



Social vulnerability and family forest owners in the United States

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ABSTRACT

Social equity, and the related topic of social vulnerability, is an important issue that is impacting many facets of society, including forests. A substantial portion, 39 %, of forests in the United States are owned by families, individuals, trusts, estates, and family partnerships, collectively referred to as family forest owners. There are many programs and services intended to help family forest owners conserve and better manage their land, but participation rates are relatively low, the efficacy of many programs has been called into question, and the social equitability of access is largely unknown. The social vulnerability of family forest owners in the United States was assessed by intersecting data from the US Centers for Disease Control and Prevention and the US Agency for Toxic Substances and Disease Registry's Social Vulnerability Index (SVI) with data from the USDA Forest Service's National Woodland Owner Survey. Family forest owners have a similar SVI compared to the general US population, but the values vary substantially for some SVI themes including family forest owners having higher values for SVI Theme 2 (household composition and disabilities) and lower values for SVI Themes 3 (minority status and language) and 4 (housing type and transportation). Based on logistic regression models, the relationships among social vulnerability metrics and selected family forest owner attributes were found to vary. SVI Theme 1 (socioeconomic status) has positive relationships with amenity and financial ownership objectives, timber harvesting, collection of nontimber forest products, and recreational activity and negative relationships with management plans and advice. SVI Theme 2 has negative relationships with timber harvesting, management plans, advice, and program participation. SVI Theme 3 has negative relationships with timber harvesting, collection of nontimber forest products, and recreational activity. SVI Theme 4 has a positive relationship with collection of nontimber forest products. Programs and services could be redesigned and retargeted to maintain and enhance the social benefits that are accruing and mitigate the shortcomings.

1. Introduction

The United States has an estimated 333 million hectares (823 million acres) of forest and woodland (Oswalt et al., 2019). This land provides timber, recreation, aesthetic value, and numerous other benefits to both the owners and to broader society. Of this forestland, families, individuals, trusts, estates, and family partnerships, collectively referred to as family forest owners, control an estimated 39 % of the acreage, excluding interior Alaska (Butler et al., 2021). This is more than any other ownership group across the United States and gives family forest owners a critical role in the fate of the nation's forests. These lands exist in not just different ecological environments, but also different social environments which impact people's relationships with the forests. This can include racial, ethnic, educational, and economic factors, all of which may impact how family forest owners interact with

their land and their access to programs and services. Because of the substantial role of family forest owners, it is important that they have access to programs and services that will help them care for their land. However, these programs and services are only helpful if they are accessible to those who need them.

There are numerous programs provided by federal and state governments, nongovernmental organizations, and market-based programs that are intended to support family forest owners, including: technical assistance, cost-share, and preferential property tax programs. Despite the many options intended to benefit family forest owners, there is still low participation. In a 2018 study (Butler et al., 2021), it was found that an estimated 18 % of the family forest ownerships with 4+ ha of forestland, who controlled 36 % of the family forestland, had received forest management advice. Cost-share programs were participated in by 4 % of the family forest ownerships, who controlled 13 % of the family

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forestland. An estimated 17 % of the family forest owners, who controlled 26 % of the family forestland, were enrolled in preferential property tax programs. Regarding African American family forest owners, they have been shown to have lower participation rates in technical and financial assistance programs (Butler et al., 2020). This is due to many reasons including not knowing of or about available programs (Gordon et al., 2013), government distrust (Dwivedi et al., 2016), not having the financial resources for cost-share matching requirements (Gan et al., 2005), or not having sufficient acreage to enroll (Gan et al., 2003).

Numerous socioeconomic factors can impact how people interact with the land, as well as participate in programs and services. For example, African American landowners can have strong ties to their land but the history of discrimination and disappropriation in the United States based on race can also impact their participation. There are many African American who do not trust the government and the programs they offer due to discrimination they have faced or might face (Gordon et al., 2013).

Income could be another crucial factor to consider when determining which socioeconomic factors influence program and service participation. While some studies have found that income does not have a substantial impact on participation (Ma et al., 2012), others found that those enrolled in certain programs, like preferential property tax programs, often have higher incomes (Meier et al. 2019). Additionally, the geographical location of family forest owners' land could have a substantial impact on participation. Song et al. (2014) found that family forest owners in the Northeast and the Mid-Atlantic United States had lower levels of program participation than those in the Midwest. Education is another socioeconomic variable to consider in landowner participation. Kaetzel et al. (2009) found that landowners who have completed high school are less likely to participate in assistance programs. However, others have found that education can positively affect family forest owner participation in incentive programs (Floress et al., 2019).

The Social Vulnerability Index (SVI) is a dataset based on US Census data developed by the US Centers for Disease Control and Prevention and the US Agency for Toxic Substances and Disease Registry to that combines socioeconomic information to analyze which communities are most likely to be negatively impacted by hazardous situations, including disease outbreaks, weather related disasters, extreme pollution events, and natural disasters (Flanagan et al., 2011). SVI has been used to assess the impacts of extreme heat, flooding, wildfires, power outages, and diseases, among other topics, across the United States and, with comparable data, across many other countries (Mah et al., 2023).

This paper assesses the relationships between social vulnerability and family forest owners in the United States. The first set of analyses presented shows how family forest owners are arrayed by SVI themes and how these compare to the general US population. This is followed by presentation of a series of models that relate selected family forest owner attributes to SVI themes. The paper concludes with a discussion of the implications of these findings in terms of more effective and equitable design and implementation of programs and services aimed at family forest owners.

2. Methods

The primary data sources for the analysis were the US Centers for Disease Control and Prevention and the US Agency for Toxic Substances and Disease Registry's (CDC/ATSDR) Social Vulnerability Index (SVI; Flanagan et al., 2011) and the USDA Forest Service's National Woodland Owner Survey (NWOS; Butler et al., 2021).

The version of the SVI used in this paper was based on 15 Census-tract level variables that the CDC/ATSDR selected from the 2014–2018 U.S. Census Bureau's American Community Survey (Centers for Disease Control and Prevention/Agency for Toxic Substances and Disease Registry/ Geospatial Research, 2022), a timeframe selected to

match the NWOS dataset. The CDC/ASTDR divided the SVI variables into four themes: 1) socioeconomic status, 2) household composition and disabilities, 3) minority status and language, and 4) housing type and transportation. The specific Census variables used are listed in Fig. 1. The CDC/ASTDR calculated the relative ranking (i.e., percentile rankings) for each variable, they then summed these rankings for the variables within each theme and recalculated relative rankings, and they calculated overall values based on the ranking of the sums of the theme rankings. The values range from 0 to 1 with higher values representing higher vulnerability. SVI summary statistics reported below for the general US population were weighted by Census Tract population.

The NWOS is part of the US Forest Service's Forest Inventory and Analysis program (FIA) and serves as the social complement to FIA's biophysically centered Nationwide Forest Inventory. The NWOS is intended to answer questions about who owns forests in the United States, why they own them, what they have done with them in the past, and what they plan to do with them in the future. Data for this analysis were for family forest owners who owned at least 4 ha of forestland and responded to the NWOS during the 2017–2018 data collection cycle. Sampling was stratified by state and ownership class (e.g., family forest owners). Within each state, a grid of hexagons was created with the hexagon size determined by the target sample size of at least 100 family forest owner respondents per state. Within each hexagon a sample point was randomly determined. The land use and ownership class for each point were determined. Sample points that were forests, as determined by aerial photography or ground truthing, and owned by family forest owners, as determined from public property tax records, were invited to participate in the NWOS. The cooperation rate was 40 % and no significant nonresponse biases were detected (Butler et al., 2021). To account for the sample design and generate unbiased estimates of family forest owner attributes, weights were used in all summaries presented in this paper, an approach that is consistent with other NWOS products. Weights were equal to:

$$w_i = \left(\frac{A_s/n_s}{A_{s,i}} \right) \times n_{s,i} \quad (1)$$

Where w_i = the weight for ownership i ; A_s = the total area of family forestland in state s ; n_s = the total number of sample points in state s (i.e., $\sum n_{s,i}$); $A_{s,i}$ = the area of family forestland owned by ownership i in state s ; and $n_{s,i}$ = the number of family forest sample points owned by ownership i in state s . Additional details about the implementation methods, sampling, and weighting are available in Butler et al. (2021) and Butler and Caputo (2021). The NWOS protocols were approved through the US Office of Management and Budget (OMB No. 0596–0078) and the University of Massachusetts Amherst Institutional Review Board (IRB No. 2016–2908).

The SVI and SVI themes for family forests in the United States were compared to the values for the general US population. The SVI values for family forest owners were determined by intersecting the georeferenced mailing addresses of the family forest owners who responded to the 2017–2018 NWOS with Census tracts and assigning the associated SVI values. The details of the methods for georeferencing were described in Caputo and Snyder (2023). Of the 83,331 Census tracts in the Census/SVI dataset, 6844 contained one or more NWOS respondents (1 to 23 respondents per tract with a median of 1 respondent per tract). The size of the Census tracts with NWOS respondents ranged from 0.1 to 24,579 km² with a median of 111 km². This compares to all of the Census/SVI tracts which ranged from 0.02 to 221,586 km², with a median of 5 km²; the large variability in tract sizes is due to the US Census defining tracts based on visible features, such as roads, and aiming for each to contain between 2500 and 8000 people per tract (US Census Bureau 1994). The distributions were compared graphically using boxplots which show weighted median values, weighted interquartile ranges, minimum and maximum values, and outliers (i.e., points that were "jittered" horizontally to avoid overlaps). Statistical significance of

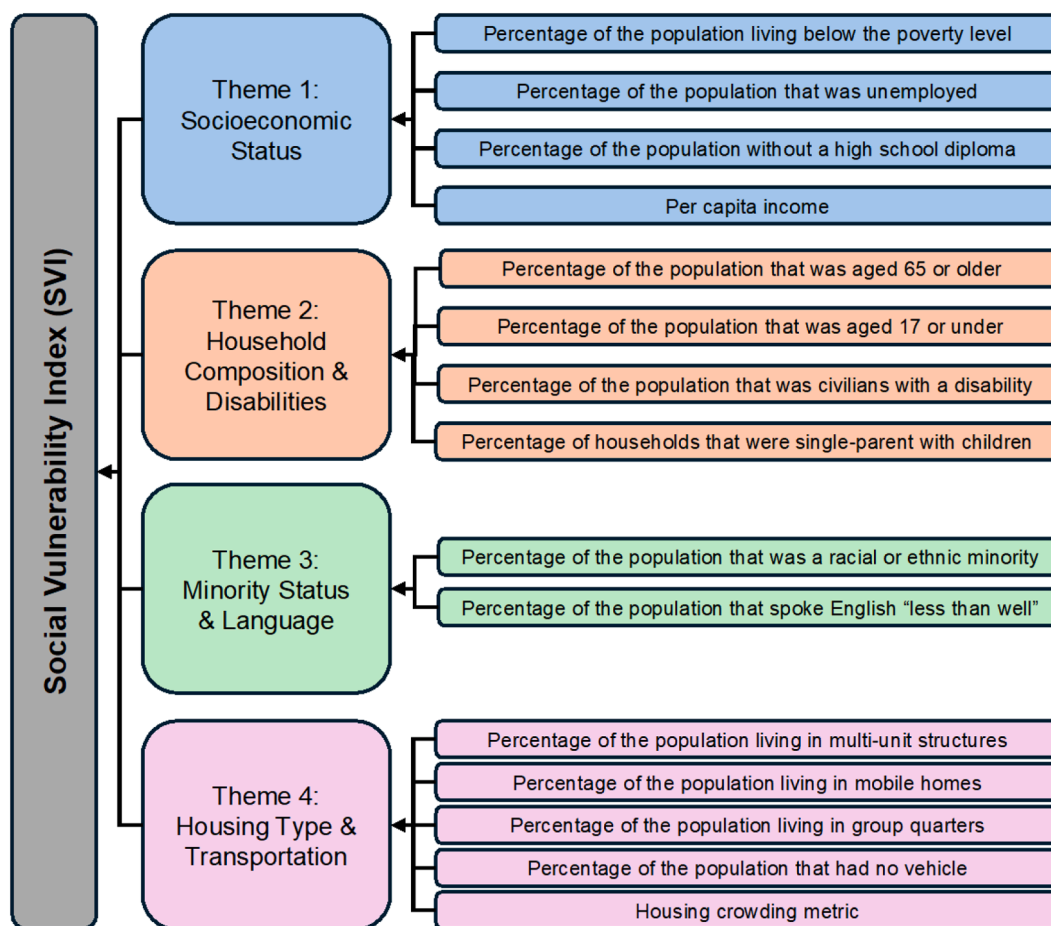


Fig. 1. Variables and themes used to calculate the US Centers for Disease Control and Prevention and the US Agency for Toxic Substances and Disease Registry’s Social Vulnerability Index (Centers for Disease Control and Prevention/Agency for Toxic Substances and Disease Registry/ Geospatial Research 2022).

differences between the group means were quantified using weighted *t*-tests.

To quantify the relationships between family forest owner characteristics and social vulnerability, a series of logistic regression models (Hosmer et al., 2013) were generated. The results of the models reported include odds ratios for each independent variable and associated *p*-values. Tjur’s R^2 (Tjur, 2009) and the Hosmer-Lemeshow test (Hosmer et al., 2013) were calculated to assess the goodness-of-fit of the models. Multicollinearity was assessed using variance inflation factors (VIFs; Fox, 2016).

The dependent, or lefthand side, variables of the logistic regression models were selected to represent a range of family forest owner attitudinal and behavioral attributes (Table 1). All dependent variables were binary, or converted to binary, and therefore logistic regression models were used. The ownership objective variables (OBJ_AMENITY and OBJ_FINANCIAL) were derived from 5-point Likert scale questions where responses of “Very Important” or “Important” were coded as 1 s and other responses were coded as 0s. The program variable was coded as 1 if a respondent had participated in preferential property tax, cost-share, conservation easement, or carbon program, and 0 otherwise. Recreation included anyone recreating on their land, not just the owners. Missing values (i.e., NAs) were assigned where respondents did not answer the relevant question, and these records were dropped from the corresponding models.

The independent, or righthand side, variables included four variables of interest and two control variables. The variables of interest were the SVI themes (SVI_THEME_1, SVI_THEME_2, SVI_THEME_3, and SVI_THEME_4). These were continuous variables that ranged from 0 to 1 as described above. In addition, variables representing region of the United

States (REGION) and size of forest holdings (LOG_HA_WOOD) were included as control variables, or covariates, because they were identified as important variables across many previous studies (Silver et al., 2015). Region was classified as North, South, or West, as defined in the footnote in Table 1. State was tested as an alternative to region, but there were no substantive differences, and the simpler variable was retained. The size of forest holdings was log transformed to account for the skewed distribution of this variable, as was done in many previous studies.

The NWOS data were joined with the SVI data using ArcGIS Pro (Esri, 2023). All other data processing and analyses were conducted in the R computing environment (R Core Team, 2024). In addition to base R packages, we used the ResourceSelection package (Lele et al., 2023) for calculating the Hosmer-Lemeshow test, the performance package (Lüdecke et al., 2021) for calculating Tjur’s R^2 , and the car package (Fox and Weisberg, 2019) for calculating VIFs.

3. Results

The overall social vulnerability of family forest owners in the United States and the overall social vulnerability of the general population of the United States are, as measured by the SVI, similar, but some of the themes are quite different (Fig. 2). The weighted US percentile rankings for SVI and the SVI themes have median values close to 0.5 and interquartile ranges close to (0.25, 0.75). The weighted family forest owner SVI percentile rankings have a median value of 0.43 and an interquartile range of (0.29, 0.66). The weighted median percentile rankings for SVI Theme 1 for family forest owners (0.48) is slightly lower than that for the general US population. The weighted median percentile rankings for SVI Theme 2 for family forest owners (0.58) is higher than the general

Table 1
Dependent and independent variables used in logistic regression models examining US family forest owners and social vulnerability.

Variable	Type ^a	Description	Proportion/ Mean (SD) ^b
Dependent			
OBJ_AMENITY	B	Respondent rated "to enjoy beauty or scenery" or "for privacy" as important or very important reasons for owning forestland	0.85 (0.36)
OBJ_FINANCIAL	B	Respondent rated "for land investment" or "for timber products" as important or very important reasons for owning forestland	0.63 (0.48)
HARVEST_TIMBER	B	Trees have been commercially harvested from the respondent's forestland in the previous five years	0.30 (0.46)
NTFP	B	Non-timber forest products have been collected from the respondent's forestland in the previous five years	0.21 (0.40)
MANAGE_PLAN	B	The respondent has a written forest management plan	0.25 (0.43)
ADVICE	B	The respondent has have received forest management advice	0.34 (0.47)
PROGRAMS	B	The respondent has participated in preferential property tax, cost-share, conservation easement, or carbon programs	0.37 (0.48)
RECREATION	B	Recreation has occurred on respondent's forestland	0.94 (0.24)
Independent			
SVI_THEME_1	N	Percentile ranking of SVI Theme 1 – Socioeconomic status	0.45 (0.26)
SVI_THEME_2	N	Percentile ranking of SVI Theme 2 – Household composition and disabilities	0.55 (0.26)
SVI_THEME_3	N	Percentile ranking of SVI Theme 3 – Minority status and language	0.30 (0.23)
SVI_THEME_4	N	Percentile ranking of SVI Theme 4 – Housing type and transportation	0.49 (0.27)
REGION^c			
NORTH	C	Respondent has forestland in the northern US	0.39 (0.49)
SOUTH	C	Respondent has forestland in the southern US	0.36 (0.48)
WEST	C	Respondent has forestland in the western US	0.25 (0.43)
LOG_HA_WOOD	N	Natural log of the hectares of forestland owned by respondent	4.13 (1.61)

^a Variable type: B = binary; N = numeric/continuous; C = categorical.

^b Proportions reported for binary and categorical variables, means reported for numeric variables; SD = standard deviation.

^c Northern United States includes Connecticut, Delaware, Illinois, Indiana, Iowa, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Vermont, West Virginia, and Wisconsin; Southern United States includes Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia; Western United States includes Alaska, Arizona, California, Colorado, Hawaii, Idaho, Kansas, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oregon, South Dakota, Utah, Washington, and Wyoming.

US population. The weighted median percentile rankings for SVI Theme 3 for family forest owners (0.22) is substantially lower than the general US population. The median percentile rankings for SVI Theme 4 for family forest owners (0.45) is lower than the general US population. All differences between the family forest owners and the general US population values are statistically different (p -value < 0.001).

Thirteen percent of family forest owners in the United States are in

areas of high social vulnerability (i.e., $SVI \geq 0.75$). The percentages vary substantially by state with generally higher levels in the southern United States and lower levels in the northern United States (Fig. 3). The highest levels are in Florida, Georgia, Nevada, New Mexico, Oklahoma, South Carolina, and Texas, where at least 25 % of the family forest owners are in areas of high social vulnerability.

The results from the logistic regression models are summarized in Table 2. Of the 8 models, four, OBJ_FINANCIAL, ADVICE, PROGRAMS, and RECREATION, did not pass the Hosmer- Lemeshow test (i.e., p -values < 0.05). In addition, three models, OBJ_AMENITY, OBJ_FINANCIAL, and NTFP, had low Tjur's R^2 values (i.e., $R^2 < 0.05$). There were no issues with multicollinearity detected in any of the models (i.e., all VIFs < 2.5).

The significant variables varied across the models (Table 2). A positive relationship means that as social vulnerability increases, so too does the probability of the given attribute. For example, for every unit increase in SVI Theme 1 (SVI_1), the probability of Harvesting Timber increases 2.30 times, after accounting for the control and other variables in the model. A negative relationship means that as the social vulnerability increases, the probability of the given attribute decreases. For example, for a one unit increase in SVI Theme 1 (SVI_1), the probability of having a management plan is 34 % lower (1.00 – 0.66). SVI Theme 1 (socioeconomic status) has a significant positive relationship in the OBJ_AMENITY, OBJ_FINANCIAL, HARVEST_TIMBER, NTFP, and RECREATION models and a significant negative relationship in the MANAGE_PLAN and ADVICE models. SVI Theme 2 (household composition and disability) has a significant negative relationship in the HARVEST_TIMBER, MANAGEMENT_PLAN, ADVICE, and PROGRAMS models. SVI Theme 3 (minority status and language) has significant negative relationships in the HARVEST_TIMBER, NTFP, and RECREATION models. SVI Theme 4 (housing type and transportation) has a significant positive relationship in the NTFP model. In addition, one or both control variables were significant across most of the models, although the signs differed.

4. Discussion

There are large disparities in social wellbeing across the United States, as there are around the globe, and these inequities have important implications ranging from access to education to life expectancy (Hurst et al., 2016). In terms of nature, social inequities affect how people impact nature and how nature impacts people through access, benefit sharing (or lack thereof), and other mechanisms. Looking at associations between social vulnerability and natural resources can help us better understand these relationships and design and implement policies, services, and programs that better meet the needs of people and help protect the resources.

Most previous studies examining family forest owners have looked at the individual choices the owners are making and the factors that are influencing those decisions (Silver et al., 2015). Although the underlying theories are often not explicitly stated, when they are the theories tend to be psychological in nature and often borrowing from behavioral change theory, such as the Theory of Planning Behavior (Floress et al., 2019). But the collective actions of family forest owners can also be considered from a sociological lens as we did in this paper.

There are potential positive and negative aspects of family forests and family forest owners being in areas of high social vulnerability. There is the potential for ecosystem services to be used to help address social equity issues (Marshall and Gonzalez-Meler, 2016) by, for example, allowing access to resources to traditionally underrepresented groups. But these same issues can also create barriers to programs and services as they are currently being implemented. Much of the social equity research in forestry has focused on urban forestry issues (e.g., Marshall and Gonzalez-Meler, 2016), but there is substantial work that can also be accomplished in rural areas. Indeed, there are many programs through the United States' Bipartisan Infrastructure Law aimed as

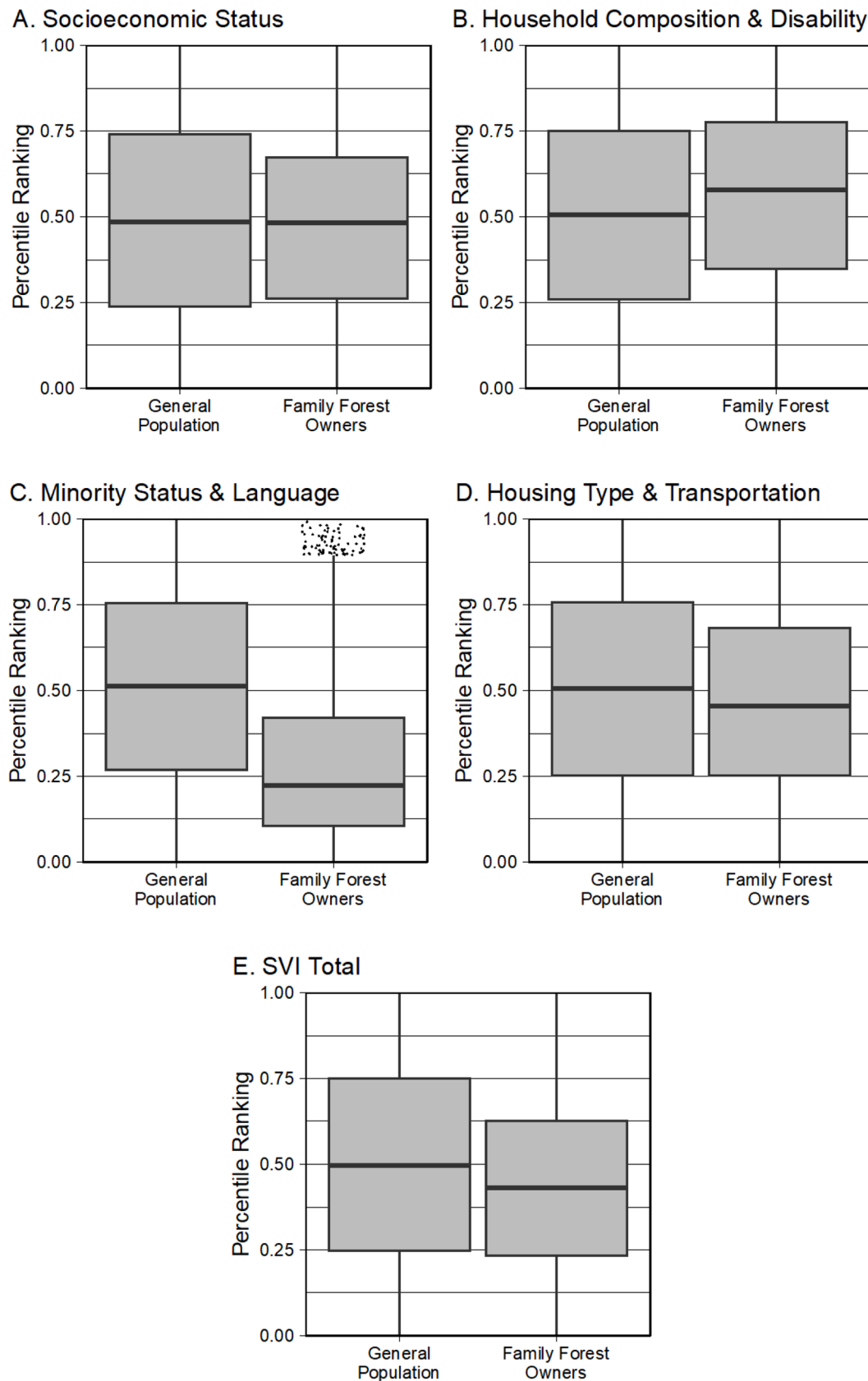


Fig. 2. Distribution of Social Vulnerability Index (SVI) values by SVI theme and total (combined) SVI weighted by the general US population and US family forest owners, 2018.

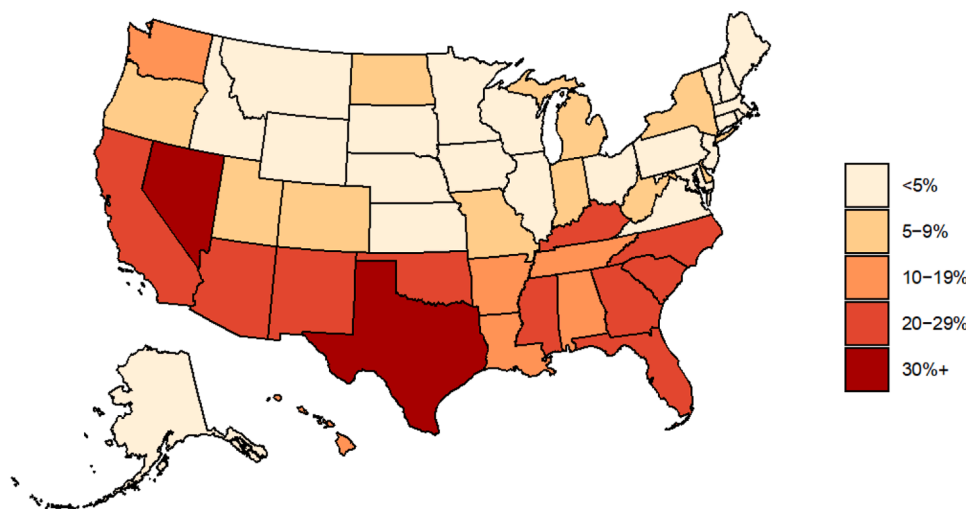


Fig. 3. Percentages of family forest owners in areas of high social vulnerability by state. High social vulnerability is defined as having a Social Vulnerability Index ranked among the top 75 % of US Census tracts.

Table 2

Summaries of logistic regression models relating social vulnerability and attributes of US family forest owners. Coefficients have been transformed to odds ratios.

Variable	OBJ AMENITY	OBJ FINANCIAL	HARVEST TIMBER	NTFP	MANAGE PLAN	ADVICE	PROGRAMS	RECREATION
(Intercept)	9.62***	0.49***	0.06***	0.36***	0.09***	0.11***	0.21***	4.45***
SVI_1	1.60**	1.79***	2.30***	1.62**	0.66**	0.74*	0.83	2.62***
SVI_2	0.96	0.84	0.74*	0.95	0.73*	0.70**	0.57***	0.97
SVI_3	0.87	1.03	0.43***	0.25***	0.94	1.06	0.91	0.14***
SVI_4	0.83	0.93	1.04	1.41**	1.04	1.11	0.96	1.14
REGION South	0.65***	1.68***	0.95	0.47***	0.61***	1.01	0.89	0.46***
REGION West	1.02	0.71***	0.29***	0.78***	0.31***	0.64***	0.47***	0.64***
LOG_HA_WOOD	0.90***	1.30***	1.70***	1.00	1.60***	1.57***	1.49***	1.63***
Tjur's R ²	0.01	0.07	0.15	0.04	0.10	0.11	0.09	0.05
Hosmer- Lemeshow test p-value	0.83	0.00	0.45	0.09	0.57	0.02	0.01	0.03

*p-value < 0.05, ** p-value < 0.01, *** p-value < 0.001.

traditionally underrepresented groups of landowners.

Many family forest owners are in areas of high or moderate social vulnerability. And we found SVI themes to have significant relationships with various landowner attributes including financial motivations, timber harvesting, collection of nontimber forest products, having a written management plan, having received forest management advice, participation in assistance programs, and recreation. The specific themes and directionally varied across many attributes.

In terms of SVI themes, the OBJ_AMENITY and OBJ_FINANCIAL models were similar. Specifically, having amenity or financial values as important or very important reasons for owning forestland are positively associated with family forest owners being in areas of high socioeconomic vulnerability (SVI Theme 1 – socioeconomic status). As socioeconomic vulnerability increases, there are increases in the reliance on forests, for both amenity and financial factors. This suggests that forests can, and do, play important roles in helping to mitigate socioeconomic challenges, a fact that can potentially be leveraged in policies and programs aimed at combatting socioeconomic challenges.

Harvesting timber has a positive relationship with SVI Theme 1 (socioeconomic status) and negative relationships with SVI Themes 2 (household composition and disability) and 3 (minority status and language). So again, there is evidence of forests helping to alleviate issues related to socioeconomic status, but concurrently there is evidence that this does not carry through to issues related to housing or minority status. These are areas policies could potentially help address, such as assistance programs that specifically aim to help minority and older owners harvest timber. It would need to be verified that this is a positive outcome for these groups and if so, the specific barriers would need to be identified.

The other model related to the extraction of natural resources, collection of nontimber forest products (NTFPs), also shows a positive relationship with SVI Theme 1 (socioeconomic status), but in addition this activity has a positive relationship with SVI Theme 4 (housing type and transportation). This is another example of the potential of family forests to contribute to the alleviation of issues related to socioeconomic challenges. NTFPs may also be more important for people who have more housing and transportation challenges as they are potentially relying on the NTFPs for sustenance, additional revenue streams, or both. SVI Theme 3 (minority status and language) has a negative relationship with NTFPs. This suggests there is room for redesigning or increasing focus of education and other programs that help minority owners understand the benefits that NTFPs may be able to provide. There are many reports of people from poor and vulnerable populations relying on NTFPs (Frey et al., 2021), but most of them are doing so by collecting NTFPs on public lands. There may be opportunities to connect family forest owners, who tend to not be part of racial or ethnic minorities, with the general population, including members of racial and ethnic minorities. Specifically, there may be opportunities to facilitate indigenous people to regain access to areas that their ancestors used.

The management plan and advice models have similar results. This is not surprising given the interrelationships between the two (i.e., plans are a form of advice and advice often leads to plans); technical advice has a low participation threshold and is a precursor to many programs and forest management activities. Both attributes are negatively correlated with SVI Themes 1 (socioeconomic status) and 2 (household composition and disabilities). Owners facing challenges related to socioeconomic, age, and related issues, may be less likely to receive these services. There are many programs across the United States that provide

technical assistance and help owners establish written forest management plans. Focusing resources on underserved communities, as is being done with some focus funding provided under the Bipartisan Infrastructure Law, can help address some of these challenges. The analyses presented here do not show any significant issues with minority status associated with advice or plans.

All of the SVI themes have odds ratios of <1.0 in the program model, but only one of the themes, SVI Theme 2 – Household Composition and Disabilities, is statistically significant. While some assistance programs have explicit aims of focusing on traditionally underserved communities, many do not, and many programs operate on a first-come, first-serve basis. This may be reflected in the lack of positive relationships with any of the SVI themes. Previous studies have discussed how a lack of funds can be a barrier to participating in programs and activities (Gan et al., 2005) and supports findings that those enrolled in certain programs, like preferential property tax programs, have higher incomes (Meier et al., 2019). However, it contradicts other studies that find that income does not have a substantial impact on program participation rates (Ma et al., 2012). If forestry programs want to reach more underrepresented groups, new efforts will be needed to find these people, identify their objectives and the barriers they are facing, and design and implement programs accordingly.

Recreation has a large (odds ratio = 2.62), positive relationship with SVI Theme 1 – Socioeconomic status. This is yet another example of the current trend and potential for family forests to provide social benefits. Given the issues with obesity and lack of access to natural resources in the United States, these benefits can be very important. But given the private property rights and concerns associated with liability associated with injuries sustained on their lands, there is the potential for larger benefits, such as those found in countries with “freedom to roam laws,” such as Finland and Sweden, that allow the public recreational access to private lands. The negative relationship between recreation and SVI Theme 3 (minority status and language) could be related to access issues (e.g., varying levels of comfort in recreating in more remote environments), different relationships that different cultural groups have with forest-based recreation, or a combination thereof. Public policies could help to address the liability issue, as has been done in some states, and programs could be used to encourage school groups or others to visit family forests.

4.1. Limitations

For this study, we chose to focus on community-level attributes, consistent with the intent of SVI. While this has advantages, it is also means that demographics of the owners themselves were not the focus. This difference needs to be considered in the interpretation of the results and comparisons with other studies.

SVI, by design, is an aggregate measure of social vulnerability. While this is useful for modeling and other quantitative analyses, it fails to address the intersectionality (Collins and Bilge, 2020) of social vulnerability. The challenges, and opportunities, that groups face are not confronted one by one, but in parallel and often multiplicative ways that need to be considered.

The models presented are descriptive and not intended for predictive purposes and should be interpreted as such. The fit of some of the models was poor and this too needs to be considered.

5. Conclusions

Social vulnerability is an issue confronting all of society, including family forest owners. The results from the analyses presented in this paper show that US family forest owners differ in terms of social vulnerability as compared to the general US population and many family forest owner attributes are correlated with metrics of social vulnerability. But the significant variables, and the directionality of the relationships, are not consistent across all attributes and have varying

signs. The finding that the relationships are not consistent across attributes needs to be considered when interpreting the implications of the findings.

The positive relationships between SVI Theme 1 (socioeconomic status) and many of the attributes tested is a strong indicator of the potential for family forests to contribute to helping alleviate socioeconomic-related issues. But the negative relationships between SVI Theme 1 and management plans and advice is an indicator that assistance programs may not be doing as much as they can in terms of these issues. There are many reasons that forestry assistance and other programs are created and many ways they can be implemented. The implementation of these programs from a social vulnerability perspective is important and can help identify potential inequities. While some programs have explicit social equity objectives, many do not.

There are many factors that influence family forest owners, some of which are related to metrics of social vulnerability. To ensure broad participation in programs and services, it is important to identify potential barriers, which may differ by program and service, and mitigate the barriers as much as possible. By helping to ensure that programs and services are meeting the needs of targeted owners, and the programs and services are implemented in accessible and equitable manners, will increase the overall efficacy of the programs. A more holistic examination of the pathways that lead to participation, e.g. technical advice leading to management plans facilitating participation in cost-share programs, should also be considered.

CRedit authorship contribution statement

Brett J. Butler: Conceptualization, Methodology, Formal analysis, Writing – review & editing, Supervision, Funding acquisition. **Morgan Bowler:** Conceptualization, Methodology, Formal analysis, Writing – original draft.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Morgan Bowler reports financial support was provided by USDA Forest Service Northern Research Station. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

The data that has been used is confidential.

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