doi:10.2489/jswc.2023.00131

Estimating landowners' willingness to accept payments for nature-based solutions in eastern North Carolina for flood hazard mitigation using the contingent valuation method

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Abstract: FloodWise is a pilot program that proposes nature-based solutions (NBS) for flood hazard mitigation (risk reduction) in eastern North Carolina to control stormwater runoff for brief periods of time. The program would provide financial incentives and technical assistance to rural landowners to adopt NBS on their properties. In this study, we assessed landowners' willingness to accept (WTA) payments for adopting NBS on their properties using a payment card contingent valuation method (CVM) via a mail survey. Payments for Ecosystem Services (PES) incentivize landowners to participate in conservation efforts, as well as provide additional opportunities for revenue. Factors such as income, age, contract term length, revenue lost from previous storm events, and size of farm operation influenced one's willingness to accept payments. The payment levels required for traditional farm conservation practices and NBS flood control practices were not significantly different, indicating that past program methods could help guide new FloodWise or similar NBS efforts. These results can help guide new NBS program development and funding deliberations in North Carolina, and perhaps other rural locations in the US Southeast.

Key words: contingent valuation—flood mitigation—nature-based solutions—payments for ecosystem services—willingness to accept

Natural hazards are unavoidable. Although human-induced climate changes are occurring, natural hazards such as hurricanes, tornadoes, and earthquakes are natural phenomena, and largely out of human control. However, disasters occur when we place people and property in harm's way. Disasters are a human construct (Peduzzi 2019; Tierney 2018; White 1974), and hazard mitigation practices can help reduce the chance of a disaster occurring or lessen the impacts of natural hazards. The US Federal Emergency Management Agency (FEMA) (2022) defines hazard mitigation as "any sustainable action that reduces or eliminates long-term risk to people and property from future disasters. Mitigation planning breaks the cycle of disaster damage, reconstruction, and repeated damage." Therefore, hazard mitigation techniques can be employed before or after disasters. Examples of common hazard mitigation strategies include improving nature-based solutions (NBS), updating building codes, policy and regulation planning, and routinely planning vulnerability and risk assessments (VRA) (FEMA 2022; Jackman and Beruvides 2013; Mileti and Gailus 2005). Hazard mitigation solicits an interdisciplinary approach by considering environmental, social, and economic conditions, and such efforts highly depend on technical expertise and analysis to understand hazard risks and vulnerabilities (Godschalk 2003; Pearce 2000).

Over time, hard-engineering approaches, or grey infrastructure ("grey" referring to the color of the concrete and materials that make up the structures), have been used as primary hazard mitigation approaches (Jones et al. 2012). However, such grey structural approaches as the construction of dams and seawalls have been deemed disruptive to natural environments, inappropriate for risk reduction, and unaffordable in the long term (Burby 1998; Burby et al. 1999).

NBS, also referred to as natural infrastructure, are an alternative to, or sometimes a complement to, grey infrastructure, and serve as an innovative infrastructure for hazard mitigation. NBS have recently grown in popularity among academic, governmental, private, and nonprofit sectors across the globe (AECOM 2021; FEMA 2020a; South Florida Water Management Districts 2018; The

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Received September 26, 2022; Revised March 14, 2023; Accepted July 13, 2023.

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Journal of Soil and Water Conservation 78(6):500-514 www.swcs.org

Nature Conservancy 2021; USACE 2021). NBS work with and enhance natural systems to address resilience and mitigate hazardous impacts (Hobbie and Grimm 2020; IUCN 2022), and have proven to support adaptation by providing improved water and air quality, reducing flooding, sequestrating carbon (C), enhancing wildlife habitat, providing urban cooling, and contributing to urban resilience (Chausson et al. 2020; Staddon et al. 2018). Although the concept is growing in popularity, deploying such projects has been limited on the ground (Chausson et al. 2020). Challenges for mainstreaming NBS include the lack of design standards, finance ability, regulatory frameworks, justice issues, and ways to scale up potential innovations (Zuniga-Teran et al. 2019).

Many rural areas experience difficulties in the face of natural hazards and disaster vulnerability (Clar 2019; Horney et al. 2016; Jurjonas and Seekamp 2018; Sadri et al. 2018). Over time, rural communities have not been equipped to establish and implement hazard mitigation plans or prepare for disasters because of social vulnerabilities related to limited resources, geographic isolation, higher poverty rates, or an aging population base (Cutter et al. 2003; Flora and Flora 1992; Glasgow 2000; Saenz and Peacock 2006).

We focused our research scope on leveraging NBS for flood mitigation in rural areas as there is a growing body of literature that concludes that NBS can reduce flooding downstream by storing or detaining water temporarily (Cutter et al. 2003; Collentine and Futter 2018; Hovis et al. 2021; IUCN 2022; Nicholson et al. 2020; Turkelboom et al. 2021). We also recognize that the current hazard mitigation literature emphasizes heavily on urban resilience, while rural resilience is understudied, even though rural and urban areas are inter-connected and are part of the same watershed. Mitigation strategies implemented in rural areas are likely to enhance urban resilience downstream. Urban areas are also more likely to have the resources and capacity to adapt to climate changes, unlike rural areas (Jurjonas and Seekamp 2018).

Our research is important for advancing rural resilience and research and leveraging local communities and landowners to assist in the advancement of rural resilience. Rural regions contain natural resource-dependent economies like farming and forestry that are vulnerable to many natural hazards (Jurjonas and Seekamp 2018), and support other rural and urban populations.

In this research, we direct our attention to eastern North Carolina where the communities largely consist of lower socioeconomic status, rural and agricultural residents, high unemployment rates, and older populations (Jurjonas and Seekamp 2018; Scharer 2001). These social vulnerabilities increasingly influence economic losses, injuries, and fatalities from natural hazards (Cutter et al. 2003). Wealthier communities can recover from losses more quickly (Cutter et al. 2003, 2000), and rural residents are more vulnerable because of lower incomes and limited locally based economies (Cutter et al. 2003, 2000). Decreasing flood hazard vulnerability in this region is a significant challenge.

Payments for ecosystem services (PES) are commonly used to provide financial incentives for landowners to adopt certain conservation practices (Costanza et al. 1997; Fisher et al. 2010). In this study, we examine whether PES will encourage NBS establishment and management for flood mitigation in rural, eastern North Carolina. Numerous studies assess the benefits of NBS for flood mitigation (Dang et al. 2021; Turkelboom et al. 2021), and many assess landowners' participation in PES programs. For example, some studies recognize the importance of participating in PES for C offsets (Soto et al. 2016), wildlife habitat (Kreye et al. 2017, 2018), water quality (Nyongesa et al. 2016), for planting forests (Kang et al. 2019), or restoring wetlands (Wei et al. 2016). However, less studied are the perceptions of and willingness to adopt NBS for flood reduction and storage on rural, agricultural landscapes via participating in a flood mitigation cost-share program.

Previous research on PES shows that landowners are generally accepting of conservation cost-share programs (Kabii and Horwitz 2006; Lupek 2014), and a large body of literature reviews landowners' specific preferences for conservation cost-share programs (Chizmar et al. 2021; Cubbage et al. 2003; Pattanayak et al. 2003). Jacobson et al. (2009) discussed that landowners prefer state incentive programs when meeting conservation objectives. Royer and Moulton (1987) found that landowners are more likely to adopt conservation practices like reforestation if they have familiarity with cost-share programs.

In addition, one reason that landowners may not choose to participate in a cost-share program is their lack of trust in the hosting organization or governmental assistance (Cross et al. 2011; Lachapelle et al. 2003; Lupek 2014). Kreye et al. (2018) found that family forest landowners in Florida were less trusting of government assistance, and De Vries and Frasier (2012) found distrust among community members with hazard mitigation grant funding, especially with approaches like floodplain buyouts. Another factor that may hinder landowners' views on conservation programs is a lack of knowledge or experience of the program or the technical aspects of adopting the practices (Pattanayak et al. 2003).

Our study aimed to understand the rural and agricultural landowner motives and the characteristics that influence their participation in a potential flood mitigation program in eastern North Carolina. We use a payment card contingent valuation method (CVM) via a mail survey to estimate the landowner's willingness to accept (WTA) the set payment (i.e., PES) price point for adopting NBS on their properties. In brief, the survey found that about 70% of landowners in Robeson County, North Carolina, were willing to participate in an NBS program similar to a farm bill conservation program. Landowners indicated they would require an average payment of approximately US\$132 ac^{-1} yr^{-1} (US\$362 ha^{-1} y^{-1}) (median of US\$130 ac^{-1} yr^{-1} [US\$321 ha^{-1} y^{-1}]) for 10 years to adopt the NBS flood control practices and US\$128 ac^{-1} yr^{-1} (US\$316 ha^{-1} y^{-1}) (median of US\$120 ac^{-1} yr^{-1} [US\$296 ha^{-1} y^{-1}]) for the common farm practices on their properties.

Theoretical Framework: Protection Motivation Theory. We draw on Protection Motivation Theory (PMT) to assess landowners' WTA payments and participate in a potential flood mitigation program. Although originating in the health discipline (Rogers 1983; Rogers and Prentice-Dunn 1997), PMT has more recently appeared in environmental disaster management, natural hazards, and climate change research because it involves any sort of threat and response carried out by an individual (Floyd et al. 2006; Grothmann and Patt 2005; Luu et al. 2019).

PMT suggests that individuals' perceptive threat and outcome are categorized in two appraisals: risk appraisal and coping appraisal. Risk appraisal consists of two factors: perceived future threats and perceived future consequences (Bubeck et al. 2017). Coping appraisal deals with the ability to deal with

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flooding and reduce its impacts (Truelove et al. 2015). A coping appraisal consists of three variables: the perceived effectiveness, the perceived ability to implement, and the perceived cost associated with the measure (Bubeck et al. 2017).

Both risk and coping appraisals influence protection motivation. Therefore, for our study, we hypothesize that risk and coping appraisal will affect landowners' WTA payments in a flood mitigation program. Hence, we adapted various PMT constructs in a landowner survey, such as landowners' concern about future flooding, their revenue losses due to flooding, water quality, knowledge of NBS, previous flood experience, and their personal responsibility to reduce flooding downstream.

Materials and Methods

We measured rural landowners' willingness to participate in NBS in eastern North Carolina by developing a survey to assess their WTA and implement various NBS practices on their farm and forest lands. The questionnaire was based on literature reviews of similar state and federal farm conservation programs, similar PES and NBS studies, and linkages to farm owner characteristics.

Site Context: Rural, Eastern North Carolina and The FloodWise Program. Eastern North Carolina, also referred to as the North Carolina Coastal Plain (figure 1), is one of the most vulnerable states in the nation for direct hurricane strikes (Ready NC 2022). Although devastated by intense hurricane wind speeds, the state's main damage and harm are caused by vast amounts of flooding from the heavy rainfall. In particular, riverine flooding impairs the region due to the rural, flat, and low-lying topography (Hovis et al. 2021).

Robeson County, North Carolina, is located in the North Carolina Coastal Plain and reported to have a population of approximately 130,600 in 2019 (figure 2) (US Census Bureau 2019). Many of Robeson County communities consist of rural, low-income residents. In 2016, approximately 33% of residents lived in poverty, compared to approximately 17% within the state (US Census Bureau 2020; Willets 2016). The county's primary economic driver is the agricultural sector (Mazzocchi 2006), and is one of the six top agriculture-producing counties in the state (Jacobs 2018).

Figure 1

Areas located east of the Atlantic Coastal Plain in North Carolina are frequently referred to as "eastern North Carolina" or "North Carolina Coastal Plain" (Baldwin et al. 2022).

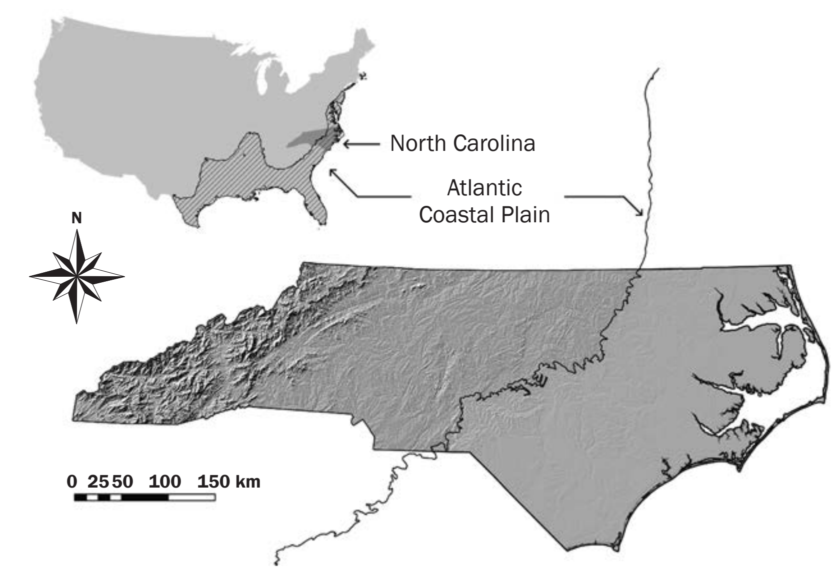
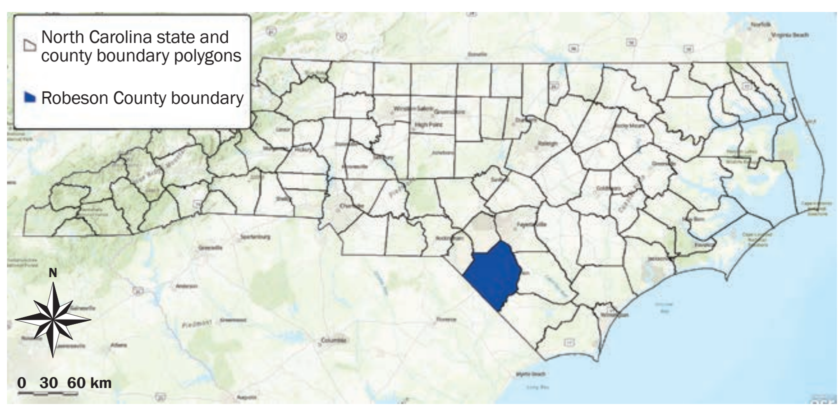


Figure 2

Robeson County, North Carolina (Baldwin et al. 2022).



In recent years, Robeson County has been damaged by severe impacts from multiple coastal storms, including Hurricane Fran (1996), Hurricane Floyd (1999), Hurricane Matthew (2016), Hurricane Florence (2018), and Hurricane Dorian (2019), which caused excessive riverine flooding of the Lumber River. The aftermath of the hazard is painful for many. Residents are affected years after these storms have abated. For example, tarps still act as some residents' roofs who do not have the means for repairs (Barnes 2019). Agricultural communities have suffered substantial revenue losses from crop yields and livestock production (Strickland 2018).

Researchers at North Carolina State University's (NCSU) College of Natural Resources and College of Design, and practitioners with the NC Foundation of Soil and Water Conservation, NC Association of Soil and Water Conservation Districts, Environmental Defense Fund, and North Carolina Farm Bureau Federation have pioneered a proposed program in the area called "FloodWise." The proposed program would assist landowners and farmers in adopting NBS on their properties by providing

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educational tools, technical assistance, and financial incentives. The FloodWise program could be funded under a variety of farm bill authorized programs, as well as current state-funded programs like the North Carolina Agricultural Cost-Share Program (NCACSP) and the North Carolina Agricultural Water Resources Assistance (NC AgWRAP). However, if the state does not have the funding or technical capacity to support the program through existing agriculture-related programs, FloodWise could be a fixed or perpetually funded project supported by federal emergency programs such as the Hazard Mitigation Grant Program (HMGP), Flood Mitigation Assistance (FMA), or Building Resilient Infrastructure and Communities (BRIC). Some of these programs, like BRIC, have recognized the effectiveness of using NBS for hazard mitigation and incentivized communities to adopt such approaches (FEMA 2020b). However, federal funding can be hard to obtain in low-capacity and small towns (Smith et al. 2013). If the pilot program succeeds in North Carolina, it could be considered for implementation in other states with similar rural topography, demographic and geographical settings, and flooding issues.

Many farm conservation practices and some NBS, such as wetland or stream restoration, are already considered best management practices (BMPs) under either the NCACSP or AgWRAP. These programs cover 75% of establishment costs; the remaining costs are left up to the private landowners, limiting and possibly preventing participation by those with limited funding. In many federal programs, nonfederal match is an ongoing challenge for many small and rural communities who do not have the resources or capacity to cover the remaining costs (Smith et al. 2013).

In order to attract adoption in the new NBS practices, we believe that state or federal programs would need to pay the full establishment and maintenance costs. This is different than traditional farm programs, where farmers can cover part of their establishment costs through their own labor and bid the extra costs for maintenance or foregone income into their annual payments received for the term of the conservation practice. The justification here is that NBS solutions are expensive to establish and may have exceptional maintenance costs exceeding farm conservation practices (Hovis et al. 2022). These costs for NBS would be larger than for traditional conservation programs, but theoretically they would be much cheaper than the costs of major downstream flooding.

Thus, the FloodWise program would cover the remaining 25% of the establishment costs—more than traditional farm conservation programs—as well as give annual payments for management and periodic maintenance costs so that landowners break even financially. We stated this assumption in the questionnaire in our case descriptions.

Building on the public policy conservation incentives approach and prior literature assessing its success, this study evaluates the factors that influence landowners' WTA payments to participate and install a NBS practice and identify the payment price required for participation. Hovis et al. (2021) identified 10 NBS practices, separated into two general categories: common farm practices and NBS structural practices (table 1). Some of these practices are common farming approaches that many farmers are familiar with, but they may not know the benefits for flood reduction. Other practices that are more structural in nature such as wetland and stream restoration have been heavily researched and proven to slow down water from storms. Hovis et al. (2021) identified these practices specifically for rural landscapes like eastern North Carolina as the most promising for flood risk reduction.

Survey Design. The main body of the survey was separated into four sections: questions regarding (1) landowner experience with flooding, (2) knowledge of conservation practices, (3) program preferences, and (4) landowner demographics. The first section of the survey asked questions regarding the landowner's property and experience with flooding. The questions sought information about landowners' concerns about future flooding; impacts on crop, tree, or livestock yields, and water quality; and the use of previous or current flood reduction tactics. The second section focused on landowners' understanding of the various farm conservation and NBS practices, their participation in previous conservation programs, and their attitudes regarding NBS effectiveness and implementation feasibility. The third section reviewed the landowner's WTA farm conservation and NBS payments. The fourth section included questions regarding participants' socio-economic status and demographics, such as total household income, education, gender, age, ethnicity, and race, which could be used to identify factors

Table 1
Most promising nature-based solutions (NBS) for eastern North Carolina (drawn from Hovis et al. [2021]).

Categories	Ten best NBS and descriptions
Common farm practices	
Cover crops and no-till	(1) Including legume and nonlegume cover crops on fields throughout the year
Hardpan breakup	(2) Breaking up compacted hardpan layers to allow for soil water infiltration
Afforestation	Planting (3) bottomland hardwood or (4) pine forest species
Agroforestry	(5) Combining mixed pine trees and pasture fields
Structural NBS practices	
Wetland restoration	Restoring natural wetlands along streams or at a lower elevation with (6) flood control wetlands with grasses, sedges, and water control structures, or (7) bottomland hardwood forested wetland banks on prior converted agriculture land
Stream restoration	(8) Restoring previously straightened streams to the original configuration
Water farming	(9) Creating catchment areas using dry dams and berms to store water during flooding
Land drainage features	(10) Installing berms and other flow controls to ditches, terraces, and drain tile systems.

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that influence the WTA estimates (Wang et al. 2016). The survey booklet is shown in Appendix A (supplemental material).

Data Collection. We followed Dillman's (1978) Total Design Method by sending a questionnaire booklet in the mail with a return paid postage envelope to a representative sampling of Robeson County landowners. We obtained participant information from an online public GIS database with landowner mailing addresses and land acreage. We reduced the list to meet the following criteria: cropland or open land of at least 20 ac (~8 ha), excluding high-value crops and basic infrastructure because we assumed NBS to be most achievable on larger tracts. These criteria reduced the list to a population of 2,822 participants. Due to limited funds, we could not survey everyone on the population list, so we performed a power analysis one sample *t*-test in SPSS to determine the estimated sample size for a power of 0.8 or greater, assuming a 25% response rate. Based on these results, we selected a random sample of 1,200 in hopes of achieving this power.

We began the survey process by sending each landowner notice of the research purpose and that a survey would be sent next. The next week we sent the subsequent survey. Following Dillman's approach, we sent postcard reminders twice and then a replacement survey. All steps were mailed to the same 1,200 mailing addresses. To encourage replies and protect the confidentiality of participants, the surveys were anonymous and had no unique numbers or other means of tracking nor any phone numbers, so we could not contact landowners for follow-up or nonresponse bias samples. To improve coverage and response, we adopted Dillman's (2011, 2014) Mixed-Method Approach using different modes. We included an electronic link and QR code if participants instead preferred to complete the survey online. Overall, we received a 16% response rate, receiving a power of 0.64, meaning there is a 36% chance or less of making a Type II error. This research was approved in accordance with the NCSU Office of IRB policies (IRB #23851).

Contingent Valuation Method. The CVM is an economic technique commonly used to measure the value of nonmarket environmental goods and services (Börger 2012; Goldar and Misra 2001). CVM uses hypothetical scenarios that resemble real market situations via a survey questionnaire. It has been widely used to set appropriate PES by assessing WTA financial incentives for participation in conservation efforts (Boyle 2003; Chandara et al. 2019). WTA is the minimum payment amount that participants will choose until some sort of change affects them (Börger 2012; Hanemann 1991; Shogren and Hayes 1997). We used CVM to determine landowners' minimum WTA compensation to adopt NBS on their properties via participating in the proposed FloodWise program.

To determine landowners' minimum payment that they are WTA, we utilized the payment card (PC) approach, one of several CVM approaches. The PC and dichotomous choice (DC) approaches are the most commonly used approaches in the literature (Zhao et al. 2013) and are most recommended by economists (Bateman et al. 2002; Pearce and Ozdemiroglu 2002). However, many scholars suggest that the PC approach is more robust, results in more conservative amounts, increases efficiency, and reduces biases compared to the DC approach (Blaine et al. 2005; Drichoutis et al. 2016; Ghanie et al. 2020; Kerr 2001; Ready et al. 2001; Reaves et al. 1999). The PC approach provides continuous values compared to the DC approach, which offers a single binary choice format. The PC approach thus also can be used with a smaller population and sample size, since it requires far fewer surveys than only having one payment choice per survey.

In a PC approach, participants are asked to choose one value that best represents their minimum WTA values (Drichoutis et al. 2016; Venkatachalam 2004). Therefore, we gave participants PC options ranging by tens from US\$40 to US\$190 ac^{-1} yr^{-1} (US\$99 to US\$469 ha^{-1} y^{-1}), containing comparable figures to similar farm conservation programs and the costs of implementing NBS in the study area that we estimated previously using discounted cash flow and capital budgeting approaches (Hovis et al. 2021).

We recognize that giving the participants the various PC options can lead to a hypothetical bias in the participant's selection of WTA amount, possibly jeopardizing the method's validity (Ajzen et al. 2004; Hoehn and Swanson 1988; Mitchell and Carson 1989). While there is a theoretical tradeoff, the PC approach was the only practical approach for our small landowner population in one county, and better than an insufficient returned survey size using a DC approach. Furthermore, the typical range for farm conservation program payments was probably already well known by most rural farm landowners in most states, so the PC ranges we used were good approximations for opening bids for both farm conservation and more structural NBS type of programs.

The CVM-PC questions that we included in our questionnaire were the following: (1) "If you enrolled in a common farm conservation practices program to reduce floods, assume you would get paid at similar rates for existing conservation programs. What is the minimum payment per acre per year you would accept to participate in the program?" and (2) "If you enrolled in a FloodWise program to reduce floods, assuming you received 100% of the establishment costs, annual payments for keeping practices for the contract terms, and payment for crop losses, what is the minimum payment amount per acre per year you would accept to participate in a FloodWise NBS program?" In addition, we asked questions regarding preferred cost-share rates for the establishment of practices and contract term lengths. In all questions, we gave the option "none" if participants wished not to participate. We coded 1 as "yes" if participants selected a payment amount and a 0 if they chose "None. I would not participate."

Research Questions. The overall research questions of our study included the following:

1. What is the average amount that participants are WTA for farm payments?
2. What is the average amount that participants are WTA for structural NBS payments?
3. What determinants influence landowners' WTA farm payments and amount?
4. What determinants influence landowners' WTA structural NBS payments and amount?

Data Analysis. We used a binary logistic regression to determine the effect size of the independent variables on the dependent variables and rank the relative importance of the independent variables (Garson 2016). The dependent variables (WTA_{Farm} and WTA_{NBS}) are binary—either the participants are WTA (1 = yes) or are not WTA (0 = no) payments. A forced dichotomous dependent variable for the models was used in similar WTA studies (Jayalath et al. 2021; Soto et al. 2016; Villanueva et al. 2017).

Theoretically, a landowner's WTA payments for adoption farm practices (WTA_{Farm}) or NBS practices (WTA_{NBS}) could be

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related to their productive land acreage (*Total_Ac_Oper*), type of land management (Manage_Land), personal experiences with flooding (*Flood_Times*), concerns of future risk (*Worry_flood* and *Worry_Yields*), preferences in a potential cost-share program such as contract term length (*Farm_Contract_Term* and *NBS_Contract_Term*), and social demographics like income status (*Income*) and age (*Age*). Appendix B displays the coded variable names and their descriptions used in the models, and the expected relationship with the dependent variables.

We examined various logistic regression models to estimate the relationships between WTA payments for conventional farm conservation practices and structural NBS. Logit Model 1 included the WTA payments for the farm common practices as the dependent variable (WTA_{Farm}), and Logit Model 2 included the WTA payments for the structural NBS as the dependent variable (WTA_{NBS}).

We also estimated a multinomial logistic regression model to provide more information on the characteristics of the participants and their WTA. The forced dichotomy of the dependent variables in the standard logit models may lead to some loss of information, and we can refer to the multinomial logit model to account for a landowner's different characteristics and to whether they are willing to accept certain ranges of payments based on those differences. The multinomial logistic regression is specified where $WTA_{Payment}$ represents the dependent variable of eight payment categories, ranging by tens from US\$40 ac^{-1} yr^{-1} to US\$190 ac^{-1} yr^{-1} (US\$99 to US\$469 ha^{-1} y^{-1}), β_0 is the estimated constant, β_1 through β_7 are the independent variables' coefficients, and unique code (e.g., *Manage_Land*) are the independent variables. The list of these variables and their descriptions are provided in Appendix B. Logit Model 1 is displayed here as equation 1:

$$\begin{aligned} WTA_{Farm} &= \beta_0 + \beta_1 Manage\_Land \\ &+ \beta_2 Total\_Ac\_Oper + \beta_3 Flood\_Times \\ &+ \beta_4 Worry\_flood + \beta_5 Farm\_Contract\_Term \\ &+ \beta_6 Income + \beta_7 Age, \end{aligned} \tag{1}$$

where WTA_{Farm} is the dependent variable; β_0 is the estimated constant, which reflects the logit of the dependent variable when the independent variables are evaluated at 0; β_1 through β_7 are the independent variables' coefficient; and unique code (e.g., *Manage_Land*) are the independent variables. Logit Model 2 is displayed here as equation 2:

$$\begin{aligned} WTA_{NBS} &= \beta_0 + \beta_1 Manage\_Land \\ &+ \beta_2 Flood\_Times + \beta_3 Revenue\_Loss \\ &+ \beta_4 Worry\_flood + \beta_5 Worry\_Yields \\ &+ \beta_6 NBS\_Contract\_Term + \beta_7 Age, \end{aligned} \tag{2}$$

where WTA_{NBS} is the dependent variable; β_0 is the estimated constant, which reflects the logit of the dependent variable when the independent variables are evaluated at 0; β_1 through β_7 are the independent variables' coefficient; and unique code (e.g., *Manage_Land*) are the independent variables.

We also created a new binary dependent variable, *Combined_WTA*, which was included if survey respondents were both WTA farm payments (*WTA_farm*) and NBS payments (*WTA_NBS*). If participants stated they were only WTA one type of payment and not the other, we assigned them "0," which indicated they were not overall WTA. Combined Logit Model is displayed here as equation 3:

$$\begin{aligned} WTA_{Combined} &= \beta_0 + \beta_1 Manage\_Land \\ &+ \beta_2 Total\_Ac\_Oper + \beta_3 Flood\_Times \\ &+ \beta_4 Revenue\_Loss + \beta_5 Worry\_flood \\ &+ \beta_6 Income + \beta_7 Age, \end{aligned} \tag{3}$$

where $WTA_{Combined}$ is the dependent variable; β_0 is the estimated constant, which reflects the logit of the dependent variable when the independent variables are evaluated at 0; β_1 through β_7 are the independent variables' coefficient; and unique code (e.g., *Manage_Land*) are the independent variables.

Results and Discussion

Descriptive Statistics. Of 1,200 mailed questionnaires, 206 were returned, and 101 were fully completed. The study sample consisted of 44 women and 121 men with a total response to that question of 161 persons (N = 161). The largest category (n = 91) reported that they were between the ages of 61 and 75 years and the second highest category (n = 38) reported to be 76 years or older (N = 165). Approximately 79% of the sample were White, 18% Indigenous or Native American, and 3% African American (N = 162). The majority annual household income reported greater than US\$150,000 (n = 31) and between US\$100,000 and US\$149,999 (n = 31).

This sample was a reasonable representation of the overall population, which were Robeson County landowners. Again, our sample does not reflect all residents in Robeson County, but only those individuals who own land of 20 ac (~8 ha) or more. Our sample consisted of approximately 25% women and 75% men, which does mirror the data from the 2017 North Carolina Agriculture Census, which reported approximately 28% women and 72% men of the total agricultural producers in Robeson County. The Census also reported that 5% were under the age of 34 years old, 58% were between 35 and 64, and 37% were over the age of 65 years. Similarly, our sample contained approximately 55% of landowners between the ages of 61 and 70 years, roughly 23% over the age of 71, and 4% under the age of 45. Additionally, our sample was similar to the overall population, with most landowners identifying as White and the second highest group identifying as Native American. The Census reported 56% White landowners, 5% African American, 36% Native American, and 1% Asian (USDA NASS 2017). Our sample did not have Asian landowner representation, as well as a slightly lower Native American representation. We surmise that this could be because we included only landowners with property equal to or greater than 20 ac (8 ha).

Of the relevant respondents (N = 196), 99% stated they were landowners in the county. Out of those landowners, 34% manage their own land and 64% (n = 198) reported they do not manage their own land—many of them lease out their land. The average number of acres the landowners owned was 292 (~118 ha), with an average of 147 ac (~59 ha) of cropland, 127 ac (~51 ha) of forest land, and 12 ac (~5 ha) of pasture or grassland (table 2). Approximately 59% of the respondents (n = 104) live on their property or within 5 mi (~8 km) of it, 20% (n = 35) live within 50 mi (~80 km), 16% (n = 29) live outside of 50 but within the state, and some (n = 8) are located out of the state. Approximately 70% of landowners (n = 135) reported owning their land for 40 years or more.

Many of our survey participants experienced major flooding from Hurricane Florence in 2016 (58%) and Hurricane Matthew in 2018 (60%). Excluding these two major storm events, survey respondents reported that they lose a mean of 11% of rev-

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Table 2
Average acres and type of land owned by survey respondents, Robeson County, North Carolina.

Land type	Average acres owned (ha)	Average acres operated (ha)
Total	292 (118)	174 (70)
Cropland	147 (59)	137 (55)
Forest land	127 (51)	39 (16)
Pastureland	12 (5)	5 (2)

enues due to flooding each year. Again, this revenue loss percentage only depicts flooding that occurs after "normal" heavy rain events; it is not including the most recent devastating storms in 2016 and 2018.

Additionally, 55% of respondents stated that they are concerned about future flooding on their properties, and 64% responded that they worry that future flooding will harm their crop, tree, or livestock yields. Most of the respondents (68%) also indicated that they are concerned that flooding may harm their local water quality.

We asked several questions regarding landowners' perceptions and concerns about future flooding on their properties. We measured variables with a rising Likert scale of 1 (strongly disagree) through 5 (strongly agree). Participants' concern of future flooding damaging their agriculture or forest yields was a median of 4 (agree), and their concern of flooding impacting water quality was a median of 3 (have no opinion). Fifty-eight percent stated they already incorporate some sort of flood reduction practice on their properties (agree and strongly agree). For instance, 11% of participants stated they incorporate tree planting and forestry practices, 15% have underground tiling, 53% have built or enhanced ditches or canals, and 21% plant cover crops. Fifty percent said they believe they are responsible for reducing flooding on their properties and preventing flooding downstream (agree and strongly agree).

Several survey questions asked participants' opinions about a potential FloodWise cost-share program. Approximately 60% stated they would require payments (agree and strongly agree) to establish NBS on their properties. Sixty-three percent would require technical help to develop and maintain NBS on their properties (agree and strongly agree). Eighteen percent believed NBS was too costly to implement (agree and strongly agree), 16% said NBS was too time-consuming and would take away from other farm activities (agree and strongly agree), and 59% stated they would require a payment from crop or forest losses due to flooding (agree and strongly agree).

Other questions included landowners' program preferences. We asked what contract term length they would accept if they were to implement common farm practices. The responses range from a 5-year contract term with annual payments to more than 30 years. The average survey response was a 10-year contract with annual payments to adopt common farm practices. We asked the same question for structural NBS, including the same response choices. The average contract term for structural NBS was also a 10-year contract with annual payments. Our survey results indicated that only 20% of the respondents had participated in a previous farm cost-share program.

Next, we asked what cost-share rate participants would require to establish common farm practices. The average rate was 53% for those who stated they would participate in typical farm conservation practices. We did not ask this for NBS practices, due to the assumption explained previously that they would require 100% coverage of establishment and periodic maintenance costs.

Most participants (n = 105) stated they would be WTA a payment to adopt common farm practices that may reduce flooding (72%), such as planting cover crops, breaking up hardpan layers, agroforestry, and planting pine and bottomland hardwood trees, while the remaining (n = 41) would not be WTA farm practice payments. The average required farm payment amount was approximately US\$128 ac^{-1} yr^{-1} (US\$316 ha^{-1} y^{-1}). In addition, many respondents (n = 100) would be WTA structural NBS payments (69%), such as water farming or flood-control wetland practices, while the remaining who answered (n = 45) would not. The average structural NBS payment amount was US\$132 ac^{-1} yr^{-1} (US\$362 ha^{-1} y^{-1}). Appendix C shows a full list of descriptive statistics.

Willingness to Accept Farm versus Nature-Based Solutions Payment T-Test. As noted, landowners were WTA an average payment for common farm practices of approximately US\$128 ac^{-1} yr^{-1} (US\$316 ha^{-1} y^{-1}) (a median of US\$120 ac^{-1} yr^{-1} [US\$296 ha^{-1} y^{-1}]), and US\$132 ac^{-1} yr^{-1} (US\$362 ha^{-1} y^{-1}) (a median of US\$130 ac^{-1} yr^{-1} [US\$321 ha^{-1} y^{-1}]) for the NBS. We performed a paired sample t-test analysis to compare the WTA farm conservation practice payment amount was statistically different from the WTA structural NBS payment amount (table 3). We found that they were not significantly different (t = 0.56).

Logistic Models of Willingness to Accept Payments. Table 4 summarizes the results

Table 3
T-test results of farm versus nature-based solutions (NBS) practice willingness to accept (WTA) payments.

Test results	$Payment_{Farm}$	$Payment_{NBS}$
Mean (US\$ ac^{-1} yr^{-1}) (US\$ ha^{-1} y^{-1})	128.21 (316.68)	131.98 (125.99)
Median (US\$ ac^{-1} yr^{-1}) (US\$ ha^{-1} y^{-1})	120 (296)	130 (321)
Variance	2,134.85	2,136.04
Observations	106	101
Pooled variance	2,135.43	
Hypothesized mean difference	0	
df	205	
t Stat	−0.587	
$P(T <= t)$ one-tail	0.279	
t Critical one-tail	1.652	
$P(T <= t)$ two-tail	0.558	
t Critical two-tail	1.972	

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Table 4

Logit Model 1, willingness to accept (WTA) payments for farm conservation practices. The statistically significant independent variables are shown in bold.

WTA_Farm	Odds ratio	Robust se	z	*P* > |z|	95% confidence interval	
Manage_Land	0.230776	0.255882	−1.32	0.186	0.0262657	2.027651
Total_Ac_Oper	1.005646	0.0025923	2.18	**0.029****	1.000578	1.010739
Flood_Times	0.7202579	0.1018641	−2.32	**0.020****	0.5458897	0.9503228
Worry_flood	1.492714	0.385891	1.55	**0.121†**	0.8993462	2.477571
Farm_Contract_Term	46.00385	96.75812	1.82	**0.069***	0.7455815	2,838.529
Income	1.961607	0.5023729	2.63	**0.009*****	1.187454	3.240463
Age	0.3782093	0.1680469	−2.19	**0.029****	0.1583157	0.9035251

Notes: Log likelihood = −16.468631. Number of observations = 97. Wald Chi^2(15) = 25.35. Pseudo R^2 = 0.6829.

***Significant at 1%.

**Significant at 5%.

*Significant at 10%.

†Significant at 15%.

for the full logistic regression models of the landowners' WTA payments to perform farm conservation practices. The statistically significant independent variables are shown in bold at various significance *P* levels. We report odds ratios, which are logistic regression's version of parameter estimates or coefficients that are used in ordinary least squares (OLS) regression. The odds ratio is the natural log base, *e*, to the exponent, *b*, which is the logistic regression parameter estimate (Garson 2016). For continuous variables, the odds ratio represents the factor by which the odds, or the WTA (either farm payments or structural NBS payments), increases or decreases one unit in the independent variable (Garson 2016).

In Logit Model 1, *Total_Ac_Oper*, *Income*, and *Age* had the greatest significance on the WTA farm payments ($p \leq 0.05$). *Manage_Land* did not show significance at the confirmatory or exploratory levels, and *Flood_Times* displayed significance at $p \leq 0.10$. In addition, the odds of WTA farm payments compared to those who are not WTA farm payment increases by a factor of 1.96 when annual household income increases, controlling for other variables. Therefore, we can state that the more income landowners make, the more likely they are to be WTA farm payments ($p \leq 0.01$).

Also, younger landowners are more likely to be WTA farm payments than older farmers ($p \leq 0.05$). Thus, the odds of WTA farm payments compared to those who are not WTA farm payments decreases by a factor of 0.38 for each year age increases, controlling for other variables.

In Logit Model 2, *Manage_Land* and *NBS_Contract_Term* showed the most significant among all other variables ($p \leq 0.05$) (table 5). Thus, the more land that a landowner manages, the more likely they are WTA payments for structural NBS. In addition, an increase in contract term length in years, the increased likelihood of WTA payments for the structural NBS. *Age* and *Revenue_Loss* showed significance at $p \leq 0.10$.

Combined Logit Model. We assessed the overall WTA (*WTA_Combined*), including both WTA farm and structural NBS payments. Logit results from this model are shown in table 6. Five of the seven independent variables showed significance at $p \leq 0.01$.

Results from the multinomial logistic regression models are shown in the supplemental material (tables S1 and S2). Compared to the base outcome, which was the "middle-ground" payment, and similar to the results from the binary logistic

Table 5

Logit Model 2, willingness to accept (WTA) payments for structural nature-based solutions (NBS) practices. The statistically significant independent variables are shown in bold.

WTA_NBS	Odds ratio	Robust se	z	*P* > |z|	95% confidence interval	
Manage_Land	2.985201	1.127256	2.90	**0.004*****	1.424122	6.257487
Flood_Times	0.8260885	0.1296631	−1.22	0.224	0.6073258	1.123651
Revenue_Loss	1.049049	0.0265767	1.89	**0.059***	0.9982317	1.102453
Worry_flood	3.20172	2.870456	1.30	0.194	0.5523966	18.55734
Worry_Yields	0.413439	0.2945866	−1.24	0.215	0.1023074	1.670767
NBS_Contract_Term	84.57859	176.4776	2.13	**0.033****	1.416396	5,050.52
Age	0.6833077	0.1528806	−1.70	**0.089***	0.4407292	1.059402

Notes: Log likelihood = −17.034034. Number of observations = 112. Wald Chi^2(15) = 20.43. Pseudo R^2 = 0.7458.

***Significant at 1%.

**Significant at 5%.

*Significant at 10%.

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Table 6

Combined Logit Model, willingness to accept (WTA) payments for both farm and structural nature-based solutions (NBS) practices. The statistically significant independent variables are shown in bold.

WTA_Combined	Odds ratio	Robust se	z	*P* > |z|	95% confidence interval	
Manage_Land	0.8777809	0.5774297	−0.20	0.843	0.241795	3.186626
Total_Ac_Oper	1.000659	0.0014733	0.45	0.655	0.9977754	1.003551
Flood_Times	0.5065916	0.094238	−3.66	**0.000*****	0.351815	0.7294603
Revenue_Loss	1.103137	0.0387661	2.79	**0.005*****	1.029715	1.181795
Worry_flood	2.548318	0.7411052	3.22	**0.001*****	1.44114	4.506104
Income	2.074741	0.5595338	2.71	**0.007*****	1.222939	3.51842
Age	0.2643132	0.1205701	−2.92	**0.004*****	0.1081015	0.6462581

Notes: Log likelihood = −32.7677918. Number of observations = 95. Wald $Chi^2(15)$ = 28.31. Prob > Chi^2 = 0.0002. Pseudo R^2 = 0.3897.
***Significant at 1%.

regression, we found productive land acreage was a significant determinant of most WTA payment categories for farm practices (table S1). In contrast, results from the multinomial regression suggest that the type of land management was significantly related to lowest and highest WTA payment categories for farm practices. Results from the multinomial regression associated with WTA payment categories for NBS practices, where the highest payment categorized was utilized as the base outcome, were comparable to the results from the binary logistic regression (table S2).

Discussion. Our study sought to understand the motives and the characteristics of Robeson County landowners' participation in a potential flood mitigation program, FloodWise. Our survey respondents had a higher average knowledge score of common farm practices than structural NBS, which was expected as some structural NBS are more complex and require newer knowledge than traditional farm practices. Based on previous literature (Bubeck et al. 2017; Jiang et al. 2018; Pattanayak et al. 2003; Truelove et al. 2015), we anticipated a positive relationship between knowledge and WTA. However, the knowledge of either practice genre (*farm_know_avg* and *NBS_know_avg*) was not a significant indicator of WTA in this study. In addition, we would presume that the 20% of farmers who had participated in previous programs would be receptive to the FloodWise program or similar conservation programs (Royer and Moulton 1987); however, previous program participation (*Program*) was also not a significant indicator of WTA. This finding that previous program experience did not matter might be related to the relatively small 20% of farm landowner respondents who had actually participated in farm bill-type conservation programs, and thus only a few had much program experience to affect their opinions. We since also have had field workshops and visited several farms as follow-up research and outreach, and while farmers seemed familiar with many of the farm conversation practices, the farmer/agency linkages seemed weaker than in some other counties.

The survey results indicated that 55% of respondents stated that they are concerned about future flooding on their properties, and 64% replied that they worry that future flooding will harm their crop, tree, or livestock yields. Most of the respondents (68%) also indicated that they are concerned that flooding may harm their local water quality. Aligning with PMT, we can see that there is a consensus on perceived threats from flooding among survey participants with the majority of participants stating their concern about future flooding harming crop, tree, or livestock yields and local water quality. This suggests that respondents would perceive future flooding as a risk and would potentially want to perform preventive actions (Bubeck et al. 2017; Rippetoe and Rogers 1987; Rogers 1975), such as participation in a flood reduction program like FloodWise. In addition, Pattanayak et al. (2003) indicate that bio-physical factors, such as greater slope, a higher chance of erosion, and a higher probability of flooding, can act as incentives for adopting new technologies to alleviate future impacts.

Our results showed that contract term lengths for both types of payments (i.e., *Farm_Contract_Term* and *NBS_Contract_Term*) had a positive relationship with the landowner's participation in the FloodWise program. Participants in this study were interested in a 5- to 10-year contract term, similar to Soto et al.'s (2016) findings, who found landowners in Florida would be WTA payments for a 5- to 10-year commitment in a C sequestration program. Markowski-Lindsay et al. (2011) also concluded that individuals would rather have a shorter contract term for planting forests in a C offset program. Similarly, Kreyes et al. (2017) and Kang et al. (2019) both discovered that 5- to 10-year contracts were most preferred when participating in a wildlife or forest conservation program. This means that a potential FloodWise program that aims to mitigate floodwaters in rural landscapes should be no more than a 10-year contract term.

The WTA payment values that participants selected fall within the range of similar PES studies. For example, Jayalath et al. (2021) found that landowners in the Gulf Coastal Plain and Ozarks would be WTA US\$290.10 ac^{-1} yr^{-1} (US\$716.85 ha^{-1} y^{-1}) to maintain forests and wetlands. Also, on the higher end, Kang et al. (2019) discovered that landowners' WTA baseline payment for planting pine and bottomland hardwood forests was US\$164 ac^{-1} yr^{-1} (US\$405 ha^{-1} y^{-1}). However, some researchers have found somewhat lower WTA estimates. Soto et al. (2016) indicated that individuals would prefer payments between US\$20 to US\$30 ac^{-1} yr^{-1} (US\$49 to US\$74 ha^{-1} y^{-1}) for maintaining forestland for C sequestration. Similarly, Yu and Belcher (2011) found that landowners in Canada would be WTA US\$31 ac^{-1} yr^{-1} (US\$77 ha^{-1} y^{-1}) for establishing wetlands.

It is important to note that these differences in estimates may be corroborated by the costs and revenues associated with various crops and forest types across different places of the world and at different points in time. The range of WTA bid estimates we offered was restricted to between US\$40 and US\$190 ac^{-1} yr^{-1} (US\$99 and US\$469 ha^{-1} y^{-1}), which would have limited the bids to within that range, and eliminated open-

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ended bid approach outcomes with high-end averages such as US$290 ac^{-1} yr^{-1} (US$717 ha^{-1} y^{-1}). The range we provided in our survey does align with actual averages and ranges experienced by current farm bill programs and by our previous calculations of breakeven costs for farmers for both farm conservation programs and NBS practices (Hovis et al. 2021). While this eliminates speculative bids by landowners and higher WTA estimates, it provides reasonable bid ranges based on previously known program payments that have been accepted by farm landowners.

We found that there was not a significant difference between the average traditional, existing WTA farm conservation practice payment amount and the proposed WTA structural NBS average payment amount, indicating that typical farm program payment expectations were almost the same as for structural NBS payments, other than our stated assumptions of differences among the payments for the establishment and periodic maintenance. This is encouraging for NBS program implementation, suggesting that landowners essentially considered structural NBS practices about the same as farm conservation practices—no riskier or more problematic for farm conservation adoption.

Determinants of Willingness to Accept Farm Payments. Two sociodemographic characteristics, *Income* and *Age*, were associated with the probability of WTA farm payments. The more income landowners make, the more likely they are WTA farm payments ($p \leq 0.01$). Additionally, we found that younger landowners were more likely to be WTA farm payments than older landowners ($p \leq 0.05$).

These findings are consistent with results found in similar PES studies (Cubbage et al. 2003; Jiang et al. 2018; Joshi and Mehmood 2011; Pattanayak et al. 2003; Jayalath et al. 2021). For example, a review by Cubbage et al. (2003) determined that the higher landowners' income, the more likely they are to plant and manage forests. Pattanayak et al. (2003) concluded that generally, income is statistically correlated with participation in agroforestry programs, and Wei et al. (2016) noted that household income was a factor that positively influenced farmers' willingness to participate in a wetland restoration program. This finding has important equity and justice implications, as landowners with higher income may be more likely to benefit from aid programs, neglecting small, poor, or minority landowners. Inequities in the implementation of NBS programs have been documented before in cities (Gerlak et al. 2021), where all water customers contribute to the funding of the program, but only the wealthy benefit from such a program.

As for *Age*, Jiang et al. (2018) noted that older farmers might have less time to understand the benefits of investing in a new practice and are less willing to try new practices than younger farmers. In addition, this could be because younger generations are typically more accepting of climate change and its impacts (Lawson et al. 2019; Stevenson and Peterson 2015; Stevenson et al. 2014).

However, other sociodemographic variables like education level and gender did not significantly correlate with the probability of WTA farm payments ($p \geq 0.15$). These two findings are consistent with Jayalath et al. (2021). Nyongesa et al. (2016) also found gender not significant ($p \geq 0.15$); however, they discovered that education had a positive relationship with WTA PES. Similarly, Jiang et al. (2018), Ma et al. (2012), and Wolde et al. (2016) discovered that more educated landowners are more likely to participate in a PES program. This, however, was not the case for our survey sample.

The total of operated acres (*Total_Ac_Oper*) showed a positive relationship with WTA farm payments. A 1% marginal increase in total acres operated leads to the increased probability of WTA farm payments by 1.3%, controlling for other variables in the model. Some of the literature suggests that the larger the land size increases the likelihood of participating in PES (Gutierrez-Castillo et al. 2022; Ma et al. 2012; Pattanayak et al. 2003; Rabotyagov and Lin 2013; Wang et al. 2016); however, this is inconsistent across studies (Cubbage et al. 2003; Jiang et al. 2018; Kang et al. 2019; Nyongesa et al. 2016). For example, Jiang et al. (2018) found a positive relationship between land tract size and their willingness to participate in an energy crop program. Still, the willingness varied among the types of crops. Additionally, the results found by Kang et al. (2019) showed that the size of the property does not impact forest owners' willingness to participate in PES. This could be because many landowners have more than one property, and the size may not be a significant factor in their decision to participate (Kang et al. 2019).

The number of flood times (*Flood_Times*) was negatively associated with the WTA farm payments ($p \leq 0.05$). The results showed that an increase in the frequency of flood time events decreases the WTA farm payments. This result is inconsistent with our anticipated relationship or the literature. We expected that the more flooding events occurred, the more likely landowners would be WTA payments. The literature states that those with a higher perception of risk, which can be influenced by previous flood experiences, would likely lead to WTA farm payments (Campbell Institute 2014; Pattanayak et al. 2003; Rogers 1975; Wildavasky and Dake 1990). Brouwer and Schaafsma (2013) also found that landowners' perceived future risk of flooding led to their decision to purchase flood insurance.

Perhaps this group of Robeson County landowners may be high-risk adverse, which could be influenced by educational, political, economic, or cultural conditions (Wildavasky and Dake 1990). They may not perceive flooding events to be threatening or severe (i.e., risk appraisal) to their crops or livestock or they may perceive that they are able to manage the risks on their own (i.e., coping appraisal and strategies) without receiving payments for flood mitigation practices (Rippetoe and Rogers 1987). The county is extremely flat and low-lying, and flooded often, so they may be inured to flood problems or doubt the effectiveness of solutions.

The relevant survey question did not specify a time period, such as "over the past year" or "over the past 10 years." Therefore, newer Robeson County landowners may have not yet experienced flooding impacts in recent memory, although many respondents said that they experienced damage from the major floods of Hurricane Matthew (2016) and Hurricane Florence (2018). Future research should follow up on this issue elsewhere to examine similar questions.

Determinants of Willingness to Accept Structural Nature-Based Solutions Payments. Like the determinants of landowners' WTA payments for common farm payments, the sociodemographic variable, *Age*, had a positive relationship with the WTA structural NBS payments. Therefore, younger landowners are more likely to be WTA structural NBS payments. The consistencies within the literature have been discussed above. Also, similarly to the WTA farm payments results, *Flood_Times* had a negative relationship with the dependent variable, and we can make

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conclusions likewise to the determinants of WTA farm payments.

However, different from the WTA farm payments results, variables *Manage_Land* and *Revenue_Loss* were found significant and positively associated with the WTA structural NBS payments. An increase in managing land (i.e., landowner that manages their own land; 0 = does not manage land) increased the odds ratio of WTA structural NBS payments by 0.95%. This agrees with Lindhjem and Mitani's (2012) and Kang et al.'s (2019) findings that suggest landowners who are more active in management are more likely to be WTA payments than those who are absentee owners.

As expected, *Revenue_Loss* displayed a positive relationship with WTA structural NBS payments ($p \leq 0.10$). Therefore, the more revenue from crop, tree, or livestock production and yields loss from flooding events, the increased likelihood of WTA structural NBS payments. The perception of income gain or loss is one of the most common factors influencing WTA (Pattanayak et al. 2003; Rogers 1975). Additionally, Brouwer and Schaafsma (2013) noted that individuals are most WTA compensation for flooding damages due to the increased risk of revenue losses. McKillop (1993) also discussed that forest owners respond to environmental regulations, such as conservation program participation, due to the loss of previous revenues from timber production (Kreye et al. 2018). In our case, we can assume that more timber, livestock, and crop damages caused by flooding will motivate landowners to participate in the FloodWise program.

Summary and Conclusions

In this study we utilized the CVM-PC to assess Robeson County landowners' WTA payments to participate in a potential FloodWise program, which could act as a hazard mitigation program within the state. Robeson County is reasonably typical of North Carolina Coastal Plain counties in physiography, flooding, and relatively impoverished demographic characteristics. However, the farmers we surveyed on average had large tracts and were relatively affluent with higher annual incomes than average Robeson County residents. These characteristics are probably favorable for farm program knowledge and enrollment and would extend to facilitating NBS adoption. Just like farm programs, any NBS programs would need to balance the advantages and efficiencies of working with such larger farmers and the equity of trying to disburse funds and assistance to have practices with willing lower income and minority landowners.

We found that the majority of survey participants would be WTA a payment to adopt common farm practices with an average WTA payment of approximately US\$128 ac^{-1} yr^{-1} (US\$316 ha^{-1} y^{-1}). Additionally, most survey respondents would be WTA structural NBS payments with an average WTA payment amount of US\$132 ac^{-1} yr^{-1} (US\$362 ha^{-1} y^{-1}). There was no significant difference between the amount of farm payments that respondents were WTA and the amount of structural NBS payments. We conclude that landowners participating in a common farm conservation program in the county would also be willing to enroll in a flood mitigation program, using NBS, if the establishment costs were covered as assumed and the annual payments were sufficient.

While the landowners appear to be financially amenable to using NBS practices, it will take considerable amount of new funding, cultural change, technical assistance, and institutional development to begin such major problems in Robeson County and elsewhere. Probably 8 of the 10 practices, from cover crops to stream restoration, are somewhat familiar farm conservation practices and would likely be adopted if the incentive price or soil conservation returns are right. The water farming and flood-control wetland restoration approaches would require large advances in acceptability and very large payment amounts. Our research on these traditional and new practices for flood mitigation are among the first steps in the United States and will require research, training of technical professionals, outreach to farm landowners, policy adaptation, agency champions, program development, and more. We have begun efforts to develop pilot demonstrations of these practices for a few locations in Robeson County and elsewhere in North Carolina, but they are early steps in the general science and practice innovation and adoption cycle. However, the flooding and adverse impacts are projected to increase, and these FloodWise hazard mitigation efforts can still be a better solution than only paying for farm, crop, or downstream damages.

We discovered the main determinants of WTA farm and structural NBS payments were landowners who were younger, wealthier, and operated larger tracts of land. This finding has important equity implications that need to be integrated into the design of and outreach for flood mitigation programs, like FloodWise, so that the less wealthy and more vulnerable may benefit.

Other factors, such as the length of the contract term and the revenue lost due to previous flooding events, affected the WTA payments. In conclusion, based on this sample in one county in eastern North Carolina, proposed programs such as FloodWise could attract landowners to implement NBS practices on their farms. Incentives could encourage landowner participation; help offset high NBS establishment and maintenance costs; and provide new revenue sources for marginal farmlands and poor rural communities that already may flood often, which is apt to increase in the future.

Overall, this research provides insights about the use of NBS to reduce flood-related damages, ranging from the experiences and concerns of farm landowners about flooding; their participation in farm programs in the past; their willingness to extend those practices and use NBS; and the amounts of payments that they would require to participate in such programs. This approach provides an important way to advance rural resilience, not only in North Carolina, but other regions across the nation with similar topography and vulnerability to flooding. Additionally, our survey results regarding the interest and WTA farm conservation and structural NBS payments provide many insights for the sample in Robeson County, which is a reasonable microcosm of the North Carolina Coastal Plain and historically experienced regional flooding issues.

Jurisdiction is the greatest constraining factor known for natural infrastructure (Collentine and Futter 2018), and there have been recommendations for state-level programs that allow for more flexibility for community-led and locally driven projects (Glavovic and Smith 2014). NBS disaster resilience programs could complement current disaster relief programs by developing new flood mitigation and prevention programs. These could reduce existing losses, provide more income for rural communities, and encourage more adaptable practices for localities. Including the voices of less-privi-

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leged groups in the decision-making process for program design and implementation is critical to address environmental justice issues (Zuniga-Teran et al. 2021).

Finally, drawing from Collentine and Futter (2018), technical assistance from practitioners would be needed for landowners and other adopters, as well as payments, to provide incentives for adopting NBS. This combination of landowner and community outreach and extension, agency and NGO technical assistance, and financial incentives can help prevent floods causing the displacement of residents, reduce crop losses, and decrease economic damages to infrastructure, for both rural farm and forest landowners and downstream communities. As global climate change increases, adapting to new institutional arrangements that adopt NBS and leverage community management is essential for natural disaster resilience, relief, and damage mitigation in the long term.

Supplemental Material

The supplementary material for this article is available in the online journal at https://doi.org/10.2489/jswc.2023.00131.

Acknowledgements

This research was funded by the North Carolina Department of Justice Environmental Enhancement Grant (2020 Grant Identification as Project Code NCSU 019- PRE). This research was approved in accordance with the North Carolina State University Office of IRB policies (IRB #23851). This research was also supported in part by the USDA, Forest Service (Chizmar's official time). The findings and conclusions in this publication are those of the authors and should not be construed to represent any official USDA or US Government determination or policy.

We thank the contributions from researchers and practitioners at NCSU, North Carolina Soil and Water Conservation Districts, North Carolina Farm Bureau, and Robeson County Extension Office. We recognize graduate student, Jaclyn West, and undergraduate researcher, Maddie Laughlin, for their work in data entry and validation. Finally, we acknowledge and appreciate the time that anonymous Robeson County landowners spent completing our survey.

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