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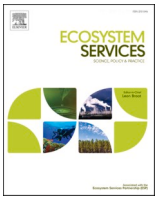

Full Length Article

Landowner concerns related to availability of ecosystem services and environmental issues in the southern United States

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ABSTRACT

The effectiveness of conservation initiatives on private lands in the southern United States plays an important role in improving provision of ecosystem services and mitigating negative environmental impacts. However, participation in conservation efforts is in part affected by landowner concern about environmental issues. This study used a seemingly unrelated regression (SUR) to quantify the impacts of local environmental conditions (e.g., air and water pollution, population density, and land cover type), private land attributes and sociodemographic factors on landowner ecosystem service and environmental concerns. The study involved a mail survey of private landowners in the Mississippi Alluvial Valley and East Gulf Coastal Plain sub-geographies of the Gulf Coastal Plains and Ozarks Landscape Conservation Cooperative. At least 37% of landowners were extremely concerned about drinking water quality, drinking water quantity, soil erosion, loss of wildlife habitat, and loss of open spaces. Local environmental conditions and sociodemographic factors were only marginally related to landowner ecosystem service and environmental concerns, although these factors could affect landowner environmental attitudes, personal health and outdoor activities. Private land attributes, such as property size and landownership objectives, strongly influenced landowner concerns about environmental issues where landowners with larger agricultural land parcels, and who owned land for profit making and provision of ecosystem services were more concerned about environmental issues than other landowners. Conservation policies should focus not only on activities that address ecosystem service and environmental issues that are of concern to landowners but also help them attain their landownership objectives because such approach is more likely to increase their participation in conservation practices.

1. Introduction

Private landowners and the general public in the southern United States have increasingly been experiencing negative impacts of environmental problems such as hurricanes and tornadoes, water pollution, pests, wildfires, invasive species, and land use changes (Grala et al., 2017; Howard, 2012; Huang and Lamm, 2015; Martinuzzi et al., 2015). Consequently, these environmental problems are contributing to the deterioration of natural ecosystems and their capacity to produce ecosystem services. For example, water quality in the Mississippi River as well as in other rivers and their tributaries in the region have been impaired due to an increasing concentration of phosphate and nitrogen constituents (Shoda et al., 2019; Sprague et al., 2011). Forests in the southern United States also face threats from numerous invasive insect pests such as southern pine beetle (*Dendroctonus frontalis* Zimmermann), emerald ash borer (*Agrilus planipennis* Fairmaire) and ambrosia beetle (*Xyleborus glabratus*) (Asaro et al., 2017; Jones, 2018; Susaeta et al., 2016). Similarly, wildfires also pose a persistent threat to forest ecosystems where, on average, human-caused wildfires (excluding prescribed fire used for forest management purposes) burnt almost 400,000 hectares (ha) per year during 2001–2017 (National Interagency Fire Center, 2018). Furthermore, urban sprawl and expansion of agricultural crop production have been the main drivers contributing to the loss of natural forests and associated ecosystem services, and this trend is predicted to continue in the absence of conservation efforts (Lockaby, 2009; Martinuzzi et al., 2015; Poudyal et al., 2016). Environmental problems limit the land's capacity to produce ecosystem services across the southern United States and conservation practices are needed to

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both mitigate negative environmental impacts and ensure sustainable levels of ecosystem services in the future.

While implementation of conservation practices on private land is crucial for increasing provision of ecosystem services and addressing environmental problems, only a small portion of landowners have participated in conservation programs that help address these issues. For example, family forest landowners, who owned 62.2 million ha of forestlands and woodlands in the southern United States, enrolled only 26% area of their forest lands in cost-share programs, 5% in forest certification systems, and 3% in conservation easements (Butler et al., 2016; Ma et al., 2012). Thus, a substantial portion of private lands is not included in a systematic conservation planning and is disconnected from regional conservation goals for increasing availability of ecosystem services and mitigating environmental problems.

In the southern United States, private forests, grazing lands (permanent pasture and rangeland) and cropland cover 39.83%, 24.38% and 16.94% of total land area, respectively (Oswalt et al., 2019; U.S. Department of Agriculture, 2019). Most of the southern forests are timberland (84.76%) and managed for wood production (Oswalt et al., 2019). Majority of private forests in the region are owned by individual (non-corporate) owners 67.44%, whereas the remaining 32.56% is in corporate ownership (Oswalt et al., 2019). Private lands in the region encompass many natural ecosystems that produce vital ecosystem services such as drinking water supply, habitat for endangered species, soil erosion control, carbon sequestration, and recreation (Bennett et al., 2018; Evans et al., 2017; Kamal et al., 2015). For example, forests in the region provide critical habitat for at least 126 threatened and endangered wildlife species, including aquatic species, and private forest lands provide almost 60% of these critical habitats (Nelson et al., 2017; U.S. Fish and Wildlife Service, 2020). Additionally, private forests contribute approximately 41% of total drinking water supply in the southern United States (Liu et al., 2020). Similarly, forests in the region can sequester up to 400 million tons of carbon dioxide equivalent (tCO_2e) per year and private forests account for 80% of that carbon sequestration capacity (Galik et al., 2013). However, private lands are more susceptible to conversion to other uses than public lands because of profitability concerns (Bennett et al., 2018). Due to ecological significance and spatial distribution of private lands in the region, their integration into large-scale conservation efforts is critical for achieving long-term regional conservation priorities related to increased production of ecosystem services and mitigation of environmental issues (Bennett et al., 2018; Leonard et al., 2017; Riitters and Costanza, 2019). Private landowner involvement in large-scale conservation efforts and subsequent implementation of appropriate forest management/conservation prescriptions will have positive environmental impacts not only on their but also surrounding land parcels (LeVert et al., 2009).

Studies on landowner conservation behavior revealed that landowners who had positive environmental attitudes and valued ecosystem services such as outdoor recreation, wildlife habitat, soil erosion reduction and land quality improvement were more likely to participate in conservation programs and implement conservation practices facilitating ecosystem services (Dupraz et al., 2003; Floress et al., 2019; Lute et al., 2018; Sweikert and Gigliotti, 2019; Wilkins et al., 2018). Thus, enhanced communication with landowners about environmental problems and the importance of conservation programs in mitigating them and facilitating an increased production of ecosystem services while concurrently achieving landownership objectives is necessary to increase their engagement in conservation activities.

Public concern about availability of ecosystem services and environmental issues can result from their interactions with local physical environment and community affluence. Liu and Mu (2016) emphasized the importance of incorporating location specific contextual factors such as economic development and pollution level, to limit a bias in quantifying the effects of individual factors on environmental concerns. When emphasizing the importance of contextual factors on individual environmental concerns, a study conducted in the United States found that local environmental incidents and air pollution were positively associated with environmental concern while local industrial wastes were not (Hannibal et al., 2016). This finding indicated that individual environmental concerns might not be affected by contextual factors if those factors were not experienced or were unnoticed. As a result, air quality and availability of clean water were the main contextual factors that affected individual's environmental concern in most instances, because these ecosystem services have greatest impacts to daily social and economic wellbeing.

Multiple studies have also examined individual-level factors affecting citizen concerns about availability of ecosystem services and environmental issues in the United States. In socio-psychological studies, females, older individuals, non-white, political liberals, people with pro-ecological views and members of environmental groups tended to be more concerned about pollution, global warming, and climate change than others (Hannibal et al., 2016; Liu et al., 2014). Policy-relevant studies found that residents who frequently visited watershed basins for recreational activities, including water-based recreation, were more concerned about loss of wetland ecosystem services, including poor water quality and water shortages, than less frequent visitors (Ehrlich et al., 2017; Flint et al., 2017; Wilkins et al., 2018). Unlike these issue-specific concerns, the influence of individual-level and contextual factors was better associated with dimensionality of environmental concerns (Marquart-Pyatt, 2012; Skogen et al., 2018). For an example, Marquart-Pyatt (2012) identified three distinct dimensions of environmental concerns such as belief about biophysical environment, engagement in awareness campaigns and willingness to make personal contributions, and she found that the level of carbon dioxide (CO_2) emissions positively affected public concerns related to belief about biophysical environment and engaging in awareness campaigns, but not their willingness to make personal contributions. As the factors influencing environmental concerns depend on their dimensions, their knowledge will help identify groups of individuals who are interested in addressing long-standing ecosystem service and environmental issues (e.g., loss of wildlife habitat, soil erosion) and recently emerged or sporadic issues (e.g., invasive plant species and pest infestations), and more likely engage in large-scale conservation/restoration efforts.

Landowner concerns about ecosystem services availability and environmental issues originate from important ecological implications and potential economic losses associated with their agricultural and forest investments (Belin et al., 2005). In addition, landowners are more sensitive to environmental issues and their impact on ecosystem services such as availability and quality of water, climate change and pollution than people from other professions (Aregay et al., 2016; Khanal et al., 2016; Skogen et al., 2018). Levels of concern about ecosystem services and environmental issues are often associated with a landowner's conservation behavior (Floress et al., 2019). Therefore, this study aimed to identify the most pertinent ecosystem services and environmental issues in southern United States as perceived by private landowners, because their participation will help increase effectiveness of conservation efforts in addressing those issues at a large scale. The study also determined relationships between landowner concerns about ecosystem services and environmental issues with policy relevant factors such as contextual, sociodemographic, and private land attributes. Study findings will be useful for designing effective conservation programs and identifying priority conservation practices and geographic locations suitable for most cost-effective implementation of conservation practices facilitating increased production of ecosystem services and mitigating negative impacts of environmental problems.

2. Methods

2.1. Study area

The study was conducted in Mississippi Alluvial Valley (MAV) and East Gulf Coastal Plain (EGCP) in the United States, which are two of five

sub-geographic regions of the Gulf Coastal Plains and Ozarks Landscape Conservation Cooperative (GCPO LCC, Fig. 1). The MAV extends from Cairo, Illinois to the confluence of the Mississippi River with the Gulf of Mexico in Louisiana. The MAV includes portions of Arkansas, Illinois, Louisiana, Mississippi, Missouri, and Tennessee covering an area of 10 million ha of which forests cover of 3.1 million ha and 6 million ha are agricultural lands (Faulkner et al., 2011; Gulf Coastal Plains and Ozarks Landscape Conservation Cooperative, 2017). Similarly, the EGCP encompasses parts of six southern states including Alabama, Florida, Georgia, Kentucky, Mississippi, and Tennessee. The EGCP extends over 25 million ha of which forests occupy approximately 13.9 million ha and agricultural lands 3 million ha (Gulf Coastal Plains and Ozarks Landscape Conservation Cooperative, 2017). Both sub-geographies cover diverse ecosystems and provide habitat to many priority, threatened, and engendered species [e.g., Louisiana black bear (*Ursus americanus*), gopher tortoise (*Gopherus polyphemus*), red-cockaded woodpecker (*Picoides borealis*) and Mississippi sandhill crane (*Grus canadensis pulla*)] (Coyle et al., 2015; Greene et al., 2016; Twedt and Somershoe, 2009).

2.2. Data collection

A mail survey was administered in spring 2015 to elicit landowner opinions in relation to ecosystem service and environmental concerns, natural resource conservation programs, and landowner willingness to implement conservation practices on their land. The survey was mailed to a sample of 2000 randomly selected forest and agricultural landowners in each of the two GCPO LCC's sub-geographies (a total of 4000 landowners). The sample size was determined to obtain at least 384 responses from each sub-geography assuming a 20% response rate and necessary to maintain a 5% margin of error at a 95% confidence level (Dillman et al., 2014). The sampling frame included approximately 493,000 landowners (firms) who owned at least 4 ha of a land classified as forest or agricultural land and located within a specified GCPO LCC sub-geography (U.S. Department of Agriculture, 2019). The minimum landownership criterion was adopted because it was often a minimum landownership area required to qualify for participation in conservation programs. Names and addresses of landowners meeting the selection criteria were obtained from a commercial mailing list provider because commercial providers update the landowner names and addresses frequently and have access to large data bases which helps obtain more representative samples. However, commercial data might still not include all eligible landowners because of recent land sales, handover of property rights, changed landowner residence, and having incorrect mailing addresses. The survey followed the Tailored Design Method developed by Dillman et al. (2009) and included multiple mailings (four contacts) to increase the response rate and minimize potential non-response bias: a brief introductory letter, a letter with a first questionnaire, a thank you/reminder postcard, and a follow-up with a replacement questionnaire. The structured questionnaire instrument included questions related to area of land owned, landownership goals, ecosystem service and environmental concerns, satisfaction with conservation programs, willingness to participate in a hypothetical conservation program facilitating production of ecosystem services, and landowner sociodemographic characteristics (Appendix A). This study mainly focused on landowner's ecosystem service and environmental concerns.

Data related to local environmental contextual factors such as population density, air pollution, water use intensity (a proxy for wastewater), proximity to a river, and forest and agricultural land coverage were collected from different sources. Population data represents 2010 zip code level census estimates obtained from United States Census Bureau (U.S. Census Bureau, 2018). In the mail survey, landowners were not asked directly about the local environmental conditions, rather the survey collected the address information in terms of zip code, county, and state, where their largest land parcels were located. Then, publicly available information related to contextual factors at zip code or county levels was used to represent individual landowner experiences with these factors. County-level air pollutant data based on 2014 National Emissions Inventory (NEI) were collected from United States Environmental Protection Agency (EPA) (U.S. Environmental Protection Agency, 2018). County-level data related to water use estimates for the year 2015 were obtained from United States Geological Survey (USGS) (Dieter et al., 2018). Geospatial data related to location of major

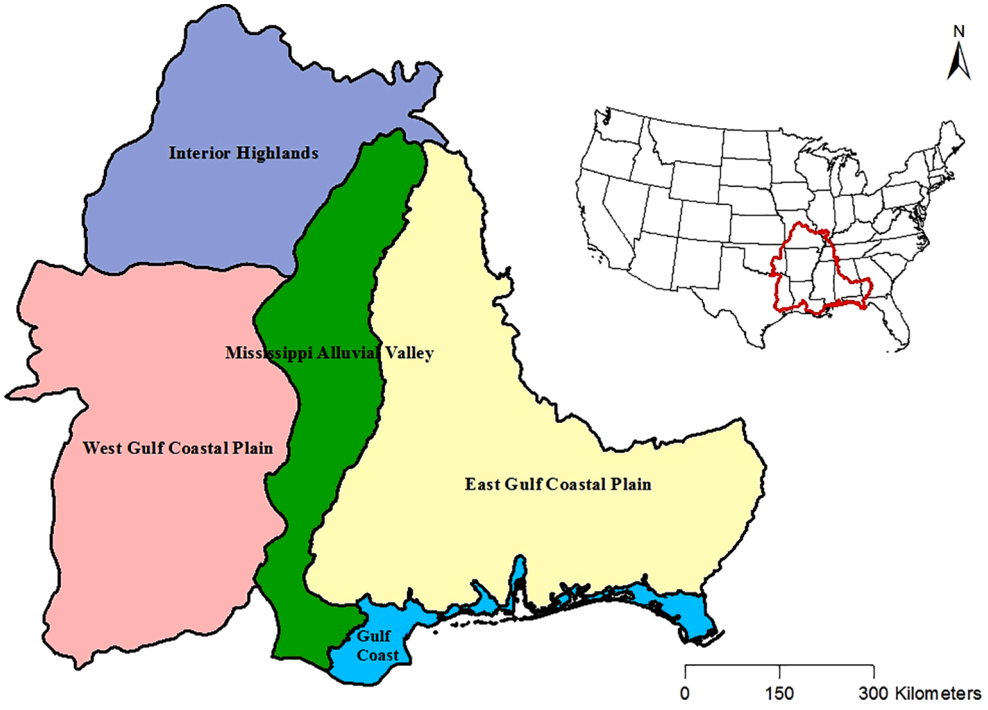

Fig. 1. Location of the study area within Gulf Coastal Plains and Ozarks Landscape Conservation Cooperative (GCPO LCC) in the United States.
Source: Data provided by the U.S. Fish and Wildlife Service/Gulf Coastal Plains and Ozarks Landscape Conservation Cooperative – a layer package available at http://www.fws.gov/GIS/data/national/FWS_LCC.zip.

permanent streams and rivers, as of 2014, were accessed from USGS's National Map Small Scale Collection (U.S. Geological Survey, 2018). Zip code level data related to forest and cultivated land cover were derived from the National Land Cover Database 2016 created by the Multi-Resolution Land Characteristics (MRLC) Consortium and represents a 30-meter spatial resolution (Multi-Resolution Land Characteristics Consortium, 2019).

2.3. Non-response bias testing

To determine if non-response bias was present in the mail survey data (Dillman et al., 2014), several key variables were compared against statistics reported in the National Woodland Owner Survey (NWOS) 2011–13 (4 + hectares) conducted in the southern United States (Butler et al., 2016). NWOS (South) data almost overlapped with the study area and included a larger sample size (3016 observations). Comparisons were made for variables such as age, gender, education, annual income, and size of forest area owned. In addition, landowner socioeconomic characteristics such as age, gender, absentee status, and forest and agricultural land area owned were compared with statistics reported in 2017 Census of Agriculture for study area states (National Agricultural Statistics Service, 2019). A similar approach to assess the representativeness of survey data was used by Miller et al. (2012). Average values of key variables with no substantial differences could indicate no non-response bias in survey data and that the sample represents the population.

2.4. Data imputation

Survey data suffer greatly from missing values when many respondents do not provide responses to every survey question. A common method for addressing missing data is to remove the particular observation entirely if any variables are missing (Håbesland et al., 2016). However, this method can result in the loss of valuable information and non-response bias if the missing data is not completely random (Greene, 2018). Thus, another approach relying on data imputation can help increase degrees of freedom by slightly compromising data variability or central tendencies (Greene, 2018).

In this study, data imputation was only implemented for two questions. First, there were 13 items under "Reasons for owning your land" question: (1) profitable working land for traditional forest, rangeland, and agricultural products (e.g., sawlogs, pulpwood, crops, livestock), (2) profitable working land for non-traditional forest, rangeland, and agricultural products (e.g., nuts and fruits, forage and shelter for livestock, organic ranching, recreation), (3) personal recreation for myself, family members and friends, (4) fee-based recreation, (5) long-term investment, (6) family tradition, (7) provide a legacy to heirs, (8) maintain healthy soils, (9) provide clean water, (10) maintain wildlife habitat, (11) protect endangered species, (12) sequester carbon, and (13) maintain visually appealing land appearance. However, some respondents did not provide a priority-level rating for all landownership reasons; most likely, those ownership reasons were not relevant to them or perhaps due to other circumstances. Second, there were 18 items under "How concerned are you about the following environmental issue:" question (1) drinking water quality, (2) drinking water quantity, (3) water quality for crop irrigation, (4) water quantity for crop irrigation, (5) water quality for recreation (swimming, boating, fishing), (6) water quantity for recreation (swimming, boating, fishing), (7) chemical drift, (8) wildfire, (9) insect pests, (10) animal pests, (11) hurricanes and tornadoes, (12) invasive species, (13) soil erosion, (14) overgrazing, (15) loss of forests, (16) loss of farmland, natural areas, other open spaces, (17) loss of wildlife habitat, and (18) loss of pollinators. In this second question too, a similar trend in missing values was observed. Thus, missing values in both instances were imputed by substituting respective mean sample values only if a particular respondent provided answers for 50% or more items in the question. For example, if a landowner provided answers only for seven of 13 items under "Reasons for owning your land" question the remaining six missing replies were imputed by respective mean rank scores. If a landowner provided responses to less than 50% of items, the entire observation from that individual was removed from analysis.

2.5. Econometric model

Understanding landowner ecosystem service and environmental concerns, and attitudes can help natural resource managers identify suitable interventions that can change conservation behavior of diverse private landowners towards private lands conservation and enhancement of ecosystem services. As attitudes towards conservation behavior are affected by social norms (social pressure), moral obligations, personal abilities, and familiarity with environmental issues (Bamberg and Möser, 2007), landowner concerns or attitudes towards ecosystem services and environmental issues can be represented by a function of local environmental context and personal characteristics (i.e. private land attributes and landowner socioeconomic characteristics). Empirical studies (e.g., Hannibal et al., 2016; Liu et al., 2014; Wilkins et al., 2018) have also indicated that local environmental conditions, socioeconomic characteristics, and other behavior-relevant factors were important determinants of environmental concern and conservation behavior. Thus, identification of environmentally conscious landowners may help mitigate not only existing threats but also new threats to provision of ecosystem services and environmental quality that will emerge in the future. Thus, landowners are more likely to actively participate in implementation of conservation practices facilitating production of ecosystem services if these practices focus on addressing farm-specific ecosystem service availability and environmental issues, and help enhance their family traditions and other ownership objectives.

Landowners were asked to simultaneously rank 18 ecosystem service and environmental issues on a 5-point Likert scale (1 = not at all concerned, 5 = extremely concerned). Constructing an independent regression model separately for each issue would not be appropriate because it was likely that errors across constructed regression models would be correlated. Therefore, seemingly unrelated regression (SUR) was utilized to address the issue of correlation between unobserved disturbances and improved efficiency of parameter estimation (Greene, 2018). As the SUR model consisted of ordinal dependent variables, maximum likelihood method was used to estimate parameters (Cappellari and Jenkins, 2003; Greene, 2018; Roodman, 2011). A general form of the SUR model has been specified as follows (Roodman, 2011):

$$\begin{aligned} y^{*'} &= \boldsymbol{\theta}' + \varepsilon' \\ \boldsymbol{\theta}' &= \boldsymbol{x}'\beta \\ y = g(y^*) &= [g_1(y^*), \cdots\cdots, g_m(y^*)]' \\ \varepsilon | x \; &i.i.d. N(0, \Sigma) \end{aligned} \tag{1}$$

where y*′ is an unobserved latent variable representing landowner concern about ecosystem service availability and environmental issues, y is an observed outcome which represents the level of concern about ecosystem service availability and environmental issues, ε is error term and a random vector, β is matrix of coefficients, $x = (x_1, \ldots \ldots, x_k)'$ is a vector of predetermined random variables representing a set of independent variables, and Σ is variance–covariance matrix with values of 1 on the leading diagonal and correlations on off-diagonal elements.

The Principal Component Analysis (PCA) was used to identify a smaller set of uncorrelated ecosystem service availability and environmental concerns from 18 issues originally included in the mail survey. Four factors, with Eigenvalues greater than one, explained 67.53% of the variation in the original data. Ecosystem service availability and environmental concerns loaded under these four factors were labeled as habitat quality decline (Factor 1), land disturbances (Factor 2), crop irrigation (Factor 3), and water-based recreation (Factor 4). Factor 1 was comprised of eight ecosystem service availability issues including loss of

farmland, natural areas, and other open spaces; loss of pollinators; loss of forests; loss of wildlife habitat; drinking water quality; drinking water quantity; chemical drift; and overgrazing. Factor 2 included six environmental issues: animal pests, insect pests, wildfires, hurricanes and tornadoes, invasive species, and soil erosion. Factor 3 included water quantity and water quality available for crop irrigation; while Factor 4 included available water quality for recreation (e.g., swimming, boating, fishing), and water quantity for recreation (e.g., swimming, boating, fishing). Ecosystem service availability and environmental concerns with the highest correlation with each factor were selected as a proxy for that factor where loss of farmland, natural areas, and other open spaces; animal pests; available water quantity for crop irrigation; and water quality for recreation served as surrogate variables for Factors 1, 2, 3, and 4, respectively.

Four empirical models had been developed to identify how local environmental conditions, private land attributes, and socioeconomic characteristics were related with each group of ecosystem service and environmental concerns. Each dependent variable was regressed on a set of identical independent variables (Table 1). Equation (2) represents the SUR model and was estimated by using STATA cmp command that can be applied to estimate recursive mixed-process and conditional mixed-process models, similar to the two-stage least squares (2SLS) and Heckman selection model (Roodman, 2011). In particular, the cmp command generated parameter estimates of multi-equation systems efficiently using maximum likelihood estimation while considering the errors associated with multivariable normal distribution (Roodman, 2011). The command also produced likelihood ratio test estimates to determine the model fit and marginal effects.

$$\begin{aligned} environmental\ concern = {} & \beta 0i + \beta 1i\ pdensity + \beta 2i\ cocapita + \beta 3i\ so2capita \\ & + \beta 4i\ wateruse + \beta 5i\ river + \beta 6i\ agcover \\ & + \beta 7i\ lnforest + \beta 8i\ lnagland + \beta 9i\ ecosystem \\ & + \beta 10i\ legacy + \beta 11i\ profitability \\ & + \beta 12i\ recreation + \beta 13i\ age + \beta 14i\ gender \\ & + \beta 15i\ education + \beta 16i\ absentee + \beta 17i\ income \end{aligned} \quad (2)$$

where *environmental concern* represents a respective proxy variable for Factors 1, 2, 3, and 4.

2.6. Variable description

Three categories of independent variables, identified from the literature, were used to explain landowner concerns about different environmental issues based on factors related to local environmental conditions, private land attributes, and landowner socioeconomic characteristics (Table 1). Local environmental conditions represent biophysical risks and threats to residents in the region and thus air pollution, water availability and quality, land cover, and land use were selected to represent local environmental conditions in the study area (Hannibal et al., 2016).

Previous studies found that local air quality, measured by concentration of sulfur dioxide (SO_2), carbon dioxide (CO_2) and soot, mostly increased an individual's level of environmental concerns (Hannibal et al., 2016; Liu and Mu, 2016; Marquart-Pyatt, 2012). Perennial rivers and streams represent the main source of freshwater in the southern United States. In addition to its sufficient availability, water quality was associated with water treatment costs, farm productivity, human health, and survival of aquatic species (Jones and van Vliet, 2018). A lower water quality was associated with greater public environmental concerns; however, knowledge of wetlands and their visitation rates were more influential predictors of public concern than residence in proximity to wetlands (Marquart-Pyatt, 2012; Wilkins et al., 2018). Public concern may increase due to cropland expansion because of its potential negative effects on surface as well as ground water quality (Bawa and

Table 1
Variable descriptions included in a seemingly unrelated regression (SUR) model to quantify the association of contextual and individual-level factors with landowner ecosystem service availability and environmental concerns based on a mail survey of private landowners conducted in the southern United States in 2015.

Variables	Descriptions	Mean	STD.
	Dependent variables		
habitat[a]	Concern about a habitat quality decline. A binary variable: 1 if a landowner was concerned about habitat quality decline, 0 otherwise.	0.65	0.48
disturbances[a]	Concern about land disturbances. A binary variable: 1 if a landowner was concerned about land disturbances, 0 otherwise.	0.49	0.50
irrigation[a]	Concern about crop irrigation. A binary variable: 1 if a landowner was concerned about crop irrigation, 0 otherwise.	0.54	0.50
wbrecreation[a]	Concern about water-based recreation. A binary variable: 1 if a landowner was concerned about water-based recreation, 0 otherwise.	0.48	0.50
	Independent variables		
	Contextual factors		
pdensity	Population density. A continuous variable: population density at a zip code level based on the 2010 Census (thousand people/sq. km.).	0.04	0.09
cocapita	Carbon monoxide (CO) emissions. A continuous variable: CO pollutant emissions at a county level in 2014 (ton/capita).	0.47	0.35
so2capita	Sulfur dioxide (SO_2) emissions. A continuous variable: SO_2 pollutant emissions at a county level in 2014 (ton/capita).	0.04	0.15
wateruse[b]	Water use intensity. A continuous variable: total withdrawals and use of surface and ground water in 2015 at a county level (million liters/day/sq. km.).	0.20	0.62
river	Proximity to a river. A continuous variable: distance to the nearest perennial river or stream (kilometers).	2.55	1.82
agcover	Cultivated land cover. A continuous variable: a percentage of cultivated land cover in 2016 at a zip code level.	24.52	26.13
	Private land attributes		
lnforest[c]	Forest land owned. A continuous variable: a natural logarithm of forest land area owned by a landowner (hectares).	3.34	1.51
lnagland[c]	Agricultural land owned. A continuous variable: a natural logarithm of agricultural land area owned by a landowner (hectares).	3.21	1.62
ecosystem[d]	Importance of ecosystem services provision as a landownership reason. A binary variable: 1 if provision of ecosystem services was a priority in landownership, 0 otherwise.	0.63	0.48
legacy[d]	Importance of providing a legacy to heirs as a landownership reason. A binary variable: 1 if providing a legacy to heirs was a priority in landownership, 0 otherwise.	0.70	0.46
profitability[d]	Importance of profitability as a landownership reason. A binary variable: 1 if profitability was a priority in landownership, 0 otherwise.	0.56	0.50
recreation[d]	Importance of personal recreation as a landownership reason. A binary variable: 1 if personal recreation was a priority in landownership, 0 otherwise.	0.51	0.50
	Sociodemographic characteristics		
age	Age. A continuous variable: landowner age (years).	64.52	11.03
gender	Gender. A binary variable: 1 if a landowner was a male, 0 if a female.	0.81	0.40
education[e]	Education level. A binary variable: 1 if a landowner completed a four-year college degree or more, 0 if landowner completed a two-year college degree or less.	0.47	0.50
absentee	Residence status. A binary variable: 1 if landowner's state residence address was in a different state than a location of her/his largest land parcel, 0 otherwise.	0.07	0.25
income[f]		87.31	46.94

(*continued on next page*)

Table 1 (*continued*)

Variables	Descriptions	Mean	STD.
	Household income before taxes in 2014. A continuous variable: Landowner income (1,000 US$).		

[a] The surrogate variable was originally measured on a 1–5 Likert scale: 1 = not at all concerned, 2 = slightly concerned, 3 = somewhat concerned, 4 = moderately concerned, and 5 = extremely concerned. It was recoded into a binary variable where the original Likert scale categories above the mean were coded as 1 (concerned) and those below mean coded as 0 (not concerned).

[b] Data was originally collected as million gallons per day in a given county.

[c] Data was originally measured in acres.

[d] The surrogate variable was originally measured on a 1–5 Likert scale: 1 = not priority, 2 = low priority, 3 = medium priority, 4 = high priority, and 5 = essential. It was recoded into a binary variable where the original Likert scale categories above the mean were coded as 1 (priority) and below mean coded as 0 (not a priority).

[e] Originally measured on a nominal scale: 1 = less than high school, 2 = high school or a General Educational Development (GED) test, 3 = some college, 4 = two-year college degree, 5 = four-year college degree, 6 = Master's degree, 7 = Doctoral degree, and 8 = professional degree (JD, MD). It was recoded into a binary variable where original nominal scale categories above the mean were coded as 1 (a four-year college degree or more) and below mean coded as 0 (a two-year college degree or less).

[f] Originally measured on an interval scale: 1 = less than $30,000, 2 = $30001-$40,000, 3 = $40,001-$50,000, 4 = $50,001-$60,000, 5 = $60,001-$70,000, 6 = $70,001-$80,000, 7 = $80,001-$90,000, 8 = $90,001-$100,000, 9 = $100,001-$110,000, 10 = $110,001-$120,000, 11 = $120,001-$130,000, 12 = $130,001-$140,000, 13 = $140,001-$150,000 and 14 = more than $150,000. It was recoded as a continuous variable using the mid-point value of interval.

Dwivedi, 2019; Shoda et al., 2019). Place of residence was another influential contextual factor. For example, urban residents were more concerned about environmental problems than rural dwellers (Newman and Fernandes, 2016). Therefore, this study included the environmental contextual factors such as population density (*pdensity*), carbon monoxide (CO) emissions (*cocapita*), sulfur dioxide (SO_2) emissions (*so2capita*), water use intensity (*wateruse*), proximity to a river (*river*), and cultivated land area (*agcover*).

The second category of the independent variables included private land attributes. This category included area of forest land owned (*lnforest*), area of agricultural land owned (*lnagland*), and landownership objectives: provision of ecosystem services (*ecosystem*), providing legacy to heirs (*legacy*), profitability (*profitability*), and personal recreation (*recreation*). PCA was used to identify unobservable latent factors or components that contributed to the variation in measurements of landownership objectives. Four factors with greater than one Eigenvalue were extracted where, provision of ecosystem services, providing legacy to heirs, profitability, and personal recreation had the highest loadings and were selected to serve as proxy variables for each factor. According to the theory of planned behavior, landowners might be motivated to achieve landownership objectives and subsequently maximize their utility or obtain rewards (Ajzen, 1991). Thus, landowners concerned about specific ecosystem service availability and environmental issues are more likely to implement actions to mitigate them, especially if these actions help achieve their landownership objectives.

The third category of the independent variables included landowner socioeconomic characteristics: age (*age*), gender (*gender*), education level (*education*), residence status (*absentee*), and household annual income (*income*). Socio-psychological studies found that socioeconomic factors related to age, social class, place of residence, political beliefs, and gender were associated with level of environmental concern (Gifford and Nilsson, 2014; Newman and Fernandes, 2016). For example, females often expressed slightly greater environmental concern than males (Xiao and McCright, 2012). However, effect of age and educational level on environmental concern did not have a clear direction (Flint et al., 2017; Hannibal et al., 2016; Wilkins et al., 2018). Variations in effects of socioeconomic factors on environmental concerns might also be attributed to the types of environmental issues and affected by the occupation and working environment of individuals (Liu and Mu, 2016; Skogen et al., 2018). For example, the level of environmental concern can be more associated with individuals who were exposed to or experienced more environmental risks than others, irrespective of their age and education level (Marquart-Pyatt, 2012).

3. Results

3.1. Survey response and checking for non-response bias

A total of 1017 usable responses were obtained from the mail survey. An adjusted survey response rate was 33% after removing questionnaires sent to deceased landowners, incorrect addresses, and respondents who did not own land. Due to missing values, only 350 survey responses were included in further analysis, of which 179 responses came from the MAV and 171 from the EGCP.

There were no differences in mean values of age, gender, education, annual income and agricultural land owned between the study sample and statistics reported in NWOS (South) as well as in the 2017 Census of Agriculture data (Table 2). The average size of forest land owned (101.04 ha) in this study was potentially inflated because of some extreme values as indicated by a median area which was 24.28 ha and comparable with NWOS and Census data. Therefore, the comparisons suggested that non-response bias did not exist in this survey data with the exception of residence status (% of absentee landowners). Census data showed that in general there were 24.97% absentee landowners, while it was only 6.86% in the study sample.

3.2. Landowner socioeconomic characteristics and their concern about availability of ecosystem services and environmental issues

Most respondents were males (81%) who completed more than a high school level education (76.57%). A completion of a four-year college degree was the most frequently reported education level (27.43%). On average, a landowner was 64 years old, owned 101.04 ha of forest land (median area was 24.28 ha) and 91.18 ha of agriculture land (median area was 20.23 ha), and had an average annual household income of $87,314. As landowners reported their annual household income on an interval scale, the most frequent income category reported was >$150,000 (19.71%). In terms of residence, 93.14% of landowners resided near their private lands, whereas 6.86% were absentee owners.

Of the total landowners, 51.14 to 78.28% were moderately concerned or extremely concerned about 12 of 18 ecosystem service availability and/or environmental issues (Table 3). Based on landowner rating of 'extremely concerned' category, the five topmost issues included drinking water quality (54%), drinking water quantity (42.57%), soil erosion (39.14%), loss of wildlife habitat (38.29%), and loss of farmland, natural areas, and other open spaces (37.14%). Landowners were least concerned about overgrazing (15.14%).

3.3. Factors affecting landowner concerns about availability of ecosystem services and environmental issues

Likelihood ratio test suggested that the overall SUR model fit was significant ($\chi^2 = 183.39$, df = 68, $p < 0.001$). The use of the SUR model was justified because Breusch-Pagan test of independence found that each of four individual regression models were correlated ($\chi^2 = 125.76$, $p < 0.001$). White's tests indicated that the four estimated regression models did not suffer from heteroscedasticity problems: habitat quality decline ($\chi^2 = 141.39$, $p = 0.89$), land disturbances ($\chi^2 = 188.08$, $p = 0.09$), crop irrigation ($\chi^2 = 182.98$, $p = 0.14$), and water-based recreation ($\chi^2 = 118.78$, $p = 0.996$). Similarly, there was no multicollinearity among independent variables (Variance Inflation Factor = 1.24). Table 4 presents the regression results and Table 5 presents the marginal

Table 2
Average values for sample responses and those reported in National Woodland Owner Survey (NWOS) and 2017 Census of Agriculture.

Survey	Age (years)	Gender (male %)	Education (above high school %)	Annual Income ($)	Residence Status (%)	Forest land area owned (ha)	Agricultural land area owned (ha)
Sample	64.52	81.00	76.57	87,314.29	6.86	101.04	91.18
NWOS (South)	62.90	76.70	72.10	81,907.45	NA	32.80	NA
Census of Agriculture (10 States)	58.78	72.33	NA	NA	24.97	38.22	95.91

NA = Not available.

Table 3
Landowner concern about ecosystem service availability and environmental issues in East Gulf Coastal Plain and Mississippi Alluvial Valley sub-geographies of Gulf Coastal Plains and Ozarks Landscape Conservation Cooperative (GCPO LCC) in the United States based on a mail survey of private landowners conducted in 2015 (n = 350).

Ecosystem service/environmental issue	Level of concern (%)					
	Not at all concerned	Slightly concerned	Somewhat concerned	Moderately concerned	Extremely concerned	Median ranking
Drinking water quality	5.43	4.00	12.29	24.28	54.00	5
Drinking water quantity	8.57	5.43	11.43	32.00	42.57	4
Water quality for crop irrigation	30.29	15.14	19.43	18.86	16.29	3
Water quantity for crop irrigation	28.29	13.43	19.72	20.86	17.71	3
Water quality for recreation (e.g., swimming, boating, fishing)	21.14	12.00	18.86	26.29	21.71	3
Water quantity for recreation (e.g., swimming, boating, fishing)	22.29	12.29	20.86	25.14	19.43	3
Chemical drift	12.57	9.43	18.29	25.71	34.00	4
Wildfire	11.14	17.71	19.43	24.57	27.14	4
Insect pests	5.43	11.71	22.29	33.14	27.43	4
Animal pests	9.71	14.86	26.57	29.14	19.71	3
Hurricanes and tornadoes	9.71	16.29	22.86	27.71	23.43	4
Invasive species	7.43	8.57	20.86	36.29	26.86	4
Soil erosion	5.43	7.14	17.71	30.57	39.14	4
Overgrazing	34.86	16.57	19.43	14.00	15.14	2
Loss of forests	12.00	11.43	17.14	28.00	31.43	4
Loss of farmland, natural areas, other open spaces	9.14	8.86	15.14	29.71	37.14	4
Loss of wildlife habitat	5.14	5.43	18.00	33.14	38.29	4
Loss of pollinators	5.71	4.57	21.71	34.00	34.00	4

effects for all four regression models.

The effects of local environmental conditions varied across concerns about ecosystem service availability and environmental issues (Table 4). No environmental contextual factors were significant predictors of landowner concerns about quality and quantity of water available for crop irrigation ($p > 0.10$). Air pollutants such as CO ($p = 0.06$) and SO_2 ($p = 0.04$) emissions were positively associated with landowner concerns about water-based recreation and habitat quality decline, respectively. A 0.1 ton/capita increase in CO emissions was associated with a 1.5% increase in probability that a landowner would be

Table 4
Results of the seemingly unrelated regression (SUR) model to quantify the association of contextual and individual level factors with landowner concerns about ecosystem service availability and environmental issues based on mail survey conducted in the southern United States in 2015.

	(1) Habitat quality decline		(2) Land disturbances		(3) Crop irrigation		(4) Water-based recreation	
Variable	*Coef.*	*SE*	*Coef.*	*SE*	*Coef.*	*SE*	*Coef.*	*SE*
pdensity	0.4314	0.9606	0.2984	0.8870	0.2755	0.8772	1.0242	0.9367
cocapita	0.0133	0.2414	0.3736*	0.2164	0.2060	0.2094	0.4379*	0.2303
so2capita	2.7655**	1.3717	0.0717	0.5243	−0.5090	0.4831	0.0554	0.5122
wateruse	−0.0167	0.1294	−0.0181	0.1156	−0.0748	0.1183	−0.2063	0.1318
river	−0.0252	0.0434	0.0701*	0.0408	−0.0587	0.0402	0.0005	0.0413
agcover	−0.0034	0.0035	−0.0089***	0.0033	0.0019	0.0033	−0.00003	0.0033
lnforest	−0.1804***	0.0593	0.0514	0.0539	−0.0219	0.0547	−0.0267	0.0552
lnagland	0.2345***	0.0624	0.1052*	0.0589	0.1570***	0.0597	0.0179	0.0593
ecosystem	0.6128***	0.1604	0.3896**	0.1565	0.6817***	0.1567	0.6699***	0.1581
legacy	0.2217	0.1673	−0.0389	0.1648	0.0499	0.1641	0.3866**	0.1688
profitability	0.2606*	0.1571	0.3850**	0.1529	0.0098	0.1529	0.1075	0.1570
recreation	−0.0837	0.1594	−0.1991	0.1538	−0.0727	0.1523	0.5017***	0.1555
age	0.0001	0.0072	−0.0036	0.0072	−0.0073	0.0071	−0.0026	0.0073
gender	0.3619*	0.1899	−0.1211	0.1857	−0.0078	0.1844	0.2241	0.1897
education	0.0513	0.1568	−0.2915*	0.1496	−0.0316	0.1501	−0.2603*	0.1543
absentee	−0.1486	0.3061	−0.5964**	0.2965	0.1084	0.2912	−0.1643	0.3014
income	−0.0025	0.0019	−0.0018	0.0018	0.0004	0.0018	0.0021	0.0018
Constant	−0.3920	0.6077	−0.3575	0.5941	−0.2801	0.5961	−1.3170**	0.6153
Obs.	350		350		350		350	

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 5
Average marginal effects of independent variables related to local environmental conditions, private land attributes, and socioeconomic characteristics on landowner concerns about ecosystem service availability and environmental issues in the southern United States.

Variables	Ecosystem services/environmental issues			
	Habitat quality decline	Land disturbances	Crop irrigation	Water-based recreation
pdensity	0.1379	0.1067	0.0998	0.3474
cocapita	0.0043	0.1335	0.0746	0.1485
so2capita	0.8839	0.0256	−0.1844	0.0188
Wateruse	−0.0053	−0.0065	−0.0271	−0.0700
River	−0.0081	0.0251	−0.0213	0.0002
Agcover	−0.0011	−0.0032	0.0007	−0.00001
Lnforest	−0.0577	0.0184	−0.0079	−0.0091
Lnagland	0.0750	0.0376	0.0569	0.0061
Ecosystem	0.1959	0.1392	0.2470	0.2272
Legacy	0.0709	−0.0139	0.0181	0.1311
Profitability	0.0833	0.1376	0.0036	0.0364
Recreation	−0.0267	−0.0712	−0.0264	0.1702
Age	0.00001	−0.0013	−0.0026	−0.0009
Gender	0.1157	−0.0433	−0.0028	0.0760
Education	0.0164	−0.1042	−0.0115	−0.0883
Absentee	−0.0475	−0.2132	0.0393	−0.0557
Income	−0.0008	−0.0006	0.0001	0.0007

concerned about water-based recreation and a 1.3% increase in probability that she/he would be concerned about land disturbances (Table 5). SO_2 emissions had a greater marginal effect where a 0.1 ton/capita increase in emissions was associated with an almost a 9% increase in probability that a landowner would be concerned about habitat quality decline (Table 5). Similarly, CO emissions ($p < 0.10$) and private land's proximity to a river or a stream ($p < 0.10$) were positively associated, whereas percentage of cultivated land cover ($p < 0.01$) were negatively associated with landowner concerns about land disturbances. A one kilometer increase in a private land's distance to a river/stream related to a 2.51% increase in the probability of being concerned about land disturbances, whereas a 1.0% increase in cultivated land area translated to a decrease in probability of 0.32% (Table 5).

Land property-related factors had a greater magnitude of association with landowner concerns about availability of ecosystem services and environmental issues than environmental contextual and sociodemographic factors (Table 4). Size of agricultural land owned was positively related with landowner concerns about habitat quality decline ($p < 0.001$), land disturbances ($p < 0.10$), and quality and quantity of water available for crop irrigation ($p < 0.01$), although the size of forest land owned was only negatively related with habitat quality decline concern ($p < 0.01$). A 1.0% increase in agricultural land owned corresponded to a 0.07%, 0.04%, and 0.06% increases in landowner concerns about habitat quality decline, land disturbances, and quality and quantity of water available for crop irrigation, respectively (Table 5). Among landownership objectives, provision of ecosystem services was related with landowner concerns about habitat quality decline ($p < 0.01$), land disturbances ($p < 0.05$), quality and quantity of water available for crop irrigation ($p < 0.01$), and water-based recreation ($p < 0.01$). Landowners who owned land for provision of ecosystem services were 19.59%, 13.92%, 24.70% and 22.72% more likely to be concerned about habitat quality decline, land disturbances, quality and quantity of water available for crop irrigation, and water-based recreation, respectively, than landowners with different landownership objectives (Table 5). Similarly, a profitability objective was associated with landowner concerns about habitat quality decline ($p < 0.10$) and land disturbances ($p < 0.05$). Landowners with profitability objective were 8.33% and 13.76% more likely to be concerned about habitat quality decline and land disturbances, respectively, than landowners with other ownership objectives (Table 5). However, landownership objectives such as providing a legacy to heirs ($p < 0.05$) and personal recreation ($p < 0.01$) were only associated with water-based recreation concerns. Probability of landowner concern about water-based recreation was increased by 13.11% if a landowner owned land for providing a legacy to heirs, and 17.02% if the ownership objective included personal recreation (Table 5).

Socioeconomic characteristics were associated only in few instances with landowner concern about ecosystem service availability and environmental issues (Table 4). Gender and residence status were associated with concerns related to habitat quality decline ($p < 0.10$) and land disturbances ($p < 0.05$), respectively. Male landowners were 11.57% more likely to be concerned about habitat quality decline than female landowners (Table 5). Absentee landowners were 21.32% less likely to be concerned about land disturbances than landowners who resided nearby their largest land parcels (Table 5). Similarly, an education level was negatively associated with landowner concerns about land disturbances ($p < 0.10$) and water-based recreation ($p < 0.10$). Landowners who completed a four-year degree or more were 10.42% less likely to be concerned about land disturbances, and 8.83% less likely to be concerned about water-based recreation, than landowners who completed a two-year college degree or less. Age and income, however, were not related to landowner concerns about availability of ecosystem services and environmental issues ($p > 0.10$). No socioeconomic variables were associated with landowner concerns about quality and quantity of water available for crop irrigation ($p > 0.10$).

4. Discussion

This study assessed the level of concern of private landowners towards ecosystem service availability and environmental issues in the southern United States which is important for increasing conservation efforts because these landowners own the majority of land in the region. In most instances, private landowners were concerned about all ecosystem services and environmental issues indicating that technical and financial assistance could increase the likelihood of implementing conservation practices by landowners if it helps address their land management needs and related concerns. Identification of the top concerns (Table 3) indicated that conservation agencies should prioritize available funding for conservation practices related to protecting drinking water sources, reducing soil erosion and promoting natural forest conservation which is important because conservation funding has leveled off since 2014, and conservation needs to increase landowner resilience to the negative environmental impacts while increasing the capacity of their lands to produce ecosystem services.

Atmospheric concentrations of CO and SO_2 were positively associated with concerns related to land disturbances, water-based recreation, and habitat quality decline, most likely because landowners lived in a polluted environment. Air quality might not be as good nowadays in the southern United States, because in the past wildland fires (wildfires and prescribed fire) burned almost 1.4 million ha annually in the region where the largest proportion (38.1%) of the U.S. population lives (National Interagency Fire Center, 2018). Air pollution is not only aesthetically unpleasant but also associated with serious health problems such as respiratory and cardiovascular diseases and reduced work capacity (Bernard et al., 2001). People also tend to avoid or reduce their outdoor recreation activities in polluted areas (Zivin and Neidell, 2009). Thus, landowners residing in areas with high levels of air pollutants might be interested in implementing land conservation practices that will help mitigate their negative impacts. Focusing conservation efforts in urban and sub-urban areas will help improve provision of ecosystem services, including recreational opportunities on private lands, and contribute to the reduction of air pollutants.

Wetlands, including rivers and streams, are particularly important because they provide crucial ecosystem services as well as have substantial ecological and economic values. In the southern United States, wetlands cover 18% of the land area and supply water for drinking, irrigation, recreation, and other uses (De Steven and Lowrance, 2011). Annual value of wetland ecosystem services in the MAV was

approximately $300 million (Jenkins et al., 2010). Distance from a forest land property to a river/stream was positively associated with landowner concerns about land disturbances. In other words, landowners whose private lands were nearby a perennial river/stream, were less concerned about land disturbances. Wilkins et al. (2018) reported that distance to the nearest wetland was not a significant predictor for public concern about loss of wetland ecosystem services. In this study, proximity of river/stream was not related to landowner concerns about habitat quality decline, crop irrigation and water-based recreation. The reason behind this unsignificant impact might be due to the fact that most surveyed landowners lived within a proximity to a river or stream (an average distance of 2.55 km, a maximum distance of 8.35 km). Another explanation might be that this study included only perennial rivers but did not include intermittent or ephemeral streams and private ponds. These streams and private ponds probably enhanced the effects of land disturbances as they may help spread invasive species and accelerate soil erosion (Vose et al., 2012). Thus, landowners may be more interested in implementing conservation practices on private lands further away from perennial rivers/streams. It implies that landowners who live further away from perennial rivers are more likely to engage in preserving soil moisture and wetland protection than landowners who reside on or own lands nearby a river side.

Typically, cropland expansion comes at the expense of forest land, pastureland, or wetlands and results in soil erosion and water pollution. Therefore, it was unexpected that the percentage of cropland cover was negatively associated with landowner concern about land disturbances. However, land disturbances in this study such as animal pests, insect pests, wildfires, hurricanes and tornadoes, invasive species and soil erosion mostly represented forest disturbances. Thus, increases in cropland area at the zip code level were associated with decreases in forest area and less frequent occurrences of forest disturbances such as animal pests, wildfires, and invasive plant species. As a result, concerns about land disturbances were associated negatively with cropland expansion. This finding implies that counties with large coverage of cropland area require strong outreach activities to promote conservation practices enhancing production of ecosystem services on working lands.

Sociodemographic variables remained statistically significant only in few instances. Male landowners were more concerned about habitat quality decline than female landowners. However, most of the previous studies found that females were more concerned about availability of ecosystem services and environmental issues than males (Flint et al., 2017; Hannibal et al., 2016; Liu et al., 2014; Wilkins et al., 2018). Size of a private property and landownership objectives might have masked the true effect of gender on landowner concern about ecosystem services and environmental issues, because male landowners usually owned larger properties than female landowners. Education level effects on ecosystem service and environmental concerns were also inconsistent with previous studies. Liu et al. (2014) mentioned that an education level had a relatively small effect on environmental concerns. However, Flint et al. (2017) found that individuals with a more formal education were less concerned about flooding and water quality issues. Individuals with a less formal education might have greater exposure to the environmental risks due to lower socioeconomic status (Flint et al., 2017). Thus, they were more concerned about ecosystem service availability and environmental problems than those with higher education degrees. Similarly, absentee landowners were less concerned about land disturbances than their counterpart resident landowners. Absentee landowners may live in locations with more economic opportunities and fewer natural hazard threats (Petrzelka and Armstrong, 2015). In addition, tenants might have to bear costs of property damage which might cause absentee landowners to be less concerns about environmental problems. Thus, landowners who live on or nearby their land are more knowledgeable of local environmental issues and can potentially be more active in addressing these issues through conservation actions. In short, this study indicated that male landowners with lower levels of formal education and living on their private land property were more concerned about ecosystem services and environmental issues than other landowners. As gender and education level were weakly associated with ecosystem service availability and environmental concerns, and the number of absentee landowners was less than 10%, focusing educational outreach programs on landowners considering provision of ecosystem services as an important ownership goal will be more effective in expanding implementation of conservation practices on private lands than on landowners with other ownership goals.

Private land characteristics which included property size, and ownership goals were major predictors of concerns related to ecosystem services and environmental issues expressed by private landowners. Past studies also found that landowners who owned larger areas of forest land were more concerned about climate change and carbon sequestration (Khanal et al., 2016). In addition, landowners who owned large land parcels had an opportunity of implementing more than one management activity simultaneously; for example, they could engage in sustainable timber harvesting as well as participate in cost-share programs (Butler et al., 2016; Godar Chhetri et al., 2018). As a result, they were more likely to be able to achieve their profitability objectives while implementing management prescriptions facilitating production of ecosystem services. However, environmental problems can be detrimental to attaining landownership goals if landowners do not adopt mitigation measures. Thus, conservation practices that address environmental concerns and help achieve landownership goals may increase active participation of landowners in production of ecosystem services. As a result, a large portion of working lands would be available for protecting water sources, promoting soil conservation, and maintaining wildlife habitat and other ecosystem services in the southern United States.

This study has several limitations. First, some variables were not included in the model as suggested by several social-psychological studies such as community affluence or economic status, water pollution, place of residence (urban or rural), political orientation, and knowledge and familiarity with different environmental issues. However, the models in this study incorporated water use intensity and population density as a proxy for water pollution and place of residence, respectively. Second, data related to landowner personal characteristics were collected via mail a survey in spring 2015; however, data related to local environmental conditions were not exactly from 2015 (see Table 1 for detail) except for the water use intensity variable. Thus, this study assumed that there was no substantial differences in values of those local contextual factors between 2015 and respective data availability dates; however, population density and pollution level may change rapidly because of economic activity. Third, there was an identical set of independent variables used for all four regression models. Generally, SUR model estimation achieves a greater efficiency if sets of independent variables vary by individual regression models. Future studies should include variables related to place of residence, political orientation, and knowledge about environmental issues which may result in better model fits for this type of predictive modeling. Finally, this study used expert opinions to identify ecosystem services and environmental issues relevant to private land conservation. However, it would be more meaningful if these aspects were identified through group discussions with landowners prior to designing the questionnaire and implementing the mail survey. This study focused only on explaining landowner attitudes toward biophysical or natural systems; however, landowner participation in conservation program is also affected by their attitudes toward environmental governance systems, specifically federal and private conservation organizations, legislative provisions, and potential land management restrictions. Thus, future research should also consider issues related to environmental governance system and its impact on landowner environmental concerns and subsequent conservation behavior.

5. Conclusions

This study developed a model of landowner concerns about

availability of ecosystem services and environmental issues as a function of local environmental conditions, private land attributes, and socio-economic characteristics. Property size and landownership objectives strongly influenced landowner concerns about ecosystem services and environmental issues. Landowners who had larger sized agricultural land parcels, owned land for providing ecosystem services, or were making profit through traditional farming and forestry activities, were more likely to engage in private land conservation that would enhance ecosystem services. Developing conservation practices and programs that address landowners' natural resource concerns (e.g., soil erosion control, pest management) on larger agricultural land parcels can be more cost effective because these landowners are more concerned about natural resource issues and are more likely to implement and continue conservation practices after program expiration. As landownership reasons, such as profitability and provision of ecosystem services, were positively associated with landowner environmental concerns, motivating landowners towards multiple-use management consistent with their landownership objectives can be an effective way to diversify environmental risks and increase their active participation in conservation programs facilitating production of ecosystem services.

Adoption of conservation practices by private landowners can not only depend on monetary incentives but also be affected by landowner attitudes and personal circumstances. At least 37% of landowners in the southern United States were extremely concerned about drinking water quality, drinking water quantity, soil erosion, loss of wildlife habitat, and loss of open spaces. When landowners have access to knowledge on how to mitigate these negative environmental impacts and resources to implement required mitigative measures, they might be more likely to adopt required conservation practices. Thus, focused outreach programs, educating landowners about how to implement needed mitigation practices and how to access available assistance resources, can help convince these landowners to implement conservation practices that will not only help mitigate negative environmental impacts of their concern but also increase the provision of ecosystem services.

Declaration of Competing Interest

The authors 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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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ecoser.2021.101283.

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