress, K., E. S. Huff, S. A. Snyder, A. Koshollek, S. Butler, and S. B. Allred. 2019. "Factors Associated with Family Forest Owner Actions: A Vote-Count Meta-Analysis." *Landscape and Urban Planning* 188: 19–29. <https://doi.org/10.1016/j.landurbplan.2018.08.024>.
- Hassan, M., and F. Schneider. 2016. *Size and Development of the Shadow Economies of 157 Countries Worldwide: Updated and New Measures from 1999 to 2013*. IZA Discussion Paper No. 10281. Bonn, Germany: Institute for the Study of Labor (IZA).
- Hilsenroth, J., K. A. Grogan, R. M. Crandall, L. Bond, and M. Sharp. 2021. "The Impact of COVID-19 on Management of Non-Industrial Private Forests in the Southeastern United States." *Trees, Forests and People* 6: 100159. <https://doi.org/10.1016/j.tfp.2021.100159>.
- Holley, K., K. L. Jensen, D. M. Lambert, and C. D. Clark. 2020. "Bivariate MIMIC Analysis of Pasture Management and Prescribed Grazing Practices Used by Beef Cattle Producers." *Journal of Agricultural and Resource Economics* 45: 56–77. <https://doi.org/10.22004/ag.econ.298434>.

- Jöreskog, K. G., and D. Sörbom. 1996. *PRELIS 2 User's Reference Guide: A Program for Multivariate Data Screening and Data Summarization: A Preprocessor for LISREL*. Chicago: Scientific Software International.
- Khanal, P., T. Straka, and S. T. Guynn. 2019. *Extension Forestry Programming in South Carolina: Preferred Topics and Delivery Method*. Clemson, SC: Clemson Cooperative Extension, Land-Grant Press.
- Kilgore, M. A., J. L. Greene, M. G. Jacobson, T. J. Straka, and S. E. Daniels. 2007. "The Influence of Financial Incentive Programs in Promoting Sustainable Forestry on the Nation's Family Forests." *Journal of Forestry* 105 (4): 184–191. <https://doi.org/10.1093/jof/105.4.184>.
- Kilgore, M. A., J. Leahy, C. M. Hibbard, J. S. Donnay, K. Flitsch, D. Anderson, J. Thompson, P. V. Ellefson, and A. R. Ek. 2005. *Developing a Certification Framework for Minnesota's Family Forests*. St. Paul: University of Minnesota Extension.
- Kueper, A. M., E. S. Sagor, and D. R. Becker. 2013. "Learning from Landowners: Examining the Role of Peer Exchange in Private Landowner Outreach through Landowner Networks." *Society & Natural Resources* 26 (8): 912–930. <https://doi.org/10.1080/08941920.2012.722748>.
- Kueper, A. M., E. S. Sagor, C. R. Blinn, and D. R. Becker. 2014. "Extension Forestry in the United States: Master Volunteer and Other Peer-Learning Programs." *Journal of Forestry* 112 (1): 23–31. <https://doi.org/10.5849/jof.13-008>.
- Kuhns, M. R., M. W. Brunson, and S. D. Roberts. 1998. "Landowners' Educational Needs and How Foresters Can Respond." *Journal of Forestry* 96 (8): 38–43. <https://doi.org/10.1093/jof/96.8.38>.
- Lambert, D. M., K. P. Paudel, and J. A. Larson. 2015. "Bundled Adoption of Precision Agriculture Technologies by Cotton Producers." *Journal of Agricultural and Resource Economics* 40: 325–345.
- Langpap, C. 2004. "Conservation Incentive Programs for Endangered Species: An Analysis of Landowner Participation." *Land Economics* 80 (3): 375–388. <https://doi.org/10.2307/3654727>.
- Lin, Nan. 2001. *Social Capital: A Theory of Social Structure and Action*. Cambridge: Cambridge University Press.
- Ma, Z., B. J. Butler, D. B. Kittredge, and P. Catanzaro. 2012. "Factors Associated with Landowner Involvement in Forest Conservation Programs in the United States: Implications for Policy Design and Outreach." *Land Use Policy* 29 (1): 53–61. <https://doi.org/10.1016/j.landuse-pol.2011.05.004>.
- Measells, M. K., S. C. Grado, H. G. Hughes, and M. A. Dunn. 2006. "Educational Needs of Southern Forest Landowners." *Journal of Extension* 44 (5): 13.
- Mitani, Y., and H. Lindhjem. 2022. "Meta-Analysis of Landowner Participation in Voluntary Incentive Programs for Provision of Forest Ecosystem Services." *Conservation Biology: The Journal of the Society for Conservation Biology* 36 (1): e13729. <https://doi.org/10.1111/cobi.13729>.
- Penn, J., A. Gutierrez-Castillo, and M. Blazier. 2024. "Family Forest Landowners' Preferences for Meeting Format and Outreach with Forest Professionals Post-COVID-19." *Small-Scale Forestry* 23: 561–579. <https://doi.org/10.1007/s11842-024-09578-y>.
- Pratama, H., M. N. A. Azman, G. K. Kassymova, and S. S. Duisenbayeva. 2020. "The Trend in Using Online Meeting Applications for Learning during the COVID-19 Pandemic." *Journal of Innovation in Educational and Cultural Research* 1 (2): 58–68. <https://doi.org/10.46843/jiecr.v1i2.15>.
- Proitsi, P., G. Hamilton, M. Tsolaki, M. Lupton, M. Daniilidou, P. Hollingworth, N. Archer, et al. 2011. "A Multiple Indicators Multiple Causes (MIMIC) Model of Behavioral and Psychological Symptoms in Dementia." *Neurobiology of Aging* 32 (3): 434–442. <https://doi.org/10.1016/j.neurobiolaging.2009.03.005>.
- Parajuli, R., S. Chizmar, M. Megalos, and R. E. Bardon. 2020. "Educating Landowners on Forest-Based Alternative Income Streams in North Carolina: Program Evaluation and Lessons Learned." *Journal of Forestry* 118 (6): 551–554. <https://doi.org/10.1093/jofore/fvaa037>.
- Rose, A. K., and M. M. Spiegel. 2011. "Cross-Country Causes and Consequences of the Crisis: An Update." *European Economic Review* 55 (3): 309–324. <https://doi.org/10.1016/j.euroecorev.2010.12.006>.

- Rosseel, Y. 2012. "Lavaan: An R Package for Structural Equation Modeling." *Journal of Statistical Software* 48 (2): 1–36. <https://doi.org/10.18637/jss.v048.i02>.
- Rubino, E. C., N. Tian, and M. H. Pelkki. 2022. "Improving Communications to Increase Nonindustrial Private Forest Landowner Participation in Forest Certification Programs: A Case Study in Arkansas, USA." *Forests* 13 (1): 86. <https://doi.org/10.3390/f13010086>.
- Sagor, E. S., A. M. Kueper, C. R. Blinn, and D. R. Becker. 2014. "Extension Forestry in the United States: A National Review of State-Level Programs." *Journal of Forestry* 112 (1): 15–22. <https://doi.org/10.5849/jof.13-007>.
- Skrondal, A., and S. Rabe-Hesketh. 2004. *Generalized Latent Variable Modeling: Multilevel, Longitudinal, and Structural Equation Models*. Boca Raton, FL: Chapman & Hall/CRC.
- Snyder, S. A., B. J. Butler, and M. Markowski-Lindsay. 2019. "Small-Area Family Forest Ownerships in the United States." *Small-Scale Forestry* 18 (1): 127–147. <https://doi.org/10.1007/s11842-018-9410-9>.
- U.S. Department of Agriculture Forest Service. 2025. "National Woodland Owner Survey." Accessed March 4, 2025. <https://research.fs.usda.gov/programs/nwos>.
- Williams, D., and J. M. Brick. 2018. "Trends in U.S. Face-to-Face Household Survey Nonresponse and Level of Effort." *Journal of Survey Statistics and Methodology* 6 (2): 186–211. <https://doi.org/10.1093/jssam/smx019>.
- Woods, C. M., T. F. Oltmanns, and E. Turkheimer. 2009. "Illustration of MIMIC-Model DIF Testing with the Schedule for Nonadaptive and Adaptive Personality." *Journal of Psychopathology and Behavioral Assessment* 31 (4): 320–330. <https://doi.org/10.1007/s10862-008-9118-9>.
- Zobrist, K. W., and M. A. Rozance. 2015. "Forest Landowner Education Interests and Delivery Preferences: A Retrospective Look at Survey Results and Actual Participation." *Journal of Extension* 53 (5): Article 13. <https://doi.org/10.34068/joe.53.05.13>.