ORIGINAL RESEARCH

Private Forestlands in South Carolina: Motivations for Implementing Conservation Practices

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Abstract

This study aims to understand the conservation practices taking place on private forestlands in South Carolina, United States. Much of the forestlands in the eastern United States are privately owned, and landowners can elect whether to implement conservation practices. A questionnaire was distributed to South Carolina landowners to elicit information on land tenure, the type of conservation practices they use, and the best methods for increasing the use of these practices. We specifically focused on prescribed fire because of its importance to management regimes and the debate that surrounds this practice. Results from our questionnaire that was randomly distributed to South Carolina forest landowners showed that many landowners use at least one conservation practice or are interested in implementing one or more practice. Our Logit regression analysis showed that certain factors including land size and belonging to an environmental group were significant and associated with increased implementation of prescribe fire. From the model and statistical analysis of the landowner responses, we inferred that educational and financial resources are two crucial factors for encouraging landowners to implement conservation practices and retain landowners already involved in the cost share programs. Furthermore, helping landowners with implementation of prescribed fire through their inclusion in prescribed fire organizations and funding opportunities would most likely increase adoption and contribute to conserving ecosystem services in South Carolina and other states with large areas of land in private ownership.

Abbreviations
ES   Ecosystem services
SC   South Carolina
BMP   Best management practice

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TPB	Theory of planned behavior
EQIP	Environmental quality incentives program
NRCS	Natural resources conservation service

Background

Family forest landowners comprise about 70 percent of forest landowners in the eastern United States (Butler et al. 2021). These landowners can have a significant impact on ecosystem services (ES) that forests provide. While some of these landowners' forested area is not a large source of timber production, ecosystem services provided by their land including carbon sequestration, increased water quality, and wildlife habitat are crucial for both humans and biodiversity. Additionally, more tangible ecosystem services such as preventing erosion and aesthetic value for recreation and hunting are services that are directly valued by family forest landowners (Bengston et al. 2011). The benefits gained from family forestlands are often contingent on the landowners' management decisions and the goals of owning their land.

The economic and social drivers of owning land directly relates to the management practices on that land (Sorice et al. 2014). There are many factors that affect land management, including land tenure, access to funding, and landowners' long-term goals. Changes in land tenure in recent years has resulted in increased parcelization of forested plots across the country. Parcelization increases variability in management and long term goals, furthering land use change that can result in urbanization, reducing forestlands, and ultimately the reduction of some ecosystem services. Between 1978 and 1994, the forestland in parcels less than 100 acres increased from 72 to 124 million acres, or 73% (Sagor 2006). In 2016, 56% of forest landowners across the country were family forest landowners, and the average land size was less than 100 acres (Butler et al. 2016a; Kuluppuarachchi et al. 2021). Across the United States, we continue to observe a change in who owns the land and their goals for ownership (Sorice et al. 2014). We are also observing changes in funding structure for management on family forestlands; funding from natural climate solutions programs, including carbon offset markets are becoming more prevalent along with federal and state cost share funds. It remains to be seen if the benefits from these funding sources will enhance ecosystem services on family forestlands. Because of these rapidly changing factors that impact land ownership and management, it is important to better understand the relationship between why forest landowners own their land and to investigate if these factors affect their decision to implement best management practices.

Studies show that best management practices (BMPs) on forestland could provide long term benefits for ecosystem services, increase economic output, and enhance social welfare (Maker et al. 2014; Cristan et al. 2016). BMPs are defined as "a practice or usually a combination of practices that are determined by a state or a designated planning agency to be the most effective and practicable means (including technological, economic, and institutional considerations) of controlling point and nonpoint source pollution at levels compatible with environmental quality goals" (SCFC 1976; Helms 1998; Ice et al. 2010).

Many studies have recognized the effectiveness of BMPs in the southern United States, especially in forestry operations (Cristan et al. 2016). Williams et al. (1999) showed that BMPs in certain forested areas in South Carolina (SC) reduced the suspended sediments in local streams that occur due to runoff. Mc Clurkin et al. (1985) suggested that using BMPs on clear-cut pine plantations in Tennessee would have significant impacts on the fragile soils and ultimately the water quality. Clinton (2011) found that riparian buffers that are at least 33 feet or wider reduce sediment transport, protecting water quality. Sawyers et al. (2012) and Wade et al. (2012) determined that utilizing mulch and slash on waterbars provides effective erosion control by limiting sediment runoff. BMPs used in SC on industrial timber tracts include: implementing streamside management zones, stabilizing soil near streams, erosion control on access roads, ephemeral stream protection, and stabilizing fire breaks (Sabin 2012). Mills often require BMPs to be implemented if they will accept timber from a landowner, and the SC Forestry Commission helps with implementation and compliance. Typically, BMPs are not required on NIPF land, but recent data has shown that in SC, NIPF landowners have had a higher rate of BMP implementation than industrial forest landowners (Welch 2020).

Because around 80% of the forest land in SC is family forest land, the adoption of pro-environmental behaviors through conservation practices implementation by these landowners is crucial for ecosystem service provisioning. Studies have shown that large scale behavioral change among individuals can reduce environmental impacts (Dietz et al. 2009; Klöckner 2013). Behavioral change among forest landowners can have an even greater impact on ecosystem services due to large-scale management. Currently, profit maximization drives many industrial forest landowners, but utility maximization is the a major driver of family forest landowner decisions, where the aesthetic value and wildlife habitat is also valued (Beach et al. 2005). Furthermore, the theory of planned behavior (TPB) is evident in forest management systems. The TPB indicates that certain attitudes towards a behavior and societal pressure can predict their acceptance of that certain behavior (Bendel et al. 2020). This is especially evident in prescribed fire acceptance, where perceptions of smoke, benefits of fire, and difficulty of implementation have been varied. Based on TPB, it is predicted that if education and funding is increased for prescribed fire, landowners would look at it favorably and implement this practice (Klöckner 2013).

Landowner surveys have been important over time to understanding economic and environmental principles that landowners abide by. Previously, it was common to assess timber producing landowners across the country via survey and disregard other types of landowners. In the late twentieth century and into the twenty-first century, more surveys have been focused on the family forest landowners and understanding their motivations for using certain forest management practices (Bengston et al. 2011). The need for these surveys is due in part to the fact that the actions of the family forest landowners are often unpredictable, because of the variety of objectives they have for the use of their land (Amacher et al. 2004).

Due to the limited number of surveys and information about conservation practices on family forest land, we designed a landowner questionnaire to better understand factors that affect forest land ownership and conservation practice implementation. The second section of this questionnaire focused specifically on

prescribed fire and identifying how prescribed fire is being used in SC. Prescribed fire can be a highly beneficial tool that aids in increasing forest health, site preparation, and enhancing wildlife habitat (Piatek and McGill 2010). Prescribed fire can mitigate larger crown fires that could result from fuel build up on the forest floor. Climate change can affect potential and frequency of destructive wildfire and storms which could significantly damage forests (Anderegg et al. 2015; Clay et al. 2019). Prescribed fire provides landowners with an opportunity to help mitigate chance of wildfire by reducing fuel loads in forests that could ignite larger, more destructive fires.

Longleaf pine (*Pinus palustris*) and other pine species require fire for regeneration, and also for clearing the forest floor, allowing the seeds to germinate and thrive, helping to retain ecosystem biodiversity (Haines and Cleaves 1999; Hiers et al. 2003). Longleaf is a "fire sub-climax" species, requiring frequent disturbance to retain its dominance in the ecosystem, and fire is the natural disturbance mechanism (Croker and Boyer 1975). Many land managers are interested in increasing the usage of prescribed fire, but there are many hazards and challenges associated with this practice, including smoke affecting surrounding neighbors, and the liability associated with fires that go beyond the boundaries of the prescribed area. Furthermore, there is limited information about perceived benefits of prescribed fire among forest landowners. As discussed above, perceptions of prescribed fire have impacted the ability for prescribed fire to be used at a large scale.

We hypothesize that: (1) land tenure and ecosystem services do affect willingness to implement conservation practices: and (2) that based on the theory of TPB, landowners will be more willing to implement conservation practices if educational resources are more readily available. The objectives of this paper are to determine: (1) how land tenure and the benefits landowners receive from their land affects implementation of conservation practices: (2) the prevalence and opinions of prescribed fire: and (3) what educational methods are preferred for increased knowledge and implementation of conservation practices for landowners.

Survey based analysis has consistently been implemented through both the USDA Forest Service, state forest service agencies, and universities to understand conservation practice implementation. Through the National Woodland Owner Survey, there has been significant research to quantify why family forest landowners own their land and many of these results are consistent with our findings in SC (Butler 2008; Butler et al. 2016b). Additionally, there is data for general BMP implementation across the southern United States and on the management practices that are being used on managed forestlands. This data has been collected by the Southern Group of State Foresters over the last 35 years (Ice et al. 2010). The SC Forestry Commission compiled a report in 2012 that detailed the BMP usage and compliance among industrial forest landowners. Based on this report, in 2012, BMP compliance among those were surveyed was 93.4% (Sabin 2012). In 2020, this report was updated to show 96.1% compliance (Welch 2020).

Methods

Questions

This questionnaire was designed to obtain information about landowner beliefs and perceptions towards managing their forestland in SC. The following questions were hypothesized to have an effect on landowner's decisions for their forestland, and they have been implemented in other forest landowner surveys (Bengston et al. 2011; Miller et al. 2012; Hiesl 2018). This questionnaire was designed based upon Alhassan et al. (2019) and Arrow et al. (1993).

The forest landowners were asked their main reasons for owning their forest land and if they have implemented certain management practices, including prescribed fire, buffer strips, fire breaks, and stream habitat and forest stand improvement. Other practices asked about included Streamside Management Zones, stream crossings, and access road systems, all of which require BMPs when they are utilized. These categories also correspond to Environmental Quality Incentives Program (EQIP) names and descriptions (NRCS 2018) for cost share/funding purposes. For those landowners who have not implemented management practices, we asked whether they would be interested in implementing them in the future. We were also interested specifically in prescribed fire. Prescribed fire is continually being encouraged as a management practice but as its use increases, the risk of smoke and fire damage also increases. Since little is known about the opinions of forestland owners on the usage of prescribed fire in SC, by gathering this information, we hope to better understand the needs to enhance its implementation safely. Because of this, all questionnaire respondents in our study were asked to determine the level of importance of benefits provided by prescribed fire.

Additionally, there are a variety of questions that were asked to gauge the respondent's preferences for receiving educational resources regarding BMPs and conservation management of forestlands. Questions regarding how extension and government agents can provide assistance to landowners were asked to determine the effectiveness of current programs and informational needs of landowners. Lastly, all respondents were asked the same questions regarding their demographics, size of their forest land, and forest type. All of these questions were asked in multiple choice and Likert scale questions.

Questionnaire Administration

The questionnaire was pretested at the SC Forestry Commission May 2019 meeting and was distributed in June and July of 2019. The contact information of forest landowners was obtained from the SC Forestry Commission database. Utilizing a modified tailored design method and to account for any bias from limited entries in the SC Forestry Commission database, we mailed a cover letter describing the project and the questionnaire to 3000 randomly selected forest landowners across the state (Dillman et al. 2014). An additional 1500 follow-up questionnaires were

mailed with another letter describing the impact of the project a month later to give landowners another opportunity to respond. All types of forest landowners were surveyed; there was no distinction between working forests and non-working forests. Our study was granted approval through the Clemson University Institutional Review Board, approval number 2018–456.

Statistical Analysis

We ran a Logit regression model to determine the factors affecting the implementation of prescribed fire. The Logit model relies on demographic data obtained from the questionnaire, and aims to predict the probability of prescribed fire implementation among landowners (Alhassan et al. 2019). Utilizing binary and ordinal response data, we used maximum likelihood to determine the probability of each independent variable to affect the dependent variable (prescribed fire implementation). The model is:

$$logit\big(P\big(Y = 1|x_1, \dots, x_k\big)\big) = \beta_0 + \beta_1 x_1 + \cdots + \beta_n x_n \tag{1}$$

here Y is a binary variable where Y = 1 denotes the default value of willingness to implement prescribed fire and Y = 0 shows landowners' unwillingness to implement prescribed fire. Also, x_n denotes the explanatory variables; these variables were selected using simple linear regression in the form of a stepwise regression to select statistically significant variables when regressed with willingness to implement prescribed fire as the dependent variable. β_n show the estimated coefficient of each independent variable (Stefan and Svetlozar 2009). Equation 1 produces coefficient values for independent/explanatory variables. The Pearson's goodness of fit test was used to determine independence (Smyth 2003). Education was ultimately dropped from the model due to collinearity.

To account for common method biases in the questionnaire responses, we also ran an exploratory factor analysis (Panwar et al. 2017). Utilizing the Harman's one factor test, we determined that no variable accounts for more than 21% of the total variance and that common method bias was most likely not an issue for this study.

Lastly, ANOVA was used to determine any statistical differences in questionnaire responses. The Logit model and other statistical analyses were carried out in the R computing environment (2020).

Results

Overview of Respondents

We received 280 complete responses, resulting in a 9.3% response rate. The largest group of respondents were those who own 200–499 acres of land, and they made up 30% of the respondents (83 respondents). The smallest group was the landowners with the smaller land tracts, 1–50 acres (7 respondents). In SC, the average tract size for family forest landowners is 67 acres; we only received 11

responses (4%) from respondents with 50–99 acres. Additionally, across the U.S., 90% of NIPF landowners hold between 1 and 49 acres of land, with 10% holding more than 50 acres (Butler and Leatherberry 2004; Butler et al. 2021). The samples derived in this questionnaire captured more of the larger property landowners, presumably due to their awareness with the information solicited. While the non-response bias testing carried out between the first and second mailing yielded no significant differences, it does seem that the responses do not fully represent the population, especially when considering land area owned. This may be due to the representation of different land sizes in the SCFC landowner database.

The forest types reported were a good representation of South Carolina's forests, and landowners had the option to select more than one forest type. The most common forest type response was Loblolly pine (*Pinus taeda)* (46% of respondents). Loblolly is commonly planted on large properties for timber production, and this was evident in our sample that 90% of the landowners with more than 1000 acres of land had Loblolly. Moreover, 19% of respondents stated that Longleaf pine is the major forest type on their property, an important species for restoration in the south. Other forest types represented in this study sample were Oak/Pine (22% of respondents), Oak/Hickory (7% of respondents), Gum/Cypress (5% of respondents), and Elm/Ash/Cottonwood (1% of respondents).

Landowners were asked to select the importance of a variety of factors for owning their land. All of the options (outlines in Fig. 1) except for "part of my home," were very important to most landowners and reasons for owning their land. Many of the landowners believed preservation of land for future generations, protection of their land for environmental quality, and timber production are very important reasons for owning their land. In this study, 45% of surveyed landowners reported that they have a written management plan for their land.
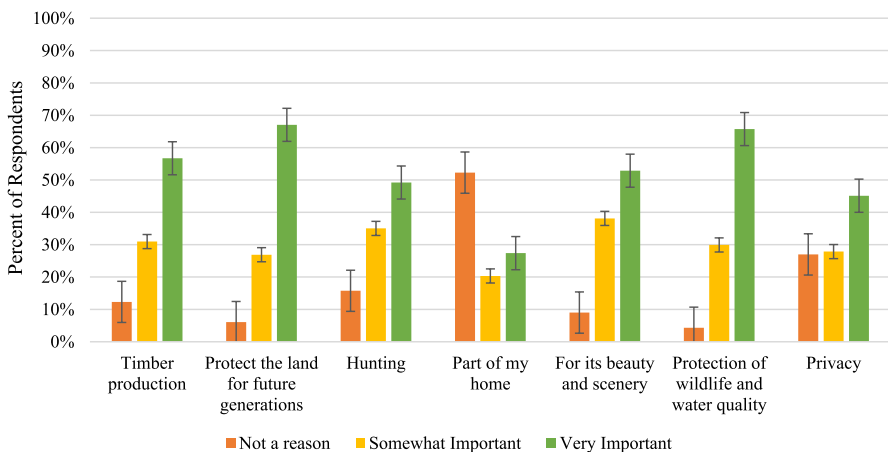

Fig. 1 Landowners' responses to reasons for owning their land

Conservation Practices

The management practices used in this questionnaire are commonly used management practices in SC and are among those practices that can be funded through the EQIP program. Many of these management practices are already used by a large number of the respondents. The most commonly used management practice was access roads that reduce sediment loading and the least commonly used practice was Stream Habitat Improvement & Management (Fig. 2), presumably due to the fact that many landowners do not have streams on their property. Additionally, 45% of respondents currently utilize prescribed fire and 30% have used prescribed fire in the past. More than half (58%) of landowners utilize fire breaks.

Those who are not currently using any of the above nine management practices were asked their level of interest in implementing them in future. They were asked to select one of the five options: Not interested, Probably not interested, Neutral, Somewhat interested, and Very interested and want to use. Figure 3 indicates there was a large number of respondents who were somewhat and very interested in utilizing some of the practices. We ranked their level of interest from 1 to 5 where 1 indicates "Not interested" and 5 indicates "Very interested and want to use." We calculated the mean for level of forest landowners' interest for implementing different practices. Our results show all values were above neutral (> 3.58), and Brush Management and Forest Stand Improvement were above somewhat interested (> 4.01) showing forest landowners are interested in implementing at least one of these practices.

Demographics

Multiple demographic factors were collected from questionnaire respondents. Gender was highly skewed toward male ownership, with 83% of the respondents. The age results were highly skewed towards older respondents, with over 60% being over the age of 65 (Fig. 4a). Previous education was also highly
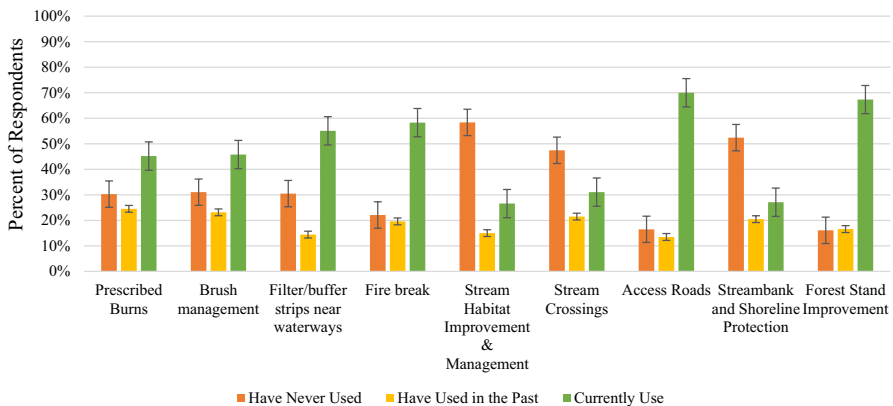

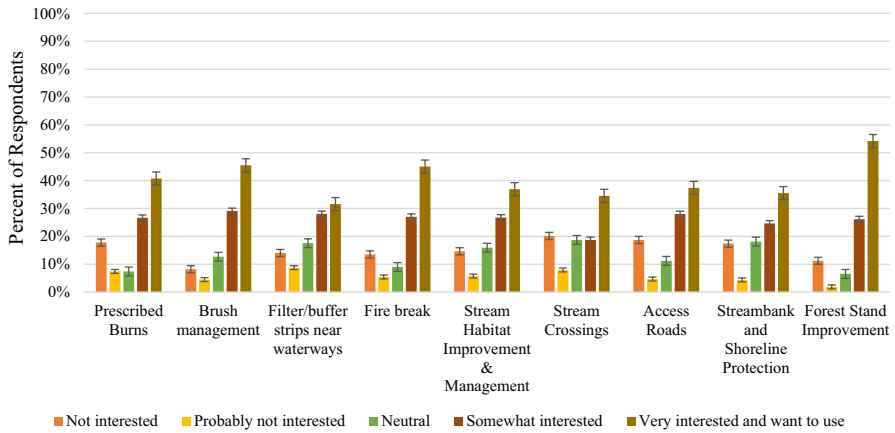**Fig. 2** Use of conservation practices by respondents

Fig. 3 Willingness to implement conservation practices for landowners who do not currently use them
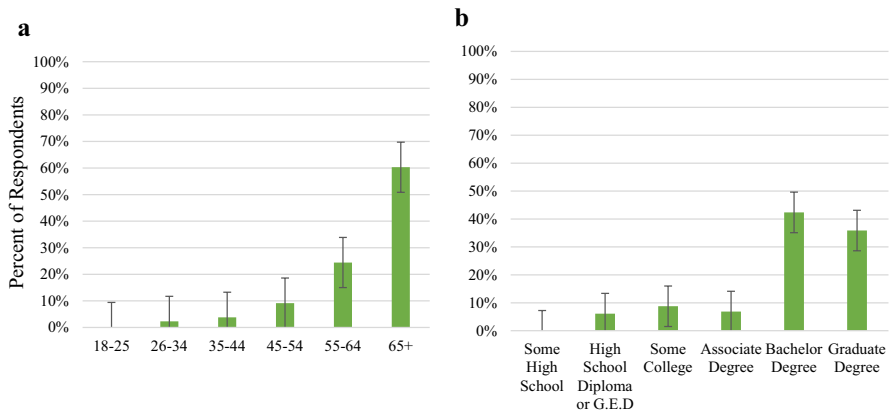

Fig. 4 Respondents' age range and highest levels of education

skewed towards college degrees, with most people earning a Bachelor's degree and the second most people earning graduate degrees (Fig. 4b). The majority of the landowners that responded (59%) made between $30,000 and $200,000 in 2018. Very few landowners (< 10) earned an income less than $30,000.

Analysis of Prescribed Fire

Most respondents indicated that the majority of prescribed fire benefits described in the questionnaire are either "somewhat" or "very" important (Fig. 5). Most
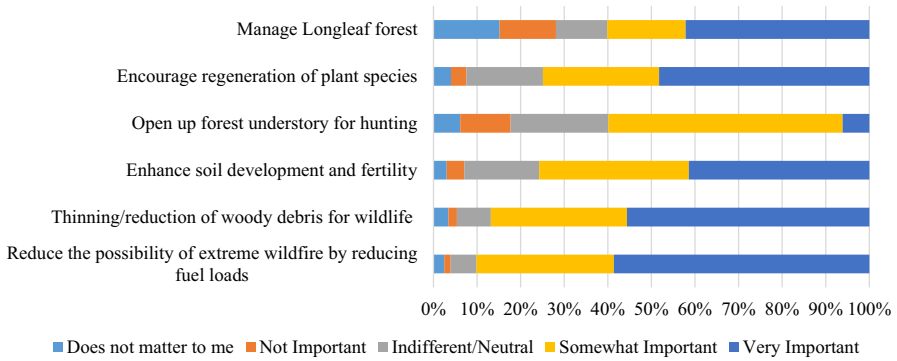
Fig. 5 Benefits of prescribed fire to respondents

respondents selected that reducing fuel loads to reduce the possibility of extreme wildfire is the most important benefit of prescribed fire.

Logit Model Results

We used a Logit model to further determine the significance of certain factors on landowners' willingness to implement prescribed fire. The landowner's willingness to implement prescribed fire (dependent variable) is a binary variable (Yes or No response), where "0" indicates landowners' unwillingness and "1" shows landowners willingness to implement prescribed fire. The independent variables utilized in the model include whether or not the landowner was involved in an environmental group (dummy variable), age, 2018 income, and their land size. These variables were determined initially by simple linear regression, AIC, and past studies use of these variables (Hiesl 2018; Alhassan et al. 2019). The result of the regression is shown in Table 1.

The regression analysis does show that land size and belonging to an environmental group (i.e. Ducks Unlimited or The Nature Conservancy) are significant for prescribed fire implementation. Age has a negative marginal effect value,

Table 1 Logit estimates and marginal effects of landowners' willingness to implement prescribed fire

Variable	Estimate	Std. error	P-value	Marginal effect
(Intercept)	− 0.737800	1.117000	0.508700	
Belong to an environmental group	0.585300[a]	0.327100	0.073600	0.0690
Age	− 0.004924	0.016490	0.765200	0.7652
Income	0.000001	0.000001	0.202200	0.2021
Land size	0.001233[b]	0.000314	0.000087	0.0001

[a]Significance at the 10% level

[b]Significance at the 1% level

and while insignificant among respondents in this study, other studies have indicated its significance in prescribed fire implementation (Bendel et al. 2020). The income estimate is also insignificant, as it indicates that for an increase in income by $10,000, landowners would be 0.01% more likely to implement prescribed fire.

Educational Opportunities

Educational opportunities and varying mediums of instruction are central to help forest landowners effectively implement conservation practices and convey new conservation practices to landowners as they are developed. We asked respondents a series of questions to determine which methods of education are most effective for them, with the assumption that all options would be available to them. Table 2 shows the respondent's opinions on their preferred educational methods for obtaining information about conservation practices. For almost all options, most of the respondents chose "Sometimes" or "Always" Effective. When asked if on-site visits were beneficial, respondents overwhelming said that they were "Always Effective" and "Sometimes Effective," while only one respondent said that it was never effective.

The types of educational preferences including "research by myself," "large regional meetings etc.," and "doing it myself": all proved significantly different in terms of their effectiveness among different age groups; older landowners preferred research by themselves ($p < 0.05$). Those options that were not significantly different were the onsite and one-on-one visits with Extension and NRCS agents. Additional analysis shows that there was not a significant difference in the implementation of conservation practices among respondents based on educational attainment or income.

Discussion

Conservation practice implementation require a variety of compliance and voluntary incentives to increase usage. BMPs are already actively implemented across southeastern states with an implementation rate of 96% in SC for industrial forest landowners and 99% for family forest owners (Welch 2020). The relatively high BMPs implementation rate in southern United States can be in part due to monitoring and implementation protocols produced by the Southern Group of State Foresters (Ice et al. 2010). Implementation of conservation practices such as prescribed fire are not as straightforward due to the funding and education required to implement. Questionnaire results indicate that many landowners in SC do utilize some conservation practices and/or are interested in implementing both BMPs and additional conservation practices. From here, discussion will be broken down by conservation management practice.

Table 2 Respondents' opinions on the effectiveness of certain educational opportunities

	Research by myself on the internet (%)	Large regional meeting with experts giving presentations about the latest information and research (%)	Meeting with NRCS experts to talk about the purpose and implementation of BMPs (%)	Local workshops where local experts and foresters present knowledge and share experiences (%)	An on-site visit by a local conservation advisor from the SC forestry commission or Clemson Extension (%)	Trying things out on my own and learning from successes and mistakes (%)	Talking over the fence with my neighbor about their BMPs (%)
Not available	10	16	13	12	13	7	23
Never effective	3	6	2	2	0	10	19
Seldom effective	18	17	11	7	5	24	22
Sometimes effective	57	42	42	47	30	41	30
Always effective	13	21	32	31	52	18	6

Land Use Change and Retaining Forestland

Most landowners have demonstrated over time that utility maximization for forestland is a common theme in management decisions (Tian et al. 2015). Non-pecuniary benefits (also more recently known as ecosystem services) such as carbon sequestration, wildlife habitat, and water quality protection are all co-benefits that are a result of carrying out the management goals shown in Fig. 1. Many of the surveyed landowners find these benefits to be very important, yet they have a diverse set of reasons for owning their land. Therefore, even though goals for the land vary, landowners are more likely to choose management practices and funding sources that result in protection of the resource (Tian et al. 2015). The resultant effect is a protection of the ecosystem services gained from conservation practices and a healthy forest for the landowner to enjoy for many years. This underscores the continued landowners' needs for financial resources for implementing conservation practices and technical support for education and writing a forest management plan. Many respondents in this study (45%) indicated they already have a written management plan and most of the respondents (93%) own over 100 acres of forestland. For the United States, around 11% of family forest landowners have a written management plan, but 50% of landowners with more than 100 acres have a written management plan (Butler et al. 2021). Of the eleven percent of forest landowners that have a written management plan, 18% have sought technical advice and these landowners own 36% of the forestland (Butler et al. 2021). While it is not crucial for small tracts of land to have a written management plan, it can help landowners be aware of how their land is affecting water quality, biodiversity, and carbon sequestration, especially as conservation practices are discussed and encouraged by land managers. In addition, it lays out a long-term plan on how to protect and manage these ecosystem services.

Education and funding are two major factors that, based on this research, we believe will affect the implementation and instill long term use of conservation practices and BMPs. As discussed with prescribed fire implementation, this may not always mean traditional education. Education here implies providing information to landowners about benefits of accessing to professional foresters and about benefits of having management plans, and subsequently helping them find additional funding. When analyzing the compliance of landowners in the northern United States, the implementation and compliance with stream crossing BMPs have shown improvement due to education about the issues (Ice et al. 2010). Respondents indicated that working directly with NRCS and extension agents to understand how to implement BMPs is their preferred method of education. These services provide learning opportunities for landowners who have specific needs and situations while creating a working relationship between the agents, landowners, and forest managers. Opportunities for Cooperative Extension and government agents to visit NIPF landowners' property can be important for understanding the landowner's specific goals and building trust. Factors such as mutual trust, humbleness, and a sense of understanding about external factors (i.e. family structure, income, and history of land) by the agent are much better understood when close relationships are built (McCaffrey 2006).

Some of the difficulties with extension/education activities is the sheer number of forest landowners compared to available agents that can provide management advice. With over 262,000 forest landowners in SC, it is almost impossible for all landowners to have the opportunity to meet one on one with foresters or extension agents (South Carolina Forestry Commission 2010). Prioritizing landowners based on certain management goals may be considered in the future but has not been broadly implemented. It is necessary for some landowners to get educational information through workshops and publications which can help them with the necessary steps for conservation practice implementation.

Prescribed Fire Implementation

Prescribed fire is gaining public support as the literature has been increasingly resolute that the benefits outweigh the costs (Oswalt et al. 2012; Fargione et al. 2018). Over the last 20 years, federal policy has shifted to recognize that need for prescribed fire to reduce fuel loads that contribute to large, destructive crown fires (Williamson 2007). While there is carbon lost to the atmosphere in this process, prescribed fire significantly limits the potential for large losses through crown fires (Fargione et al. 2018). Longleaf pine ecosystems also require fire to reduce understory debris for regeneration. These factors make prescribed fire an obvious choice to achieve these goals, but the perception that fire is a negative practice is still common. Wildfires are increasingly becoming more destructive due climatic changes affecting the soil moisture and precipitation. Many people that live close to forested areas understand that environmental conditions and ignition sources can drastically affect the change of wildfire (McCaffrey 2006). Since many people are familiar with the negative effects of wildfire, it is plausible to assume that they are fearful when it is suggested that fire will be purposefully set to the land for regenerative purposes. Education can make a significant difference in changing the perception that fire is always negative.

The results presented here shows that over 58% of respondents either have used prescribed fire or are interested in utilizing prescribed fire for woody debris reduction to reduce the chance of large wildfire. More than half of the respondents have utilized prescribed fire on their land, and 90% of the respondents believed that the benefit of reducing fuel loads was either somewhat important or very important. When compared to demographic information, there was not statistically significant differences in opinion among landowners with different educational, income levels or ages.

The Logit regression analysis shows that land size and belonging to an environmental group (i.e. The Nature Conservancy, Ducks Unlimited, a local hunting club, Tree Farm) are significant in determining whether or not a landowner will use prescribed fire (Table 1). This is consistent with other studies that have shown that specifically belonging to prescribed fire associations has greatly increased prescribed fire implementation (Toledo et al. 2014; Kreuter et al. 2019). Increased land size has also been shown to increase the use of certain conservation practices, especially habitat and predator management (Golden et al. 2013). Additionally, the coefficient value for age is negative. Golden et al. (2013) showed that younger landowners are

more likely to implement prescribed fire, and Bendel et al. (2020) indicates that income and financial incentives play a factor in implementation. Levels of education were not significant in this model and therefore not included. This is consistent among other studies; some studies show access to resources is more important than education when implementing prescribed fire. Landowners are more likely to be restricted by financial resources and labor instead of education (Bendel et al. 2020). It is worth noting that in the study by Bendel et al. (2020), the respondents were primarily educated at the college level and above, and education was not a significant factor in the implementation of prescribed fire, much like the results presented herein.

Restrictions on prescribed fire can greatly affect the ability to implement it. A survey of government agencies that utilize prescribed fire indicated that narrow burn windows, regulations, and lack of adequate personnel were the major impediments with implementing prescribed fire (Quinn-Davidson and Varner 2012). In SC, there are a variety of protections for landowners that utilize prescribed fire. Landowners are required to file a burn plan with smoke management guidelines with the state to limit the liabilities landowners may face (Haines and Cleaves 1999; Morris 2006). Additional precautions are required, including plowing fire lanes if natural breaks do not exist. It is possible that landowners who allow fire to escape from the prescribed area could be held criminally liable for damages. Most times, this would only happen if reasonable care was not taken to contain the fire (Haines and Cleaves 1999). There are many policies that help landowners have the opportunity to utilize prescribed fire on their land and reduce their liability for damages. While the risk of uncontrolled fire can limit implementation, continued education of landowners, professional foresters, and those who may live near prescribed fire will help overall acceptance of prescribed fire to increase. Furthermore, access to organizations or non-profits that specifically focus on prescribed fire may help increase implementation. Helping landowners find a professional forester and create a management plan will most likely help increase implementation and continue to make prescribed fire a safe and effective management tool. Additional dialogue between forest landowners, agencies, and those affected by prescribed fire can foster increased tolerance and trust among all parties (McCaffrey 2006).

Demographics of Landowners and Education Mediums

It is commonly known that farmers and forest landowners of this generation are aging and will be transferring ownership in the near future (Butler et al. 2021). Over 60% of the questionnaire respondents are over the age of 65. Additionally, there were no respondents between the ages of 18 and 25. Because ownership of land is held significantly by the older generation, management decisions are affected directly by this older generation that has experience seeing changes in the land use and markets over time. Educational mediums must be tailored to different learning styles that are more relatable to different age groups.

Conclusions

Private landowners in SC account for a significant portion of the forested land and their management directly affects the quality of the soil, water, and air in SC. It is imperative that environmental policy and education for landowners reflect the constant need for landowner engagement and professional development. Landowners in SC and other southern states have been implementing BMPs since the late 1970 s, driven by the Southern Group of State Foresters and their development of a framework to increase accountability and monitoring of the BMP implementation rates (Ice et al. 2010). Respondents show that continued support from both state agencies and Clemson Cooperative Extension is beneficial in continuing the education on implementation of these conservation practices. Through education and outreach, landowners can be more effectively informed about all of their options for sustainable, long term management. Additionally, updated information and legal guidance for professional foresters would be beneficial for implementing prescribed fire. Organizations such as the American Forest Foundation use tools such as the Tool for Engaging Landowners Effectively with the goal of furthering landowner competency in forest management (Sustaining Family Forests Initiative [SFFI] 2009).

Based on the Logit regression model results, landowners are willing to implement both prescribed fire and other conservation practices, but they need more resources, including funding, management plans, professional advice, and an organizational structure or a group that focuses on prescribed fire. When these tools are accessible, landowners follow the theory of TPB and the use of prescribed fire increases. As the importance of climate-smart forest management increases and natural climate solutions are employed to reduce carbon from the atmosphere, forest management goals will change and require reliable insight from professionals to help make these changes. Continued communication aimed at building strong relationships among landowners, agencies, technicians, and scientists will help increase and sustain conservation practice implementation in SC and throughout the United States to promote landscape level conservation.

Appendix

Questions	Minimum	Maximum	Mean	Std. deviation
Have you ever used best management practices (BMPs) on your land?	0	1	0.64	0.480
Do you have a written management plan for your forest land?	0	1	0.42	0.495
Have you ever consulted a professional forester for management advice?	0	1	0.78	0.414
Have you participated in a state or federal government cost share program for these BMPs?	0	1	0.37	0.484
Have you ever used prescribed fire?*	0	1	0.52	0.501

Questions	Minimum	Maximum	Mean	Std. deviation
Are you a member of any environmental organizations (i.e. The nature conservancy, ducks Unlimited; local hunting club; tree Farm)?	0	1	0.44	0.497
Please indicate your age bracket**	30.0	69.5	63.2	9.7
What is the highest level of education you have completed?***	2	6	4.94	1.157
What was your gross household income in 2018 (USD)?**	5000	525,000	213,846	172,148
What is the size of your forest land (all land personally owned, acres)?**	25	2250	680.58	683.591

0 = NO; 1 = YES

*Question was in the form of a check box, the options being "Currently Use," "Have Used in the Past," and "Have Never Used." The two former options were recoded to "Yes" and the latter option was recoded to "No"

**Values were recoded to median values from the categorical options

***Values represent categorical options; beginning with Some High School and increasing to Graduate School

Data Availability Descriptive statistics of the questions used in the analysis are described in Appendix. The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Code Availability The R code used in the current study are available from the corresponding author on reasonable request.

Declarations

Conflict of Interest The authors declare no conflict of interest.

Ethical Approval The Clemson University Institutional Review Board (IRB) reviewed this project and granted approval number 2018-456.

Consent to Participate Not Applicable.

Consent for Publication Not Applicable.

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