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Research article

Recognizing the insurance value of resilience: Evidence from a forest restoration policy in the southeastern U.S.

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ABSTRACT

The long-term supply of ecosystem services is dependent on properly functioning ecosystems and their susceptibility to natural and anthropogenic disturbances such as climate change and urbanization, as they can alter ecosystem structure and function. Forest function is not static, but rather a risky asset that fluctuates and can decrease as a result of forest disturbance. Therefore, concepts such as resilience and insurance value as well effective policy formulation, management, and restoration are key to maintaining these benefits. This study estimates the insurance value that the public places on a policy that promotes restoration for increased resilience and ecosystem services using binary choice (BC) and best-worst scaling (BWS) models to estimate willingness to pay (WTP) and to vote for the restoration of longleaf pine (LLP) forests in the southeastern United States. Our BWS findings indicate that respondents seemed to only prefer programs with low risk of forest damage and lower monthly costs, while BC models show that low and moderate risk programs increased the likelihood of voting for them and that excellent wildlife habitat was also highly valued by our respondents. Positive attitudes towards the environment also positively influence voting for forest restoration programs. Findings contribute to an emerging body of literature on social-ecological systems and how the voting public conceptualizes trade-offs among ecosystem services, insurance value, and resilience. Results may help assess the use and incorporation of concepts such as resilience, ecosystem services, and insurance value in restoration, environmental, fire management, and climate change-related policy instruments and programs.

1. Introduction

Forests are not only sources of timber, wood pulp, and litter, but also other ecosystem services including recreation and aesthetics, carbon sequestration, water provisioning, and overall climate regulation (Millennium Ecosystem Assessment ed, 2005; Chazdon 2008). Provision of these services is dependent on properly functioning ecosystems and the susceptibility of forests to natural and anthropogenic disturbances that can alter ecosystem structure and function. Extreme weather events, including hurricanes and tropical storms, wildfires, droughts, and disturbance from invasive species, are expected to increase as a result of global and climate change (Dale et al., 2001; Seidl et al., 2017). Thus, the benefits derived from forest ecosystems can be characterized as risky assets which fluctuate erratically, with lagged responses over time. In particular, their supply can decrease as a result of forest disturbance (Admiraal et al., 2013). This poses challenges to managers and landowners as well as the public that benefits from these services, each of whom has an interest in maintaining properly functioning ecosystems across space and time.

There is an expansive literature on the resilience of socio-ecological systems (Li et al., 2020). Ecological resilience (Holling 1973) and *insurance value* are frequently used to convey the role of biodiversity and ecosystems in buffering the negative effects of disturbance (Quaas and Baumgärtner 2008; Green et al., 2016; Baumgärtner and Strunz 2014). Resilience can be defined as the amount of disturbance an ecosystem can withstand before its functioning decreases to a lower-productivity state (Holling 1973). Ecosystem *resilience* may then function as *insurance* for continued and long-term ecosystem function and provision of ecosystem services at society's desired level.

A common land management approach to reestablishing degraded or maintaining desirable ecosystem function and subsequent services is through landscape-scale restoration. Landscape restoration can also

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provide greater resilience against extreme events. Large-scale landscape resilience can be improved by policy instruments and incentives that restore degraded forests or change landowner objectives from those that emphasize forest conversion or resource extraction (e.g., timber, cattle, agriculture, real estate premiums) to those that yield multiple ecosystem services and goods (Goldman et al., 2007; Chazdon 2008). Accordingly, the level of resilience across the landscape can vary as managers choose specific land management practices and objectives such as crop diversification on agricultural lands or uneven-aged management practices on forested lands (Lin 2011; Lafond et al., 2014).

Ecological restoration often emphasizes the original, pre-disturbance structure and composition of degraded landscapes (Frost, 1993; Chazdon, 2008). However, pine forests in the southern United States (U.S.) provide an example of landscape-scale restoration opportunities that can recover pre-disturbance ecosystem structure, composition, and functions (Chazdon, 2008); thereby increasing the suite of ecosystem services that are of value to society (Tyner and Boyer, 2020), including the provision of habitat for endangered species such as the red-cockaded woodpecker (Wood and Kleinhofs 1995), and overall *socio-ecological resilience*—as opposed to just *ecological resilience*—to disturbances (Holling 1973; Johnsen et al., 2009). The transition from a single-species pine plantation to a restored longleaf ecosystem necessitates tradeoffs between revenue from timber production and the provision of diverse ecosystem services. Therefore, many federal and state-level programs, e.g., the Longleaf Pine Private Landowner Incentive Program (LLPI), Conservation Reserve Program (CRP), Environmental Quality Incentive Program (EQIP), Partners for Fish and Wildlife (PFW), and the Southern Pine Beetle (SPB) Cost-Share Program aim to incentivize this transition through financial and technical assistance in establishing and managing longleaf pine. These include activities such as longleaf seedling site preparation, planting, and seedling cost, prescribed burn implementation, and native understory vegetation establishment, among others (e.g. Natural Resources Conservation Service 2014).

Overall, the related concepts of resilience and insurance can provide examples of how restoration policies can sustain the long-term provision of ecosystem services to society. To ground the example, suppose an altered or degraded ecosystem supplies fewer (or more degraded) benefits to a community. Assuming a socio-ecological system's threshold at which the ecosystem becomes degraded or altered, the impacted community may be willing to pay an insurance premium to avoid such a state (Farber et al. 2002). This theoretical grounding has been further developed in the literature to show that the value of resilience might decrease if financial insurance is a viable alternative; in other words, financial insurance and ecosystem insurance are substitutes (Quaas and Baumgärtner 2008). In particular, studies demonstrate that insurance value is a component of the economic value of resilience (Baumgartner and Strunz 2014). However, increasing resilience is often simultaneous with co-benefits such as improving biodiversity—a characteristic of resilient ecosystems (Chazdon 2008)—with noncommitant values for recreationists and hunters (Gowdy 1997). Therefore, studies that attempt to estimate insurance value should speak to both the impact of resilience of the future flow of ecosystem services and other benefits to socio-ecological systems.

Empirical estimation of ecosystem insurance value has been somewhat limited (Figge 2004; Crowe and Parker, 2008; Matthies et al., 2019; Hoekstra 2012; Walker et al., 2010). Researchers have applied modern portfolio theory to ecosystems, showing that biodiversity functions as a diverse portfolio of investments and considerations of genetic diversity can also inform conservation and management decisions (Figge 2004; Hoekstra 2012). Crowe and Parker (2008) have also applied portfolio theory to forest restoration. They demonstrate that under climatic uncertainty, an optimal restoration program should include a diverse composition of species that specialize in different possible climate scenarios. There have also been efforts to empirically estimate the value of ecosystem resilience in different contexts. Many of these studies rely on an ecological approach. For example, Brookhuis and Hein (2016) estimate the value of forest cover and reduced flood risk in terms of averted damage costs. Another related strand of literature investigates the relationship between risk perceptions and property owner's WTP to reduce risk from wildfire damage. A study of valuation of fire risk reduction practices found that even those who experience direct benefits are not willing to pay for programs if they believe the risk to their property is low (Sánchez et al., 2019).

Using a combination of focus groups and survey-based valuation, Bernues et al. (2014) estimated that both landowners and the public have a positive valuation of ecosystem services provided by mountain agroecosystems, roughly half of which is attributed to the prevention of forest fires. The study also found that other components of value included the production of marketed goods and the support of biodiversity. In a contingent valuation study of public WTP for forest watershed restoration, Mueller (2014) found that on average, Flagstaff, U.S. households were willing to pay between \$4 and \$5 per month to contribute to restoration efforts. While such findings are significant, there is no guarantee that preferences for ecosystem attributes are in line with maintaining resilience against extreme events; a lack of information could contribute to divergence between public preferences and the necessary levels of attributes to maintain ecosystem functioning (Chee 2004; Ludwig 2000).

Overall, there is little empirical evidence on the extent to which the general public conceptualizes the risk and tradeoffs associated with restoration and socio-ecological resilience as a form of insurance value, which would be a key driver of decision-makers' ability to develop policies and management strategies to enhance resilience. Given the risk associated with extreme events detrimentally affecting forests, our study uses stated preference survey methods to estimate the insurance value that the public places on the use of forest restoration policies (e.g. cost-share agreements, technical assistance programs) to increase resilience and subsequent ecosystem services provision (Tyner and Boyer, 2020). The study has three specific objectives. First, we estimate the public's willingness to pay (WTP) for reduced risks of forest damage in the southeastern U.S. Hereafter, a high risk of forest damage corresponds to low levels of resilience, while low risk of damage corresponds to high levels of resilience. Second, we employ a recent innovation in choice modeling best-worst choice (BWC) to examine the value of resilience to the U.S. population against extreme weather events Third, we assess whether framing restoration as a form of socio-ecological insurance affects relative values and likelihood of voting.

2. Data and empirical methods

The past few centuries have seen major ecological change: a move from biologically diverse, frequently burning, pine-savannas to more common single-species industrial forests with little diversity. A study by Frost (1993) found that longleaf pine (LLP) forests were once dominant on 30 million hectares of land in the southeast, and present in mixed forests on another 7 million hectares. However, a combination of land-use pressures, a policy of fire suppression, and years of commercial forestry, which favors faster-growing loblolly and slash pines, have greatly reduced the range of LLP; its area reached a low of around 3% its original range in the early 1990s (Frost 1993). Despite recent restoration efforts, it is still much reduced. Longleaf pine restoration is a focus for many agencies as well as landowner groups and NGOs located in the southeastern U.S. A combination of cost-share and technical assistance programs are available for landowners interested in establishing and maintaining longleaf pine savanna on their forestland.

We use longleaf pine (*Pinus palustris*) forests in the southeastern U.S. as means to study the insurance value the public places on the use of landscape-scale restoration policies for increased resilience. LLP was selected given its ecosystem function and biodiversity advantages over pine plantations of loblolly (*Pinus taeda*) and slash pine (*Pinus elliottii*) that often were used to convert longleaf stands over the course of the 20th century as landowners focused on faster-growing commercial species that could be optimized for timber production. Longleaf forests provide critical habitat for endangered and threatened wildlife (Kirkman and Jack 2017) and are well-suited for long-term carbon sequestration because of their lifespan (Kush et al., 2004). LLP is also among the most well-adapted southern pines to climate change as it is a highly resilient species, less prone to damage by windthrow (Johnsen et al., 2009), and wildfire adapted (Outcalt 2000). LLP also produces high-quality timber and forest products and provides opportunities for recreation and hunting and is also reported to have one of the most diverse understory plant communities in the U.S. (Timilsina et al., 2013). Thus, restoring LLP in its natural range in the southeast US is one viable policy to improve the overall resilience of working forests and the ecosystem services they provide.

2.1. Study area

Our study area consists of four U.S. states within the historic range of LLP primarily along the outer, mid, and lower coastal plain ecoregions of the southeastern U.S. This region is generally characterized by warm, temperate to warm, humid, subtropical climates (Timilsina et al., 2013). The four-state study area (Alabama, Florida, Georgia, and Mississippi) contains over 17 million hectares of privately owned forestland (Butler et al., 2020), which provides diverse ecosystem services to nearby communities including timber, wildlife habitat, and hunting grounds, and water and air purification, among others.

2.2. Online survey sample and design

To study public preferences for the insurance value of restored LLP forests, we utilized a representative sample of the general public in each of the four study states sourced from Qualtrics, an online panel provider. We used a BWC format (see Fig. 4) that combines best-worst scaling (BWS) and binary choice (BC) methods; i.e. one choice profile (list of programmatic features) with two tasks, a rankings exercise using 'best' and 'worst' choices, followed by a valuation method using choices on 'accept' or 'reject.' The BWC approach used in this study improves upon traditional ranking tasks by observing the extremes of the utility space which are more well-defined than preferences in the middle (Flynn et al., 2007). The BC task follows BWS to produce WTP estimates.

Choice experiments and related discrete choice methods are frequently used to value environmental changes, especially where data on market transactions are unavailable (Bliem et al., 2012; De Valck et al., 2014; Dias and Belcher 2015; Yoo et al., 2008). The survey was developed following the Tailored Design Method (Dillman et al., 2009) and refined through preliminary launches of the survey, along with detailed feedback from 10 forest researchers and experts in survey design. To improve data quality, those who completed the survey in under 6.7 min and those who responded incorrectly to an attention check (Fig. 1), were not included in the final sample.

Data collection took place between September and November 2019. Our survey consisted of four main sections: (1) Sociodemographic characteristics; (2) Background information on LLP restoration and information treatment; and (3) Preferences towards forest restoration programs (binary choice and best-worst scaling); (4) Attitudinal information. The survey elicited sociodemographic characteristics first as a means of targeting demographically representative panel samples. We targeted quotas for gender, age, race, and education based on the 2017 American Community Survey (ACS) 5-Year Estimates for each state (Table 2). Due to sampling difficulty, our final sample was heavily biased towards female respondents; to adjust for this and other differences, we use an iterative proportional fitting algorithm to calibrate the survey data to the census estimates in the final models. The next section introduced background information on LLP forests as well as the concept of risk management in forests through photographs and interactive questions. After informing respondents that LLP forests are less profitable to landowners but provide more benefits to the public, we included a treatment to examine the influence of framing the forest restoration program directly as "insurance" on WTP for risk reduction. Half of the respondents were randomly sorted into the treatment group and shown a short paragraph of text that states that choosing low-risk forests on the landscape can be thought of as insurance. The other half received control text (see Figs. 2 and 3 for a comparison of control and treatment groups).

In the next section, respondents were given a choice experiment exercise. The hybrid choice format in our study was answered in two steps (see Fig. 4): respondents first selected a 'best' and a 'worst' item from a list of features (best-worst scaling; BWS task), followed by 'accepting' or 'rejecting' the entire set of features presented as a single hypothetical forest management program (binary choice; BC task). As in most choice experiment surveys, participants were asked to consider several programs—each offering various combinations of features from Table 1; these were arranged using an experimental design (Marley and Louviere 2005; Soto et al., 2018; White et al., 2018). Programs consisted of four attributes: 1) Risk of forest damage once the program is in place; 2) quality of wildlife habitat; 3) public accessibility; and 4) cost of the program (per household per month; see Table 1). Each attribute varied in terms of its 'levels'. Our main attribute of interest is the risk of forest damage. Though in general, LLP ecosystems are more resilient to disturbances than pine plantations (Johnsen et al., 2009), their resilience depends in part on management activities that affect the structural diversity of forests (Sharma et al., 2020). Therefore we allow a range of possible risk of forest damage, and for interpretability, we defined forests as having low, moderate, or high risk of forest damage. We assume that positive WTP for low or moderate risks of forest damage is evidence of insurance value.

As WTP for an activity that improves resilience may be a function of both insurance value and other ecosystem services, we disentangled this by including separate benefits as attributes in the design. Good wildlife habitat, provided by most forest types, was defined as habitat suitable for generalist species, while excellent wildlife habitat was defined as habitat suitable for both generalist and specialist species (including some threatened or endangered species). Finally, the inclusion of a cost variable allowed for the estimation of WTP. SAS software version 9.4 was used to generate a D-optimal experimental design that consisted of 12 choice questions, each with varying levels of attributes. To reduce respondent fatigue, the questions were grouped into four blocks of three questions each, and the final design had a D-efficiency score of 97.3.

Finally, we hypothesized that the respondent's level of risk aversion, as well as environmental preferences, would be key determining factors in their WTP for environmental insurance. As such, attitudes towards risk-taking were elicited using a 10-point Likert scale question that asked about their willingness to take risks (adapted from Dohmen et al., 2011). Attitudes toward the environment were evaluated using the 15-item New Ecological Paradigm (NEP) scale (Dunlap et al., 2000), and a factor analysis was used to construct variables from the NEP scale used in the analysis. These factors are included as explanatory variables in the

> How familiar are you with commercial forestry? Please ignore the next sentence and select the number two regardless of how familiar you are. Please rate your answer on a scale of 1 to 10 where 1 is "Very unfamiliar" and 10 is "Very familiar".

Fig. 1. Attention check question used in our panel survey of public willingness to pay for the insurance value of restored longleaf pine forests.

Extreme weather events

Every year there is a chance that a hurricane, fire, or other extreme weather event will occur and damage forests in Florida. When that happens, the benefits the public receives from forests such as timber, wildlife, and recreation decrease. Extreme weather events that can harm forests are becoming more frequent and some types of forest are more vulnerable than others.

Fig. 2. Control group text used in our panel survey of public willingness to pay for the insurance value of restored longleaf pine forests.

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In particular, longleaf pine forests are less likely to be damaged by extreme weather events than other forests. Longleaf pine forests act as **insurance** for forest benefits, protecting against damage when there is an extreme event.

Fig. 3. Treatment group text used in our panel survey of public willingness to pay for the insurance value of restored longleaf pine forests.

STEP 1

Please indicate which feature is the **best** and which feature is the **worst**.
Longleaf Forest Restoration Program A has the following features…

Best Feature		Worst Feature
☐	There is low risk of forest damage	☐
☐	Provides excellent wildlife habitat	☐
☐	No leases are available to the public	☐
☐	Costs $10 per month for your household	☐

STEP 2

Would you vote for or against this program?

Vote for	Vote against	Would not vote
☐	☐	☐

Fig. 4. Example Best-Worst Choice Question from our panel survey of public willingness to pay for the insurance value of restored longleaf pine forests.

choice models to provide insight as to which environmental attitudes affect preferences and to what extent (Bryant and Yarhold 1995). Specific econometric methods describing our models are presented in Appendix A.

3. Results

The survey had a final sample of 1244 complete responses, roughly 300 each in Alabama, Florida, Georgia, and Mississippi. Complete responses exclude those who were removed due to overfilled demographic quotas, did not reside in one of the four states in our sample area and did not move past the first page of the survey. Of the 5564 respondents who were not filtered out using any of the previous three criteria, an additional 3913 (70%) were removed from the survey after failing our attention check, and 73 (1%) were excluded from the final sample for speeding. Finally, 335 respondents (6%) who did not fully complete the survey were excluded. The survey completion rate is 22.4%.

3.1. Factor analysis

A factor analysis was used to reduce the number of environmental attitude variables from 15 NEP items to five factors. The original NEP statements, along with the factors and associated factor loadings after orthogonal varimax rotation are presented in Table 3. Based on the factor loadings, we define the factors as follows:

1. Pro-environmental factor has high loadings on statements related to concern for the environment
2. Ingenuity factor has high loadings on statements regarding humans' ability to overcome crises and modify the environment

Table 1
Attributes and their levels used in our panel survey of public willingness to pay for the insurance value of restored longleaf pine forests.

Attribute	Description	Levels
Risk of forest damage	Qualitative risk of damage to forest resources given implementation of a given program	Low Moderate High
Access to forest	Amount of public accessibility to the private forests affected by a given program	No public access Hunting leases available Wildlife viewing leases available
Wildlife habitat	Quality of wildlife habitat in forests associated with a given program	Good Excellent
Cost	Fee per household per month for implementation of a given program	$1 $3 $7 $10

3. Anti-exemption factor has high loadings on humans being subject to the laws of nature and the consequences of interference
4. Limitations factor has high loadings on those statements regarding limited resources
5. Eco-centrist factor has positive loadings on plants and animals having rights to exist and negative loadings on humans being meant to rule over nature

3.2. Best-worst scaling model

Table 4 shows results of the best-worst scaling model using data from the first task of best-worst choice, in which respondents selected their most and least preferred attribute levels. The first column shows the results for a simple BWS model with attribute impact variables and level scale values. The second column displays the results for an alternate specification that interacts a binary treatment variable with the risk attributes, and the third column interacts risk preferences with the risk attributes.

All level scale values and attribute impact variables included in the model were significant at the 1% level. Risk, access, and cost all have

Table 2
Sample and Population Demographics results from our panel survey of public willingness to pay for the insurance value of restored longleaf pine forests.

Demographic Categories (%)	Alabama		Florida		Georgia		Mississippi	
	Sample (N = 310)	Census	Sample (N = 314)	Census	Sample (N = 315)	Census	Sample (N = 305)	Census
Gender								
Female	62.6	52.3	60.8	51.7	61.3	52.0	73.4	52.3
Male	37.4	47.7	38.9	48.3	37.8	48.0	25.9	47.7
Age								
18–34 Years	22.9	29.4	16.8	27.0	24.4	31.3	24.9	30.7
35–54 Years	30.0	33.2	30.0	32.2	27.0	36.1	30.5	33.4
55 Years or More	47.1	37.4	53.2	40.8	48.6	32.5	44.6	35.9
Race/Ethnicity								
Black	20.3	26.4	14.7	15.4	27.6	30.9	30.5	37.5
Hispanic	2.3	4.1	19.1	24.7	7.3	9.3	4.0	2.1
White	73.6	65.9	61.8	54.9	60.3	53.6	62.0	57.0
Others	3.9	3.6	4.5%	50.0	4.8	6.2	3.6	2.1
Education								
No Bachelor's Degree	69.4	77.6	67.5	73.7	71.4	72.9	68.5	80.7
Bachelor's Degree	30.7	22.4	32.5	26.3	28.6	27.1	31.5	19.3
Household Income								
Less than $25,000	26.8	28.1	22.9	23.5	27.0	23.4	30.8	31.2
$25,000 to $49,999	27.7	24.8	29.9	25.6	22.9	23.9	28.5	25.6
$50,000 to $99,999	27.1	28.7	29.9	30.0	28.9	29.8	25.9	27.9
$100,000 to $199,999	15.5	15.2	15.0	16.1	17.8	17.8	14.4	12.7
$200,000 or more	2.9	3.3	2.2	4.8	3.5	5.1	0.3	2.4

Note: Population demographics are based on the ACS 2017 5-year estimates for each state. A third gender category was available to be selected in the online sample.

Table 3
Factor analysis of New Ecological Paradigm (NEP) statements with varimax-rotated factor loadings.

	NEP1.	NEP2.	NEP3.	NEP4.	NEP5.
	Pro-environmental	Ingenuity	Anti-exemption	Limitations	Eco-centrist
We are approaching the limit of the number of people the earth can support	0.4000	−0.0319	0.0431	0.5415	0.0598
Humans have the right to modify the natural environment to suit their needs	−0.2615	0.4624	−0.1590	0.0320	−0.2583
When humans interfere with nature it often produces disastrous consequences	0.4417	−0.0783	0.4591	0.1201	0.0195
Human ingenuity will ensure that we do NOT make the earth unlivable	−0.1796	0.5198	0.0059	−0.0470	0.0590
Humans are severely abusing the environment	0.5426	−0.1065	0.3506	0.1238	0.0428
The earth has plenty of resources if we just learn how to develop them	−0.0379	0.4326	0.2603	−0.1951	0.0473
Plants and animals have as much right as humans to exist	0.4367	0.0037	0.3084	0.0922	0.3225
The balance of nature is strong enough to cope with the impacts of modern industrial nations	−0.4244	0.5305	−0.0283	−0.0426	−0.0466
The so-called ecological crisis facing humankind has been greatly exaggerated	−0.6404	0.3415	0.0239	−0.0688	−0.0618
The earth is like a spaceship with limited room and resources	0.3139	−0.0465	0.0886	0.5528	−0.0019
Humans were meant to rule over the rest of nature	−0.2549	0.3791	−0.0081	−0.1106	−0.3393
The balance of nature is very delicate and easily upset	0.5424	−0.0308	0.2950	0.2115	0.0745
Humans will eventually learn how nature works to be able to control it	0.0419	0.5406	−0.1112	0.0186	−0.0198
If things continue on their present course, we will soon experience a major ecological catastrophe	0.7548	−0.0955	0.1067	0.2435	0.0555
Despite our special abilities, humans are still subject to the laws of nature	0.2323	−0.0202	0.4229	0.0539	0.0620

Table 4
BWS results from our panel survey of public willingness to pay for the insurance value of restored longleaf pine forests.

	No Interactions	Treatment x Risk	Risk Preferences x Risk
Impact Variables			
Risk of forest damage	−1.757***	−1.876***	−1.735***
	(<0.001)	(<0.001)	(<0.001)
Access to forest	−1.708***	−1.824***	−1.709***
	(<0.001)	(<0.001)	(<0.001)
Cost per month	−2.229***	−2.368***	−2.230***
	(<0.001)	(<0.001)	(<0.001)
Level Scale Values			
Low risk of forest damage	1.331***	1.341***	1.273***
	(<0.001)	(<0.001)	(<0.001)
Moderate risk of forest damage	−0.125***	−0.082	−0.315***
	(0.006)	(0.198)	(0.007)
High risk of forest damage (e)	−1.206	−1.259	−0.958
	(na)	(na)	(na)
Good wildlife habitat (e)	−0.125	−0.155	−0.125
	(na)	(na)	(na)
Excellent wildlife habitat	0.125***	0.155***	0.125***
	(0.001)	(0.001)	(0.001)
No public access (e)	−0.161	−0.193	−0.162
	(na)	(na)	(na)
Hunting leases available	−0.182***	−0.144***	−0.181***
	(<0.001)	(0.005)	(<0.001)
Wildlife viewing leases available	0.343***	0.310***	0.343***
	(<0.001)	(<0.001)	(<0.001)
$1/month (e)	0.651	0.690	0.678
	(na)	(na)	(na)
$3/month	0.204***	0.310***	0.203***
	(<0.001)	(<0.001)	(<0.001)
$7/month	−0.344***	−0.403***	−0.344***
	(<0.001)	(<0.001)	(<0.001)
$10/month	−0.511***	−0.597***	−0.510***
	(<0.001)	(<0.001)	(<0.001)
Treatment x Risk impact		0.133	
		(0.287)	
Treatment x Low risk		0.129	
		(0.398)	
Treatment x Moderate risk		0.161	
		(0.261)	
Risk preferences x Risk impact			−0.004
			(0.809)
Risk preferences x Low risk			0.011
			(0.638)
Risk preferences x Moderate risk			0.034*
			(0.084)
Observations	44,784	30,132	44,784

Notes: The impact variable for Wildlife habitat was omitted from the model to serve as the reference for the remaining impact variables. Effects-coded level scale values are denoted by (e). Robust pval in parentheses ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

negative impact scores compared to wildlife, implying that quality of wildlife habitat provides the highest average utility to respondents across all its levels. As expected, respondents seemed to only prefer programs with low risk of forest damage and lower monthly costs. We allowed three possible scenarios for public access to forests, given that these forests would be in private lands: no public access, the availability of hunting leases for sale, and the availability of wildlife viewing leases. The level scale values for these indicate that respondents derive more utility from wildlife viewing leases, followed by hunting leases.

To further examine preferences for risk reduction in the BWS model, we included treatment status and risk preferences as covariate-attribute impact interactions and covariate-level scale interactions (Table 4; Columns 2 & 3). We first tested whether the insurance framing treatment influenced preferences for the risk variables. However, because some respondents may not have read the framing, in the Treatment x Risk model, we limited the sample to people who spent at least 24 s (equivalent to a reading speed of 250 words per minute) on the survey page with the treatment. None of the interaction terms between treatment and risk variables are significant, and a joint test of all three interaction terms is also insignificant. Interacting the Likert variable indicating a willingness to take risks in general with the risk impact and risk level scale values similarly does not explain variation in the model.

3.3. *Binary choice model*

A binary choice model was used to assess whether program features increase or decrease the likelihood of voting for a given forest restoration program (Table 5). We found that while both low and moderate risk programs increased likelihood of voting for the program, low risk of forest damage had a significantly greater effect; a test of parameter equality is significant at the 1% level. Excellent wildlife habitat was also highly valued by our respondents, as it significantly increased the probability of voting for a program ($p = 0.016$). However, public access as defined in the survey, availability of hunting leases, and availability of wildlife viewing leases, was not significant in the voting decision. We found that a higher willingness to take risks was associated with higher probabilities of voting for a restoration program ($p < 0.001$) even after prompting information on the benefits of risk reduction from forests.

Factors derived from the NEP items were included in the logit model. Preliminary analyses indicated that only three were influential in the choice and the other two were removed from the final model. Pro-environmentalism as well as ecocentrism (i.e., agreeing that plants and animals have as much right as humans to exist and that humans do not rule over nature) positively influenced voting for a forest restoration program. Liberal political beliefs also positively influenced voting for ($p = 0.027$), while being older as well as being female decreased likelihood of voting for a program (both were significant at the 5% level). The

Table 5
Logit model of voting results from our panel survey of public willingness to pay for the insurance value of restored longleaf pine forests.

	Full Sample	Careful Readers
Cost per month	−0.118***	−0.137***
	(<0.001)	(<0.001)
Low risk of forest damage	0.605***	0.657***
	(<0.001)	(<0.001)
Moderate risk of forest damage	0.224**	0.314***
	(0.020)	(0.009)
Excellent wildlife habitat	0.200**	0.167
	(0.016)	(0.110)
Hunting leases available	0.008	0.011
	(0.942)	(0.932)
Wildlife viewing leases available	0.020	0.043
	(0.839)	(0.723)
Treatment	−0.011	0.246
	(0.925)	(0.128)
How familiar are you with longleaf pine?	0.080***	0.096***
	(<0.001)	(<0.001)
Willingness to take risks	0.127***	0.105***
	(<0.001)	(0.001)
Pro-Environmental factor	0.364***	0.227***
	(<0.001)	(0.014)
Human Ingenuity factor	0.110	0.140
	(0.162)	(0.136)
Ecocentrism factor	0.353***	0.392***
	(0.005)	(0.006)
Affected by hurricane	−0.075	−0.011
	(0.565)	(0.945)
Age	−0.008**	−0.013***
	(0.022)	(0.001)
Female	−0.288**	−0.306**
	(0.022)	(0.040)
Liberal	0.299**	0.491***
	(0.027)	(0.004)
Observations	3031	2039
State fixed effects	Yes	Yes

Note: Respondents in the treatment group who took less than 24 s to read and consider the treatment are excluded from the Careful Readers sample. Robust pval in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

insurance treatment effect was insignificant in the likelihood of voting for the program both in the full sample, as well as when the sample was limited to careful readers, defined as those in the treatment group who took 24 s or more on that page, and all those in the control group.

3.4. Willingness to pay

For a program with a low risk of forest damage and excellent wildlife habitat, people were willing to pay on average \$11.49 per month, while average WTP for a program with a high risk of forest damage and good wildlife habitat was \$4.65 per month. In addition to average WTP for programs, we estimated the marginal WTP for attributes of restored longleaf forests, reported in Table 6. Marginal WTP is interpreted as the willingness to pay for a change in an attribute level from its base level. In the case of risk of forest damage, on average respondents were willing to pay \$5.14 for an improvement from high risk of forest damage to low risk and were willing to pay \$1.90 for an improvement from high risk of forest damage to moderate risk. Similarly, respondents were willing to pay on average \$1.70 for excellent wildlife habitat compared to good habitat.

4. Discussion

In this study we used a two-part choice modeling strategy, BWC, to estimate the value of reducing risks of forest damage to the U.S. public in Georgia, Florida, Alabama, and Mississippi. Results indicate that the public does value risk reduction but may not be willing to pay for programs with uncertain results. Both the BWS and BC models indicated that people valued low risk of forest damage much more greatly than moderate risk of forest damage, suggesting there may be some threshold after which benefits are perceived to be worth investing in. This finding is like those of Sánchez et al. (2019) who found that property owners are not willing to pay for fire risk reduction measures on their property if they believe they experience relatively low risk.

Our logit model estimated a monetary WTP for reductions in risk—on average—of \$5.14 per month or roughly \$62 per year to achieve low risk of forest damage compared to high risk of forest damage (Table 6). This estimate is comparable to a similar study on forest restoration in Flagstaff which found that residents were willing to pay around \$5 per month for restoration (Mueller, 2014). We also found that a greater willingness to take risks was associated with a higher probability of voting for a restoration program (Table 5) despite prompting information on the benefits of risk reduction from forests.

We also find evidence that respondents value co-benefits of risk reduction, such as higher quality wildlife habitat, separately to risk reduction itself (Tables 4 and 5). These results suggest that policies or restoration programs that promote diverse landscapes with goals of biodiversity preservation may be under-counting the co-benefits of success, namely, the value of resilience and the suite of ecosystem services that are also provided (Chazdon, 2008; Tyner and Boyer, 2020). Results of the BWS model show that "excellent wildlife habitat", defined as habitat that supports specialist species as well as generalist species, has a positive, highly significant influence on voting behavior (Table 5). We estimate that on average respondents are willing to pay \$1.70 per month for excellent wildlife habitat compared to good habitat. Results are more mixed regarding public access to restored forestland; the BWS models show that respondents derive more utility from wildlife viewing leases, followed by hunting leases (Table 4). However, neither form of access was significant in the voting decision, and neither was significant in terms of WTP compared to no access. Given the limitations on walking, hunting, or recreating on privately owned forestland in the U. S., the levels of the access attribute were framed as availability of leases for sale rather than free public access, and this likely drives the null result. We also examined the impact of describing the proposed policy as an insurance product, introducing language about insurance as a treatment for half of the respondents. We hypothesized that this treatment would lead to a higher valuation of risk reduction. However, even when limiting the sample to "careful" readers, the treatment had no significant impact on results. Indeed, Baumgärtner and Strunz (2014) discuss how concepts such as "insurance" or even "states of nature" (i.e., ecosystem structure, degradation, and restoration as applied in our study) are influenced by both objective and subjective characteristics related to "risk" and risk preferences by different stakeholders.

Table 6
Marginal willingness to pay for attributes of restored longleaf pine forests.

Attribute	Levels	Marginal WTP
Risk of forest damage	Low	\$5.14***
	Moderate	\$1.90**
Access to forest	Hunting leases available	\$0.06
	Wildlife viewing leases available	\$0.17
Wildlife habitat	Excellent	\$1.70**

Note: Confidence intervals were calculated using the delta method. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

We do note some limitations to our study. First, our approach using panel respondents resulted in a non-random sample of the study area population and preferences might not be fully representative of the general public. Nevertheless, they are a cost-effective way of reaching populations across a large geographic region. We corrected for differences that might have been driven by demographics by weighting observations according to the ACS estimates as outlined in our methods. Our survey instrument also incorporated photographs and interactive questions to provide a greater understanding of the link between restored ecosystems and reduced risk of damage to forests. It also provided a non-expert description of the specific benefits forests provide to the general public. Second, there has also been a frequent criticism of stated choice methods in that results suffer from hypothetical bias (Hensher 2010). When revealed preference methods are available, researchers may use those instead, however, in our case the good of interest is resilience which is not observable through direct behaviors. Empirical studies have suggested that hypothetical bias in stated preference studies can be mitigated through several techniques such as cheap talk and certainty scales; accordingly, we addressed this bias by using a 10-point certainty scale as suggested in Morrison and Brown (2009).

5. Conclusions

This study examined public preferences for forest restoration programs and specifically the value of increased ecosystem resilience in the form of reduced risk of damage to forests and a subsequent decrease in benefits to society. Our findings contribute to a growing body of evidence on the insurance value of ecosystem services by estimating positive and significant WTP for reduced risk. Therefore, results show that WTP for resilience is an additive component of total resilience value, as co-benefits such as wildlife habitat quality are estimated separately. We hope that studies such as ours can be used to better incorporate more nuanced concepts such as resilience, function, and insurance value when formulating policy instruments and programs related to landscape-level restoration initiatives and climate change mitigation and adaptation strategies.

This is one of the first studies to estimate the insurance value that the public places on forest restoration policies for increased socio-ecological resilience. However, we acknowledge the difficulty of communicating concepts such as insurance and resilience. Indeed, our BWS and binary choice model findings that people valued low risk of forest damage much more greatly than moderate risk of forest damage, could also have been influenced by the terminology used in the survey.

Our findings have direct implications regarding issues such as climate change, urbanization, and the increasing frequency and severity of recent mega-fires and their short to long-term cumulative effects on the provision of ecosystem services (Sánchez et al., 2019). Although this study addresses public preferences for resilience, and results do suggest that respondents value the resilience of ecosystem services, further research may help to better understand the influence of educating and communicating to the public the benefits of restoration and other specific management activities such as prescribed fire or fuel treatments to enhance the resilience of fire-prone ecosystems (e.g., long-leaf pine, ponderosa pine, chaparral shrublands) and their provision of context-specific benefits, and avoidance of costs (e.g., smoke emissions and property loss).

That said, this study contributes to an emerging body of socio-ecological systems literature that examines whether individuals conceptualize the insurance value of risk reduction and ecosystem services. Future research may compare insurance value findings against other relevant ecosystem services and restoration literature we present in our introduction. Similarly, research related to the relationship between the likelihood of success and willingness to pay for conservation and restoration programs in other types of ecosystems, policy environments, and geographic contexts may be of interest in the future.

Credit author statement

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Disclaimer

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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

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Appendix A

The two choice tasks are estimated separately: first, a paired conditional logit model is used to analyze the BWS task (e.g., Flynn et al., 2007; Flynn et al., 2008); and second, the binary choice of voting for or against the proposed forest restoration program as a whole is estimated using a logit model. Both models have the same theoretical grounding as discrete choice experiments, which have often been used to estimate the preferences for non-market ecosystem services (Smyth et al., 2009; Bliem et al., 2012); they are analyzed under the random utility maximization (RUM) framework (Louviere et al. 2000, 2015). Explanatory demographic and attitudinal variables are included directly in the binary logit models and indirectly in the conditional logit through models with interaction effects (Louviere et al. 2000, 2015).

Following Flynn et al. (2008), the BWS task is estimated using a paired conditional logit model. For each of the hypothetical programs presented, respondents selected a pair of attribute levels which represented the maximum difference in utility among all possible pairs of attribute levels. Given that each profile in our study consisted of four attribute levels, each respondent was confronted with a total of 12 possible combinations of best and worst choices per profile, one of which was selected. For an individual i, faced with a profile t, the difference in utility is denoted $BW_{it} = V_{ij} - V_{ik} + (\varepsilon_{ij} - \varepsilon_{ik})$. Assuming a linear utility function, and that $(\varepsilon_{ij} - \varepsilon_{ik})$ has an Extreme Value Type I distribution, the probability of choosing attribute levels j as best and k as worst, respectively, in a profile t, follows the conditional logit format:

$$P(x_{tj}, x_{tk} | \mathbf{x}_t) = \frac{\exp(\beta_j x_{tj} - \beta_k x_{tk})}{\sum_{\substack{m, m' \\ m \neq m'}} \exp(\beta_m x_{tm} - \beta_{m'} x_{tm'})} \tag{1}$$

When estimated empirically, this approach allows estimation of both attribute impact variables (a measure of the overall importance of an attribute; i.e. mean utility of an attribute across all its levels) and level scale values (the additional gain or loss in utility associated with a specific level of the attribute; i.e. deviations from mean utility) (Flynn et al., 2007). In our study, following Flynn et al. (2008), the empirical specification is as follows:

$$\begin{aligned} BW_{it} = {} & \beta_{Risk} Risk_t + \beta_{Access} Access_t + \beta_{Wildlife} Wildlife_t + \beta_{Cost} Cost_t \\ & + \beta_{RiskLo} D_{RiskLo,t} + \ldots + \beta_{RiskHi} D_{RiskHi,t} \\ & + \beta_{AccessNo} D_{AccessNo,t} + \ldots + \beta_{AccessWL} D_{AccessWL,t} \\ & + \beta_{WLGood} D_{WLGood,t} + \beta_{WLExcel} D_{WLExcel,t} \\ & + \beta_{Cost1} D_{Cost1,t} + \ldots + \beta_{Cost10} D_{Cost10,t} \end{aligned} \tag{2}$$

Where each attribute has an attribute impact variable and corresponding level scale values. To better understand the relationship between demographic factors that may be of interest to policymakers and the choices, we expand on the basic model by interacting the Likert-scale rankings for willingness to take risks with the impact and level scale values for risk of forest damage (e.g. Flynn et al., 2008; Soto et al., 2016). Similarly, we include interactions of the insurance treatment effect (an indicator variable for being in or out of the treated group) on risk of forest damage and political ideology on all attributes.

In the second choice task, respondents voted to accept or reject one entire profile of attributes. We estimate the probability of voting "yes" as a function of program attributes and individual characteristics. When the error term is *iid* Type I Extreme Value, the probability of observing a “yes” vote takes the logit form. The empirical model that individual *i* accepts a profile *t* is given by:

$$Vote_{it} = \beta_0 + \beta_{Risk}Risk_t + \beta_{Access}Access_t + \beta_{Wildlife}Wildlife_t + \beta_{Cost}Cost_t + \boldsymbol{\delta D}_i + \varepsilon_{it} \quad (3)$$

Where $\boldsymbol{D}_i$ are characteristics of the individual *i* such as age, gender, race, and political leanings. Risk, access, and wildlife are coded as categorical variables, while cost is a numeric variable. The insurance treatment variable was also included as an indicator variable in the logit models. To account for the panel nature of the repeated choice data, standard errors for all logit models are clustered at the individual level. Marginal willingness to pay for attribute *i* was calculated by the formula $WTP_i = -\frac{\beta_i}{\beta_{cost}}$ where β_i is the estimated coefficient on the attribute level of interest and β_{cost} is the estimated coefficient on the numeric cost attribute. We multiplied the estimated coefficients from the full sample model with mean values of significant demographics (familiarity with LLP, willingness to take risks Pro-environmental and Ecocentrism factors, age, gender, and liberal politics) and divided by β_{cost} to estimate an average WTP for programs as a whole.

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