Payments for Carbon Sequestration to Alleviate Development Pressure in a Rapidly Urbanizing Region

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Abstract

The purpose of this study was to determine individuals' willingness to enroll in voluntary payments for carbon sequestration programs through the use of a discrete choice experiment delivered to forest owners living in the rapidly urbanizing region surrounding Charlotte, North Carolina. We examined forest owners' willingness to enroll in payments for carbon sequestration policies under different levels of financial incentives (annual revenue), different contract lengths and different program administrators (e.g., private companies versus a state or federal agency). We also examined the influence forest owners' sense of place had on their willingness to enroll in hypothetical programs. Our results showed a high level of ambivalence towards participating in payments for carbon sequestration programs. However, both financial incentives and contract lengths significantly influenced forest owners' intent to enroll. Neither program administration nor forest owners' sense of place influenced intent to enroll. While our analyses indicated payments from carbon sequestration programs are not currently competitive with the monetary returns expected from timber harvest or property sales, certain forest owners might see payments for carbon sequestration programs as a viable option for offsetting increasing tax costs as development encroaches and property values rise.

Keywords: stated choice methods; urbanization; payments for ecosystem services

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Introduction

Across the United States, forest and agricultural landscapes are becoming increasingly fragmented as urban populations grow and cities expand (Theobald 2005; Theobald 2001; Theobald and Romme 2007). The fragmentation of urban-proximate forest and agricultural landscapes can have both immediate and long-term effects on natural systems. Immediate impacts include the displacement of wildlife as habitat degrades as well as reductions in water quality as erosion increases due to the direct removal of above-ground biomass (Hansen et al. 2005; Paul and Meyer 2001). The long-term environmental impacts of urban-proximate landscape fragmentation are more difficult to observe. The loss of endemic plant and animal species as well as biological diversity more generally, may only be realized after urbanization is well underway (Theobald, Miller, and Hobbs 1997). Similarly, alterations to natural or semi-natural hydrologic systems (primarily as a result of increased water use) may impact the ability of ecological systems to respond to drought and climate-related stressors (Allan 2004). In response to these direct impacts and long-term feedbacks, urban planners, forest managers and agricultural associations are actively seeking out and exploring viable policies and programs that conserve forest and agricultural landscapes and maintain the ecosystem services they provide (Gobster, Stewart, and Bengston 2004).

Payments for ecosystem services policies are one of many potential policy options to slow the rate of land use conversion in urbanizing areas (Bengston, Fletcher, and Nelson 2004; Salzman 2005). Payments for ecosystem services can provide non-industrial private forest owners a financial incentive to conserve or manage their land for the production of a valued

ecosystem service like sequestering carbon from the atmosphere, maintaining water quality or conserving wildlife habitat (Jack, Kousky, and Sims 2008; Engel, Pagiola, and Wunder 2008). Simply put, payments for ecosystem services programs are policy instruments which require individuals (typically landowners) to engage in a specific land management practice that: 1) comes at a personal cost (which can include opportunity costs); and 2) results in the continued or enhanced production of an ecological service that benefits society (Shelley 2011). As a note, we use the terminology 'payments for ecosystem services' given it connotes the Millennium Ecosystem Assessment's simple definition of 'ecosystem services' as "the benefits people obtain from ecosystems" (2003, 3). Interested readers are referred to Shelley (2011) and Derissen and Latacz-Lohmann (2013) for substantive reviews of the terminology used to describe these types of policy instruments.

Payments for carbon sequestration policies are particularly attractive mechanisms because they often do not require intensive investments of either time or money from the forest owner, allowing the forest owner to benefit financially from non-intensive management strategies (Bigsby 2009; Lippke and Perez-Garcia 2008). Payments for carbon sequestration policies may be especially appealing in the United States where most non-industrial private forest owners do not actively manage their property through a forest management plan. Just 4% of non-industrial private forest owners in the United States have a written management plan and only 14% have ever sought out professional advice about their woodlands (Butler 2008). Other potential policy solutions such as cost-share programs have not been widely adopted, presumably because they are designed to supplement the forest products industry and often stipulate forest owners actively manage their woodlands for timber extraction (Kilgore et al. 2007); only 6% of

non-industrial private forest owners in the United States have ever participated in a cost-share program (Butler 2008).

Aside from the appeal of not being directly tied to the forest products industry, payments for carbon sequestration policies might also be attractive to forest owners because they align directly with non-timber values (Bengston, Asah, and Butler 2010). Over the past 45 years, the nonuse and noneconomic values private forest owners' ascribe to their woodlands have become stronger (Bengston, Asah, and Butler 2010). Urban residents in particular, tend to hold the strongest nonuse forest values (Tarrant, Cordell, and Green 2003). Additionally, the average age of the non-industrial private forest owner in the United States is declining as older forest owners either sell their properties for development or transfer them to their children (Butler 2008). The growing body of research on the shifting values of non-industrial private forest owners suggests younger generations who inherit land have very strong psychological attachments to their properties (Bliss and Martin 1989; Creighton, Blatner, and Carroll 2015; Gordon, Barton, and Adams 2013; BenDor et al. 2014). The strong meanings forest owners tie to their properties is likely an important factor affecting decisions about how they manage their land. Logically, the stronger the psychological meanings a forest owner has towards their woodlands, the less likely they would be to sell; conversely, the more likely they would be to enroll in a program allowing them to manage their land in a low-intensity yet financially-beneficial way.

Aim and Objectives

Despite the anticipated benefits associated with payments for carbon sequestration policies, only a few studies have explicitly examined the willingness of forest owners in urbanizing regions to enroll in voluntary payments for carbon sequestration programs (Fletcher, Kittredge, and Stevens 2009; Dickinson et al. 2012; Markowski-Lindsay et al. 2011). Recent

related research has been conducted on forest owners' *attitudes* towards carbon sequestration programs (Khanal et al. 2016). In this study we explored individuals' willingness to enroll in a voluntary payments for carbon sequestration program through the use of a discrete choice experiment delivered to non-industrial private forest owners living in the rapidly urbanizing region surrounding Charlotte, North Carolina (USA). Specifically, we examined forest owners' willingness to adopt payments for carbon sequestration policies that varied in their financial incentives (i.e., annual payments), contract length requirements and type of administration (e.g., private companies versus a state or federal agency). Given payments for carbon sequestration programs may be more appealing to individuals who ascribe strong personal meanings to their forestland, we also examined the influence forest owners' 'sense of place' has on their willingness to enroll in a program. Our analysis was guided by four distinct hypotheses, each of which is grounded in the literature, these are:

H_1: Financial incentives will positively influence individuals' intent to enroll in payments for carbon sequestration programs.

H_2: Contract length will negatively influence individuals' intent to enroll in payments for carbon sequestration programs.

H_3: The type of organization (federal agency, state agency or a private company) administering a payments for carbon sequestration program, will not influence individuals' intent to enroll in payments for carbon sequestration programs.

H_4: There will be a positive relationship between individuals' sense of place toward their forested land and their intent to enroll in payments for carbon sequestration programs.

In addition to explicitly testing these hypotheses, we used data collected from site visits to respondents' properties to estimate those properties' development and timber value; these values were compared against the financial returns that would be realized if the forest owner were to enroll in the hypothetical programs described in the discrete choice experiment. Our intent is to see how a hypothetical carbon market compares to current timber and development markets that are driving land use conversion throughout the region.

Literature Review

Forest Owners' Intent to Enroll in Payments for Carbon Sequestration Programs

There is a growing body of research that has examined the willingness of private forest owners to participate in payments for carbon sequestration programs using discrete choice methods. Previous research has predominantly focused on the northern Atlantic and Midwestern states (Table 1), we were unable to identify any research on the preferences for carbon sequestration program attributes in the Southeastern United States.

Existing research focused on the willingness of private forest owners to participate in carbon sequestration programs has assessed the relative influence of different program attributes on willingness to participate. Fletcher et al. (2009) assessed the willingness of seventeen Massachusetts private forest owners to sequester carbon on their forestland based on six hypothetical programs. In their study, program attributes such as expected payment per acre ($5, $15 or $30), length of contract (5 or 10 years), penalty for early withdrawal and the requirement to have a forest management plan in place were evaluated. The results suggested contract length, expected payment per acre and early withdrawal penalties were significant determinants of program participation. Similar results were identified in a related study by Dickinson et al. (2012) which estimated participation of Massachusetts private forest owners across three

hypothetical carbon sequestration programs. The program attributes examined included: contract length (5, 10 or 15 years), financial incentives ($5, $15 or $30 per acre annual revenue), the requirement for a forest management plan to be in place and the stipulation of a penalty for early withdrawal from the program. The results indicated per acre annual revenue was a positive predictor of program enrollment, while contract length, the requirement to have a forest management plan in place and the stipulation of a penalty for early withdrawal were all negatively related to forest owners' intent to enroll. In another study investigating the intentions of Massachusetts forest owners to participate in payments for carbon sequestration programs, Markowski-Lindsay et al. (2011) found shorter contracts (15 years), higher payments ($1000 per acre per year), the ability to withdraw from the program without penalty and not being required to have a forest management plan in place were positive predictors of program enrollment. The authors note that financial incentives (annual revenue per acre) were very inelastic (i.e., the intent to enroll did not change much as the incentive price increased or decreased, Png 2012). The inelasticity of financial incentives suggests forest owners' participation is likely dependent upon other factors. Markowski-Lindsay et al.'s (2011) study determined the overall probability of enrollment in payments for carbon sequestration programs for Massachusetts forest owners was less than 38%, even when desirable attributes were maximized and undesirable attributes were minimized.

Other studies have examined the influence of program attributes associated with payments for other ecosystem services, aside from carbon sequestration (Rabotyagov and Lin 2013; Knoot, Rickenbach, and Silbernagel 2015; Kelly, Germain, and Stehman 2015). Knoot et al. (2015) investigated the effect of four cumulative requirement levels (i.e., no requirements, management plan, practices and inspection) and their impact on Wisconsin forest owners'

willingness to participate in programs that offered payments for the provisioning of three ecosystem services: bird habitat, carbon sequestration and water quality. Their results revealed requirements involving more commitment deterred participation; participation rates dropped from 42% when no requirements were stipulated to 18% when all of the aforementioned land management practices were required. Knoot et al. (2015) also found that program administration (government or market) held no significant influence on participation across all requirement levels. This is inconsistent with findings from stakeholder focus groups in the Charlotte metropolitan region, which indicated strong anti-government sentiment that could affect forest owners' receptivity to government administered programs in our study area (BenDor et al. 2014). Similarly, Kelly et al. (2015) assessed the likelihood of New York forest owners to enroll in various payments for forest conservation programs. The payments for conservation programs received an average enrollment of 8% regardless of time commitment. However, financial incentives (annual payment levels) and management plan requirements were significant attributes affecting enrollment. In another similar study, Rabotyagov and Lin (2013) explored the preferences for attributes of working forest conservation contracts among Washington forest owners. Of the three program attributes investigated, contract length significantly influenced the likelihood of program participation. Finally, through focus groups with Forest Guild members, Wade and Moseley (2011) found profitability to be the greatest barrier to private forest owners' enrollment in voluntary payments for carbon sequestration programs. Financial incentives positively affecting enrollment rates is a consistent finding across the literature.

Psychological and Sociodemographic Factors Influencing Program Enrollment

Aside from the attributes associated with payments for carbon sequestration programs, forest owners' psychological attachments to their property might affect their intent to enroll

(Markowski-Lindsay et al. 2011). However, no previous study has explicitly and empirically examined this relationship. 'Sense of place' is a positive bond between individuals and their environment, based on affect, cognition and symbolic meanings (Stedman 2002). Several studies suggest the sense of place that an individual forest owner has towards their property will affect how they manage that property (Lai and Kreuter 2012; Lokocz, Ryan, and Sadler 2011).

Lai and Kreuter (2012) examined how 'place attachment' (a construct very similar to sense of place) influenced Texas landowners' intent to retain their land and engage in conservation behaviors. Much like the forest owners near Charlotte in our study, the landowners examined in Lai and Kreuter's study were facing development pressure from the nearby cities of Austin and San Antonio. Landowners living in the Hill Country region adjacent to the metropolitan areas surrounding both of these cities indicated a strong intent to keep their property in the family. Land owners' attachments to their personal properties, as well as their perceptions of environmental change throughout the region, were significantly and positively related to the intent to retain their properties. In addition, landowners who indicated they were either heavily dependent upon, or attached a lot of social meanings to, their properties were willing to invest more in conservation-oriented land management strategies.

Relatedly, Lokocz et al. (2011) utilized photo-elicitation methods to examine how rural Massachusetts residents' psychological attachments to local landscape features influenced their attitudes toward conservation and land use planning. Participants in the study indicated a high level of attachment towards natural areas (consisting of forests, streams, ponds and meadows) and the majority of participants showed strong support for protecting local woodlands and natural resources. The study's qualitative methods illustrate how the strong, personally

meaningful connections an individual has towards local and familiar landscapes can shape support for conservation-oriented land use planning efforts.

In addition to sense of place and place attachment, Thompson and Hansen (2013; 2012) identified other psychological, cultural and social factors likely to influence individuals' willingness to participate in payments for carbon sequestration programs. These factors included landowners' values, their ecological knowledge, the risk they associate with encroaching development, as well as their willingness to communicate and learn about payments for carbon sequestration programs.

Methods

Study Region

This study focused on the area surrounding Charlotte, North Carolina (USA) (Figure 1). Since the 1980s the city and its surrounding metropolitan region have experienced rapid population growth characterized by disjunct, low-density development (Meentemeyer et al. 2013). Urban development throughout the region has come at the expense of forest and agricultural lands, and growth projections for the region suggest more than 210,000 ha of forested and agricultural land will be converted to development by the year 2030 if observed trends between 1996 and 2006 continue (Meentemeyer et al. 2013). The majority of forested land throughout the region is owned by non-industrial private forest owners, and these holdings tend to be relatively small (< 10 ha), which limits forest owners' ability to financially benefit from either harvesting timber or biomass (Dorning, Smith, et al. 2015). Past research in the region suggests forest owners are concerned with rising property taxes and the lack of tax-relief policies focused on conserving forested lands; this concern is compounded by strong emotional and psychological ties to the region's culturally rich landscapes (BenDor et al. 2014). Currently,

there are no established policies that provide non-industrial private forest owners with an opportunity to benefit financially from conserving or managing their woodlands (North Carolina Department of Revenue 2015). The region does have a present-use value program that allows land to be valued based upon its use for forestry or agriculture, which is substantially less than its development value. However, not all forested land throughout the region qualifies for the present-use value program. The program requires forest owners to own at least 20 acres (8.09 hectares) and have a forest management plan in place that allows timber harvesting. These requirements limit the ability of the present-use value program to be an indirect tool capable of slowing urban growth. Given this, other more direct land use policies need to be explored. It is possible a regional carbon sequestration market could allow forest owners the ability to benefit financially from conserving or managing their woodlands while maintaining their strong emotional and psychological connections to their properties.

Discrete Choice Experimental Design

We developed a discrete choice experiment to explore contingent forest owner behaviors in response to hypothetical payments for carbon sequestration programs. Stated choice methods are commonly used to understand individuals' behavioral responses to hypothetical choices (Louviere, Hensher, and Swait 2000). Our goal was to understand which factors exhibit the most influence on forest owners' behavioral intentions, including the attributes of the payment program as well as individual psychological and sociodemographic factors. Our analysis was guided by a desire to better understand if, and how, the attributes of the payment program alterd forest owners' preferences for those programs. Our intent was not to estimate a willingness to accept value for all of the non-financial attributes of payments programs, rather we were primarily interested in taking advantage of the methodological benefits of discrete choice

experiments (i.e., requiring respondents to cognitively evaluates specific trade-offs among program attributes (Hanley, Mourato, and Wright 2001)) to develop a better understanding of the program attributes forest owners considered important when contemplating enrolling in a payments for carbon sequestration program.

Econometric Model of Contingent Behavior. In trying to understand the likelihood that private forest owners would enroll in payments for carbon sequestration programs, we were specifically interested in whether or not financial incentives, contract lengths and program administration influences individuals' contingent behaviors. These three factors were combined and varied across meaningful ranges to create a suite of hypothetical, yet realistic, payments for carbon sequestration programs. For each program, forest owners were asked to carefully consider the combination of attributes being presented and make a "yes/no" choice as to whether or not they would participate in the program. A "yes" response indicates forest owners derive more utility from participating in the program than they would otherwise. Utility formulation for each binary discrete choice made in response to a hypothetical program follows the random utility framework (McFadden 1973). Across an entire set of choices, *j*, and a sample of individuals, *i*, the linear equation used to estimate random and explainable (systematic) utility is expressed as

$$U_{ij} = V_{ij} + \varepsilon_{ij} = \beta' X_{ij} + \varepsilon_{ij}.$$

The explainable (systematic) utilities V_{ij} are a function of the design matrix X, which represents attributes presented in various combinations across the choice set. The β' coefficients are estimated for each attribute.

Scenario Development, Attributes and Levels. To elicit the most valid responses, the survey instrument included a narrative frame describing the general characteristics of payments for carbon sequestration programs and how they could be implemented in the study region. Following the narrative framing statement, forest owners were asked to evaluate a set of nine possible payments for carbon sequestration programs and, for each program, to carefully consider its attributes and indicate whether or not they would participate in the program. Respondents were also given an opt out response option to avoid the likelihood of a forest owner providing a response if they felt uninformed or unqualified to make a decision (Banzhaf, Johnson, and Mathews 2001; Kontoleon and Yabe 2003). The choice set was comprised of various combinations of the three key attributes: financial incentives, contract lengths and program administration. Each of these three attributes were varied across three levels; the levels were set to encompass realistic ranges based upon previous research and consultation with experts in the region's potential for a carbon sequestration market. The full narrative frame and choice set are shown in Figure 2; individual attributes and their specified levels are noted in Table 1. The narrative was developed such that it clearly described the essential components of a payments for ecosystem services program, as outlined by Engel et al. (2008). These essential components are: 1) an explicit description of the type of land being conserved and the ecosystem service it provides; 2) the ability of enrollees in the program to terminate the contractual relationship; and 3) the establishment of a monitoring system (in our case a written forest management plan that required conservation) in order to ensure payments are the result of additional land management activities. Given payments for ecosystem services programs often fail to demonstrate additionality, producing more of a given ecosystem service than would have been produced without the program, we attempted to make it as clear and as explicit as possible

that the payments would not be "money for nothing" (Engel, Pagiola, and Wunder 2008; Ferraro and Pattanayak 2006).

With three attributes, each presented at one of three levels in any given program, there were a total of 27 possible combinations to represent different carbon sequestration programs. Given it was deemed too burdensome to have each forest owner consider and respond to all 27 combinations, we opted for a fractional factorial design comprised of nine combinations (i.e., hypothetical payments for carbon sequestration programs). All sampled forest owners received the same choice set of nine possible carbon sequestration programs.

Variables Used in Econometric Model

A summary of all variables used in the econometric modeling is provided in Table 2. Respondents' sociodemographic characteristics were captured through the first mail-back survey. Specifically, we collected data on forest owners' age, gender, education and income. We also collected data on the amount of time the forest owner has spent on the property (*presence*); this was calculated as the total years of ownership multiplied by the number of days they spend on the property per year. The first mail-back survey also ascertained whether or not respondents had a forest management plan in place (*management plan present*) and whether they currently harvested timber for income on their property (*harvest for income*).

The first mail-back survey was also used to measure forest owners' psychological connections to forested areas on their properties. We used Jorgensen and Stedman's (2006) psychometric scale, modifying each statement so that it referred explicitly to respondents' forested property. Data obtained via the 5-point Likert scale were analyzed for reliability (Cronbach's α greater than 0.70 were deemed acceptable following Nunnally and Bernstein 1994), adequate factor loadings (loadings greater than 0.60 were deemed acceptable following

297 Hair et al. 2009) and their fit to a hypothesized single-factor measurement model (relative χ^2
298 values less than 3.0 were deemed acceptable following Carmines and McIver 1981). With these
299 criteria satisfied, a single *sense of place* factor score was calculated for inclusion in the mixed
300 effects logistic regression model described below. This method is identical to that used in
301 previous analyses of these data (Dorning, Smith, et al., 2015).

302 Other variables included in the model were derived from either the analysis of satellite
303 imagery/LiDAR data or publically available property tax records. Specific measures included the
304 size of the forest stand on the respondent's property estimated via satellite imagery (*forest size*)
305 and the appraised value of the parcel extracted from 2011 tax records (*economic value*). Very
306 few stated choice experiments have used biophysical variables derived via remote sensing as
307 factors influencing forest owners' decisions; exceptions include the work of Naidoo and
308 Adamowicz (2005) and Dorning and her colleagues (2015).

309 **Econometric Model Specification**

310 We used a mixed effects logistic regression specification to estimate the probability that
311 forest owners would participate in payments for carbon sequestration programs depending upon
312 the level of attributes presented. The mixed effects logistic regression is a flexible specification
313 that can approximate any random utility model (McFadden and Train 2000). The mixed effects
314 logistic regression specification decomposes random error into two components; the first
315 component is correlated over alternatives and heteroskedastic while the second part is assumed
316 to be independently and identically distributed over alternatives and individuals (McFadden
317 1984). This is noteworthy because individuals' responses within the choice set are likely to be
318 highly correlated. Preferences and subsequently utility functions will vary between individuals;
319 the mixed effects specification accommodates this and is commonly used to overcome the

limitations of standard logit and conditional logit specifications (McFadden and Train 2000). Our model is specified as:

$$Pr(y_{ij} = 1) = \mu + \beta_1 Financial\ Incentives_{ij} + \beta_2 Contract\ Length_{ij} + \beta_3 Program\ Administration_{ij} + \beta_4 Age_i + \beta_5 Education_i + \beta_6 Gender_i + \beta_7 Income_i + \beta_8 Presence_i + \beta_9 Sense\ of\ Place_i + \beta_{10} Forest\ Size_i + \beta_{11} Management\ Plan\ Present_i + \beta_{12} Harvest\ for\ Income_i + \beta_{13} Economic\ Value_i + \varepsilon_{ij}.$$

The model posits the probability of enrolling in payments for carbon sequestration programs is a function of the program's attributes, an individual's sociodemographic characteristics and the characteristics of their property. Estimation was completed using dummy variable coding for attribute levels and the *meqrlogit* command in Stata 14.0 (StataCorp 2015).

Data Collection

Data on forest owners and their contingent enrollment in hypothetical payments for carbon sequestration programs were collected via two self-administered mail-back surveys. We sent surveys to a sample of forest owners in a five-county region on the eastern side of Charlotte, an extent characterizing the region's full development gradient. We drew a sample of 2,500 landowners from a sampling frame comprised of private forest owners within the five-county study area; forest owner names and addresses were obtained from publically available tax records. The sample consisted of forest owners who owned more than 2 ha of contiguous forest (determined via analysis of both 2011 Landsat and LiDAR data (Singh et al. 2012)). The initial sample of forest owners were asked to agree to an on-site ecological assessment and timber cruise of their property and, subsequently, to complete two mail-back surveys; a total of 143

(5.7%) forest owners agreed. The first mail-back survey was administered from November 2011 to April 2012; it asked about forest owners' sociodemographic characteristics, how they managed woodlands on their property as well as their psychological attachment to their property. A total of 126 out of the 143 woodland owners (88%) completed this first mail-back survey. The second mail-back survey was administered in November 2013 to the 126 forest owners who responded to the first survey. The second mail-back survey was substantially shorter than the first, containing only a series of stated preference questions related to the forest owners' willingness to participate in payments for carbon sequestration programs. A total of 65 forest owners, out of the 126 who received the second mail-back survey, completed and returned the instrument. This tabulates out to a 49.6% response rate, which is high relative to most mail surveys administered to either the general public or forest owners (Dillman, Smyth, and Christian 2008). Five respondents indicated their property had been sold since they responded to the first mail-back survey two years earlier. All results presented in this study are for the remaining 60 forest owners and their properties.

Both survey packets mailed to respondents included a personalized map with an aerial photo of forested land on the respondents' property. In a cover letter, we asked forest owners to respond to the questions in reference to the forested land shown on the map, excluding from consideration other forested areas they might have owned. These explicit instructions were included to make responses and contingent decisions personally meaningful.

Results

The characteristics of our sample of forest owners and their properties are reported in Table 2. The majority of respondents (71.7%) were men and the mean age was 64.2 (*SD* = 11.2). All respondents had graduated from high school, with the majority (68.3%) also having a

366 bachelor's degree. Respondents' properties ranged in size from one to fifty-one hectares, with an
367 average size of 6.9 hectares (*SD* = 8.4). On average, respondents indicated owning their
368 forestland for at least twenty years (*M* = 20.4, *SD* = 12.8); this varied widely however, with
369 length of ownership ranging from two to fifty-eight years. The majority of respondents (68.3%)
370 lived on or within a half-mile of the forested property.

371 The average size of respondents' forests was 6.9 hectares (*SD* = 8.4) and the assessed tax
372 value of their entire property was just under $400 thousand USD. However, both the size of
373 respondents' forest stands and the value of their properties varied widely (Table 2), mitigating
374 some of the concern over coverage error given the relatively small sample. Only a relatively
375 small proportion (18.3%) of our sample reported harvesting timber to generate income and just
376 under one-third (31.7%) reported having a management plan in place.

377 When queried about the sense of place respondents had towards their forested property,
378 respondents on average reported strong personal meanings (Table 3). For example, 77.2% of
379 sampled forest owners indicated moderate or complete agreement with the statement "I feel
380 relaxed when I'm on my wooded land." Similarly, 62.5% of the sample indicated moderate or
381 complete agreement with the statement "I feel happiest when I'm on my wooded land."

382 The results from the hierarchical mixed effects logistic regression model, which predicted
383 forest owners' intent to enroll in payments for carbon sequestration programs, are shown in
384 Table 4. The model's estimates can be interpreted as the welfare of each attribute's level. For the
385 non-price attributes (contract length and program administration) and the price attribute (per acre
386 annual payment), increases (decreases) in welfare are indicated by positive (negative) values.

387 The results revealed annual payment levels do significantly influence individuals'
388 likelihood of enrolling. The odds of a forest owner enrolling in a payments for carbon

sequestration program were 18.5 times higher if that program yielded $25 per acre annual payments as opposed to $5 per acre annual payments (Coef. = 2.917, $p < 0.001$). More notably, the odds of a forest owner enrolling in a payments for carbon sequestration program were nearly 110 times greater if the program resulted in $50 per acre annual payments instead of $5 per acre annual payments (Coef. = 4.702, $p < 0.001$). These results supported our proposed hypothesis (H_1) that financial incentives would positively influence individuals' intent to enroll in payments for carbon sequestration programs.

The results also revealed contract length significantly influences individuals' likelihood of enrolling, with respondents preferring shorter contracts (15-year contract, Coef. = -2.266, $p < 0.001$; 30-year contract, Coef. = -4.855, $p < 0.001$). While contract length was significant, its influence was marginal relative to the effect of annual payment levels, which exhibited a very strong signal. This result supported our proposed hypothesis (H_2) that contract length would negatively influence individuals' intent to enroll in payments for carbon sequestration programs.

The final attribute of the hypothetical programs, the type of agency administering the program, was not significantly related to individuals' intent to enroll (Administered by a state agency: Coef. = 0.451, $p = 0.266$; Administered by a federal agency: Coef. = 0.613, $p = 0.291$). This result followed our proposed hypothesis (H_3) that the type of organization administering a payments for carbon sequestration program would not influence individuals' intent to enroll.

The results also suggested forest owners' education level and income influenced their intent to enroll in payments for carbon sequestration programs. Forest owners who had obtained a higher level of formal education were significantly more likely to enroll in a program, regardless of program characteristics (Coef. = 0.597, $p < 0.045$). Additionally, wealthier individuals were significantly less likely to enroll in a program, regardless of program

412 characteristics (Coef. = -0.286, $p < 0.082$). None of the other characteristics describing forest
413 owners (age, gender, presence on the property or sense of place) were significantly related to
414 their intent to enroll in a program. The finding of no significant relationship between forest
415 owners' sense of place towards their forested property and their willingness to enroll that
416 property in a payments for carbon sequestration program was dissimilar to our proposed
417 hypothesis of a positive relationship (H_4).

418 None of the characteristics of forest owners' property (size of forest stand, the presence
419 of a management plan, whether or not timber was harvested for income generation or economic
420 (property) value) were significant predictors of the forest owners' intent to enroll in payments for
421 carbon sequestration programs.

422 We began this investigation by posing the question "Can a payments for carbon
423 sequestration program alleviate development pressure in a rapidly urbanizing region?" We
424 formally addressed this question by calculating the annual revenue generated by each of the
425 hypothetical payments for carbon sequestration programs for each forest owner. For each forest
426 owner *i* and each discrete choice opportunity *c*, this is

427

428 $$Annual\ revenue_{ic} = \ annual\ payment\ per\ acre_c \times forested\ acres_c.$$

429

430 The average initial annual revenue required to elicit an intent to enroll response varied widely,
431 from $51 per acre for policies guaranteeing a $5 per acre annual payment, to $753 per acre for
432 policies guaranteeing a $50 annual payment. After calculating all of the initial annual revenues
433 for the choice opportunities in which a forest owner indicated an intent to enroll, we applied an
434 annual discount rate of 4% across the hypothetical contracts' lengths to account for the time

value of cash according to Folmer et al. (1995). This allowed us to arrive at a total discounted contract length revenue value. Our calculation was based on the assumption annual revenue would be received beginning in the second year of enrollment. The variation in intent to enroll prices was even more evident when viewed over the life of the contract; average discounted contract length revenue ranged from $190 per acre for the $5 per acre policies to $8,540 for the $50 per acre policies.

We estimated the years of enrollment that would be required for respondents to receive equal returns from a payments for carbon sequestration program relative to returns they would receive from either cutting all of their forest for timber or selling it at its current (2014) market value; the results are shown in Table 5. If a payments for carbon sequestration program were available that yielded the maximum $50 per acre annual return over a 15-year contract length, forest owners would not be able to generate an equivalent amount of revenue from the program, even if they enrolled for two consecutive contracts (years of enrollment to match timber value = 38.4). This result suggests that even under the highest-return option and a relatively long contract-length program, a payments for carbon sequestration program would not be an attractive alternative to either selling property for development or harvesting for timber. As can be seen in column 6 of Table 5 the years of enrollment required to equal their properties' current market value is well beyond any planning time frame (i.e., 600 to > 13,000 years). Obviously there are a variety of factors that affect forest owners' decisions to sell their property for development or harvest it for timber production; the purpose here is to compare the options purely on their financial returns.

Discussion

Policy Implications

As exurban development spreads across landscapes, large contiguous tracts of forest have become increasingly fragmented, threatening the ecosystem services they provide (Theobald 2005; Theobald 2001; Theobald and Romme 2007). Payments for ecosystem service programs, and payments for carbon sequestration in particular, provide a mechanism through which regional planners and policy makers can conserve urban-proximate forestlands and the ecosystem services they provide by allowing private forest owners to benefit financially from not selling their land for development or harvesting for timber production (Bigsby 2009). Alternative policy mechanisms, such as the procurement and conservation of private forestland by a public or not-for-profit organization, can also alleviate development pressure (Newburn et al. 2005). However, transferring land from the private to public domain is only likely to occur near highly valued resources such as riparian areas, simply pushing development pressures to other areas around a metropolitan region (Dorning, Koch, et al. 2015). Additionally, the efficient transfer of private land to the public-domain requires complex payment and/or transfer options capable of meeting the needs of different types of private landowners (e.g., rural residents, farmers, forest owners) (Nielsen-Pincus, Ribe, and Johnson 2015). Payments for carbon sequestration programs offer a flexible policy alternative, allowing forest owners the ability to continue living on their properties while simultaneously receiving an annual payment for the carbon being sequestered and stored in their forest stands.

While payments for carbon sequestration programs are attractive policy mechanisms at a conceptual level, their implementation has been severely limited by the lack of regional carbon markets (Newell, Pizer, and Raimi 2013). In the United States, the voluntary Chicago Climate Exchange (CCX) served as the primary outlet for such programs while in operation from 2003 to 2011. Currently, there are only two active regional markets, California and the Regional

Greenhouse Gas Initiative (RGGI) in the northeastern portion of the country (Center for Climate and Energy Solutions 2016). These markets establish the price per ton of carbon sequestered based upon industries' need to offset emissions and private forest owners' willingness to manage their forests for carbon sequestration. In this research, we leveraged the ability of discrete choice experiments to determine if a payments for carbon sequestration program could succeed in the southeastern United States, where exurban forest owners are highly attached to their private lands and consequently may be more willing to opt into payments for carbon sequestration programs at a discounted rate, if it means their forest will remain intact.

On many points, our results echoed the findings of previous research. Our sample of forest owners expressed a relatively limited interest in enrolling in payments for carbon sequestration programs. Even when presented with a very large annual payment of $50 per acre, only 45.8% of respondents indicated an intent to enroll; this proportion declined as annual payments were reduced and contract lengths were extended. This result is consistent with previous research (Fletcher, Kittredge, and Stevens 2009; Markowski-Lindsay et al. 2011; Miller, Snyder, and Kilgore 2012; Miller et al. 2014) and perhaps expected given most private forest owners in the United States are passive managers. We had expected a higher level of interest in payments for carbon sequestration programs given a recent region-wide study found non-industrial private forest owners to be generally receptive to payments for carbon sequestration programs (Khanal et al. 2016). Khanal and his colleagues found 30% of a sample of non-industrial forest owners from across the Southeastern US agreed with the statement "carbon sequestration could generate additional revenue for me"; only 11% of the sample disagreed with the statement. Similarly, 45% of the sample indicated they were "interested in

503 exploring carbon sequestration opportunities on [their] forestland"; only 12% were not
504 interested.

505 Our sample's low level of interest in enrolling in payments for carbon sequestration
506 programs is likely attributable to a variety of factors. First, they are likely to have a limited
507 knowledge of the 'ecosystem services' concept and, relatedly, are likely to know very little about
508 how carbon markets would actually work in practice (Metz and Weigel 2010). Given this, it is
509 logical for forest owners to be hesitant about making, or even indicating their preferences for,
510 decisions related to the long-term use of their property. More focused research, particularly
511 research using multiple types of data (i.e., quantitative and qualitative), needs to be conducted to
512 determine if a lack of knowledge and familiarity are in fact major barriers to forest owners'
513 intent to enroll in emerging carbon markets. Second, through the use of a stated choice
514 experiment, our study required forest owners to carefully consider their forested property and
515 what the consequences of each hypothetical policy scenario would be for themselves and their
516 property. Previous research may have over-estimated forest owners' interest in carbon
517 sequestrations programs due to the fact simple statement items presented in mail-back
518 questionnaires are context-deficient and do not require forest owners to carefully consider the
519 details and consequences of their land-use decisions (Khanal et al. 2016).

520 When our sample of forest owners did indicate an intent to enroll, their preferences were
521 influenced by the financial returns yielded by the program as well as its length. Respondents had
522 strong preferences for programs yielding higher returns, which is logical and consistent with all
523 previous empirical research (Fletcher, Kittredge, and Stevens 2009; Dickinson et al. 2012;
524 Markowski-Lindsay et al. 2011; Rabotyagov and Lin 2013; Knoot, Rickenbach, and Silbernagel
525 2015; Kelly, Germain, and Stehman 2015; Miller, Snyder, and Kilgore 2012; Miller et al. 2014).

The majority of previous research has also found non-industrial private forest owners tend to be hesitant to make long-term decisions committing them to managing their forestlands in any one particular way (Dickinson et al. 2012; Markowski-Lindsay et al. 2011; Newell, Pizer, and Raimi 2013; Miller, Snyder, and Kilgore 2012; Miller et al. 2014). This unfortunately does not bode well for the prospect of establishing a regional payments for carbon sequestration market within the study area. At the high point of the CCX (trading price of $7.50 per metric ton in 2008; Climate Policy Initiative 2016)), the maximum potential payments in the Southeast would have been around $15 per acre per year based on CCX's estimated carbon sequestration rates across all Southeastern forest types. Current rates for the RGGI are even lower though their reports suggest prices are generally increasing over time, while trading prices in California are generally a bit higher (Climate Policy Initiative 2016). These markets have required contracts of a minimum of 15 years (CCX), with longer contracts (RGGI) sometimes required. Creation of a market in the Southeast would require a critical mass of tradable carbon, in this case, a large pool stored in private forests under long-term management contracts. For regional markets to be successful, industries that might see them as viable mechanisms to offset emissions would need some long-term assurances in the market's stability. Absent that stability, alternative mechanisms or alternative carbon markets (e.g. REDD+) are likely to be preferred.

We focused our survey on payments for carbon sequestration based on market prices for similar markets in the U.S., though other carbon payment mechanisms do exist. Payments for carbon storage, or avoided carbon release from deforestation, would likely provide much higher payment rates than those for sequestration as forest owners would be compensated for the total amount of carbon stored rather than incremental carbon sequestered. Additionally, estimates of the social cost of carbon at $36 per metric ton (Interagency Working Group on the Social Cost of

549 Carbon 2013) far exceed the current value in most markets, bringing the potential payment level
550 up to $72 per acre per year for carbon sequestered in Southeastern forests if the true cost of
551 carbon were to be reflected in market prices (though Moore and Diaz (2015) argue the figure
552 should be much higher). Given the preference of forest owners for greater financial returns,
553 higher payment rates could increase the feasibility of carbon programs for alleviating
554 development pressure in urbanizing areas.

555 Despite the relative ambivalence of forest owners towards participating in payments for
556 carbon sequestration programs at current rates and their aversion to programs with longer
557 contract lengths, our results did identify some demographic groups that can be targeted as 'early
558 adopters' to pilot payments for carbon sequestration programs. Specifically, our results
559 suggested more educated individuals as well as individuals with smaller incomes were
560 significantly more likely to indicate intent to enroll relative to forest owners with fewer years of
561 formal education and wealthier individuals. These findings could be insightful for efficiently
562 targeting specific types of forest owners most likely to participate in a pilot payments for carbon
563 sequestration program, if one were initiated throughout the region. These findings can be used to
564 develop communication strategies targeted at specific forest owners that are most likely to enroll.
565 Given our findings suggest the populations most likely to enroll are those forest owners who are
566 more educated and who also have smaller annual incomes, the logical 'target population' would
567 be retirees looking to maintain the aesthetic appeal of their forested land while also having some
568 formal policy mechanism that would allow them to generate a cash-flow from their passive
569 ownership.

570 It is interesting to note forest owners' sense of place was not significantly related to their
571 intent to enroll in payments for carbon sequestration programs. This is especially noteworthy

given forest owners, on average, indicated strong personal meanings attached to their forested property. Previous research into payments for ecosystem services programs suggests that when the amount of the payment itself is marginal relative to landowners' other sources of income (as is the case in our study area), the larger the influence of other benefits such as maintaining a desired aesthetic or family/cultural values tied to the land (Muradian et al. 2010). We can only speculate as to why sense of place was not significantly related to forest owners' willingness to enroll, as anticipated. One possible explanation is that simply having the word 'program' attached may cause forest owners to wrongfully identify payments for carbon sequestration programs with other more intensive programs, such as present use valuation programs. Simply put, some forest owners may not associate payments for carbon sequestration programs with an increased ability to maintain the non-market values they ascribe to their forested property, marginalizing the true and expected relationship between the sense of place construct and willingness to enroll. Payment may actually be viewed as undermining the intrinsic values the forest owner wishes to protect (Muradian et al. 2013).

Limitations

Estimating the utilities associated with the attributes of hypothetical policies and programs via stated choice methods is a difficult task for economists and other social scientists who focus on human decision making. This difficulty comes from a variety of different sources ranging from deciding which attributes define the hypothetical policy or program to establishing a realistic range of values across which those attributes will vary in the choice set. Attributes and levels selected should be both understandable (DeShazo and Fermo 2002) and relevant (Hensher 2006) to respondents. In this study, we attempted to meet both of these criteria through a detailed review of previous research on the feasibility and costs associated with payments for carbon

595 sequestration programs and consultation with several bioeconomists who were able to inform the
596 levels we chose to use for our annual payments per acre attribute. While we hope this
597 precautionary step increases the validity of our findings, there are undoubtedly a wide variety of
598 program characteristics (e.g., method of payment, compliance requirements, etc.) that also likely
599 to influence forest owners' willingness to enroll in payments for carbon sequestration programs.
600 We were only able to focus on a small set of attributes within this study, but hope future research
601 will build upon our findings and the findings of similar work (Table 1).

602 Another difficulty in estimating the utilities associated with the attributes of hypothetical
603 policies and programs via stated choice programs is the proper analytical treatment of collected
604 data. Resource economists have gradually adapted more complex and sophisticated statistical
605 specifications, moving from the simple binary logit model to the multinomial logit model to the
606 conditional logit model and now the mixed effects logit model (Hensher and Greene 2002). With
607 the addition of each additional specification comes a new set of assumptions that analysts must
608 be wary of. Here, we used a mixed logit model with one random parameter, the individual, that
609 we specified as being normally distributed. Our specification is not analytically novel, but it does
610 mitigate all of the concerns raised by Hensher and Greene (2002). These concerns include:
611 appropriate selection of parameters to be included as random parameters, appropriate selection of
612 the distribution of the random parameters and appropriate specification of the way random
613 parameters enter the model. We felt the mixed logit specification was appropriate given it relaxes
614 independence of irrelevant alternatives property inherent in standard logit and conditional logit
615 models and subsequently allows response variable to be correlated across the choice situations
616 presented to each individual (Train 2009). Future work that chooses to used stated preference
617 data to estimate forest owners' intent to enroll in payments for carbon sequestration programs,

and chooses to fit those data with mixed effects logit specifications should be mindful of the concerns detailed by Hensher and Greene (2002)

Conclusion

We began this investigation to determine forest owners' willingness to enroll in a payments for carbon sequestration market in an urbanizing region. In our study area surrounding metropolitan Charlotte, the potential for market failure is high as urbanization is rapidly consuming the landscape (Meentemeyer et al. 2013; Terando et al. 2014). Even if private forest owners are committed to not developing their properties, they can benefit financially from stands on their property by harvesting them for timber production. Both development and harvesting for timber production are financially enticing, but dramatically alter the ecological function of the landscape. While the majority of forest owners in our study were reluctant to indicate an intent to enroll in payments for carbon sequestration programs, we did identify several groups of forest owners likely to capitalize on the benefits provided by payments for ecosystem services programs, namely the ability to receive annual revenue capable of offsetting rising property taxes *and* the ability to maintain non-market values such as local aesthetics and recreation use values. If a payments for carbon sequestration program could be combined with payments for other ecosystem services such as water quality and wildlife habitat, it is possible these individuals would be even more likely to see these 'alternative' forest management programs as viable mechanisms from which they could benefit financially and maintain the strong personal meanings they hold towards their forestlands. Programs could become even more attractive if payments accounted for carbon already stored or the social cost of carbon. On a strategic level, payments for carbon sequestration programs offer the promise of preserving local ecological

640 structure and function while simultaneously enabling forest owners to benefit financially from
641 the public goods they provide to society.

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Table 1
Carbon sequestration program attributes and levels examined using stated choice methods in this, and previous, research

	Attribute and Levels											
	Financial incentives (annual payment per acre (USD))			Contract length (yrs.)			Program administration			Geographic region of the United States		
Previous research	> 5 to < 25	≥ 25 to < 50	≥ 50	5	15	30	State agency	Federal agency	Private company	North Atlantic and New England	Northern Midwest	Pacific Northwest
Fletcher, Kittredge, and Stevens 2009	✓	✓		✓							✓	
Dickinson et al. 2012	✓	✓		✓	✓						✓	
Markowski-Lindsay et al. 2011	✓		✓		✓	✓	✓	✓	✓		✓	
Knoot, Rickenbach, and Silbernagel 2015	✓	✓	✓					✓	✓			✓
Miller et al. 2014	✓	✓	✓		✓	✓						✓
Rabotyagov and Lin 2013				✓		✓						✓
Miller, Snyder, and Kilgore 2012	✓	✓	✓	✓	✓	✓						✓
Kelly, Germain, and Stehman 2015			✓			✓				✓		
Finley and Kittredge 2006				✓			✓	✓	✓			
Wade and Moseley 2011										✓	✓	

Note. Other program attributes investigated in the literature: The requirement of a management plan (Fletcher, Kittredge, and Stevens 2009; Dickinson et al. 2012; Markowski-Lindsay et al. 2011; Rabotyagov and Lin 2013; Knoot, Rickenbach, and Silbernagel 2015; Kelly, Germain, and Stehman 2015; Wade and Moseley 2011; Miller et al. 2014; Finley and Kittredge 2006); an early withdrawal penalty (Fletcher, Kittredge, and Stevens 2009; Dickinson et al. 2012; Markowski-Lindsay et al. 2011); payment mode (Kelly, Germain, and Stehman 2015); development and/or timber rights conveyed (Kelly, Germain, and Stehman 2015); inspections (Knoot, Rickenbach, and Silbernagel 2015); enrolled acreage (Markowski-Lindsay et al. 2011; Rabotyagov and Lin 2013).

5

Table 2
Characteristics of sampled forest owners and their properties

				Range	
	Percent	Mean	S.D.	Min.	Max.
Characteristics of forest owner					
Age		64.2	11.2	47	91
Education					
High school degree or equivalent	15.0				
Some college (no degree)	16.7				
College degree	40.0				
Some graduate school	6.7				
Graduate degree or higher	21.7				
Gender (female)	28.3				
Income					
Less than $24,999	13.3				
$25,000 - $49,999	10.0				
$50,000 - $99,999	40.0				
$100,000 or more	30.0				
Unsure/Don't know	6.7				
Presence		15.3	14.9	0.1	58.0
Years of forest ownership		20.4	12.8	2.0	58.0
Sense of place[a]		0.0	1.0	-2.3	1.4
Characteristics of forest owners' property					
Forest size		6.9	8.4	1.0	51.0
Management plan present	31.7				
Timber harvested for income generation	18.3				
Economic value (thousands $US)[b]		397.8	394.3	34.3	2553.0

Notes. [a] Factor score calculated from modified version of Jorgensen and Stedman's (2006) psychometric scale
[b] Tax assessed value of entire parcel

Table 3
Sampled forest owners' sense of place towards their properties

	Proportion of sampled forest owners				
Sense of place statement item	Complete disagreement	Moderate disagreement	Neither disagree nor agree	Moderate agreement	Complete agreement
Everything about my wooded land is a reflection of me	16.7	16.7	27.8	13.0	25.9
I feel that I can really be myself when I am on my wooded land	8.9	1.8	28.6	1.9	13.5
My wooded land reflects the type of person I am	11.1	14.8	24.1	27.8	22.2
I feel relaxed when I'm on my wooded land	3.5	7.0	12.3	28.1	49.1
I feel happiest when I'm on my wooded land	7.1	8.9	21.4	26.8	35.7
My wooded land is my favorite place to be	8.9	10.7	28.6	19.6	32.1
I really miss my wooded land when I'm way from it for too long	16.0	10.0	32.0	20.0	22.0
My wooded land is the best place for doing the things that I enjoy most	9.3	18.5	33.3	16.7	22.2
For doing the things that I enjoy most, no other place can compare to my wooded land	16.7	25.9	29.6	14.8	13.0

Table 4
Results of multilevel mixed-effects logistic regression

Independent variable (fixed-effects)	Coef.	S.E.	Odds Ratio	S.E.	$p > \|z\|$
Program attributes					
Contract length[a]					
15-year contract	-2.266	0.405	0.104	0.042	***
30-year contract	-4.855	0.947	0.008	0.007	***
Annual payment[b]					
$25 per acre annual payment	2.917	0.623	18.492	11.521	***
$50 per acre annual payment	4.702	0.780	110.131	85.884	***
Program administration[c]					
Administered by a state agency	0.451	0.405	1.569	0.636	
Administered by a federal agency	0.613	0.581	1.847	1.073	
Characteristics of forest owner					
Age	-0.059	0.037	0.943	0.035	
Education	0.597	0.297	1.816	0.539	**
Gender	1.136	0.773	3.115	2.407	
Income	-0.286	0.164	0.751	0.123	*
Presence	-0.005	0.028	0.995	0.028	
Sense of place	-0.086	0.380	0.918	0.349	
Characteristics of forest owners' property					
Size of forest stand	-0.030	0.020	0.971	0.020	
Management plan present	-1.122	0.803	0.326	0.261	
Timber harvested for income generation	1.411	0.898	4.100	3.681	
Economic value	$8.97e^{-07}$	$9.08e^{-07}$	1.000	$9.08e^{-07}$	
Constant	-1.995	2.964	0.136	0.403	
Random-effects Parameters					
Respondent (constant)	4.377	1.63			

Notes. $n = 60$ (540 discrete choices); Wald $\chi^2(16) = 68.24$; $p > \chi^2 < 0.001$; *** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$

[a] 5-year contract is the base category

[b] $5 per acre annual payment is the base category

[c] Administration by a federal agency is the base category

Table 5. Revenue generated from payments for carbon sequestration programs relative to timber harvest and development.

Annual payment per acre	Contract length (years)	Average discounted annual revenue[a]	Average discounted contract length revenue[a]	Years of enrollment to match timber value[b]	Years of enrollment to match land value[c]
$5	5	$47	$190	493	8376
$5	15	$30	$426	769	13072
$25	5	$353	$1,411	66	1128
$25	15	$261	$3,648	90	1527
$25	30	$96	$2,774	245	4159
$50	5	$654	$2,617	36	608
$50	15	$610	$8,540	38	652

***Notes*.** Programs with the highest level of financial incentives ($50 per acre per year) were not combined with the longest contract length (30 years) in the fractional factorial design.

[a] Annual discount rate of 4.0% applied (Folmer, Gabel, and Opschoor 1995).

[b] Mean total timber value was $23,398 (*SD* = $27,076). Timber value estimates derived from on-site assessments of: number and type of tree species present; average tree age; maximum diameter at breast height; and total forested area. Values were calculated only for forest owners' properties where on-site assessments were conducted (*n* = 41). This value does not include any interest the forest owner would accrue from the timber harvest.

[c] Mean total land value was $397,821 (*SD* = $394,287).

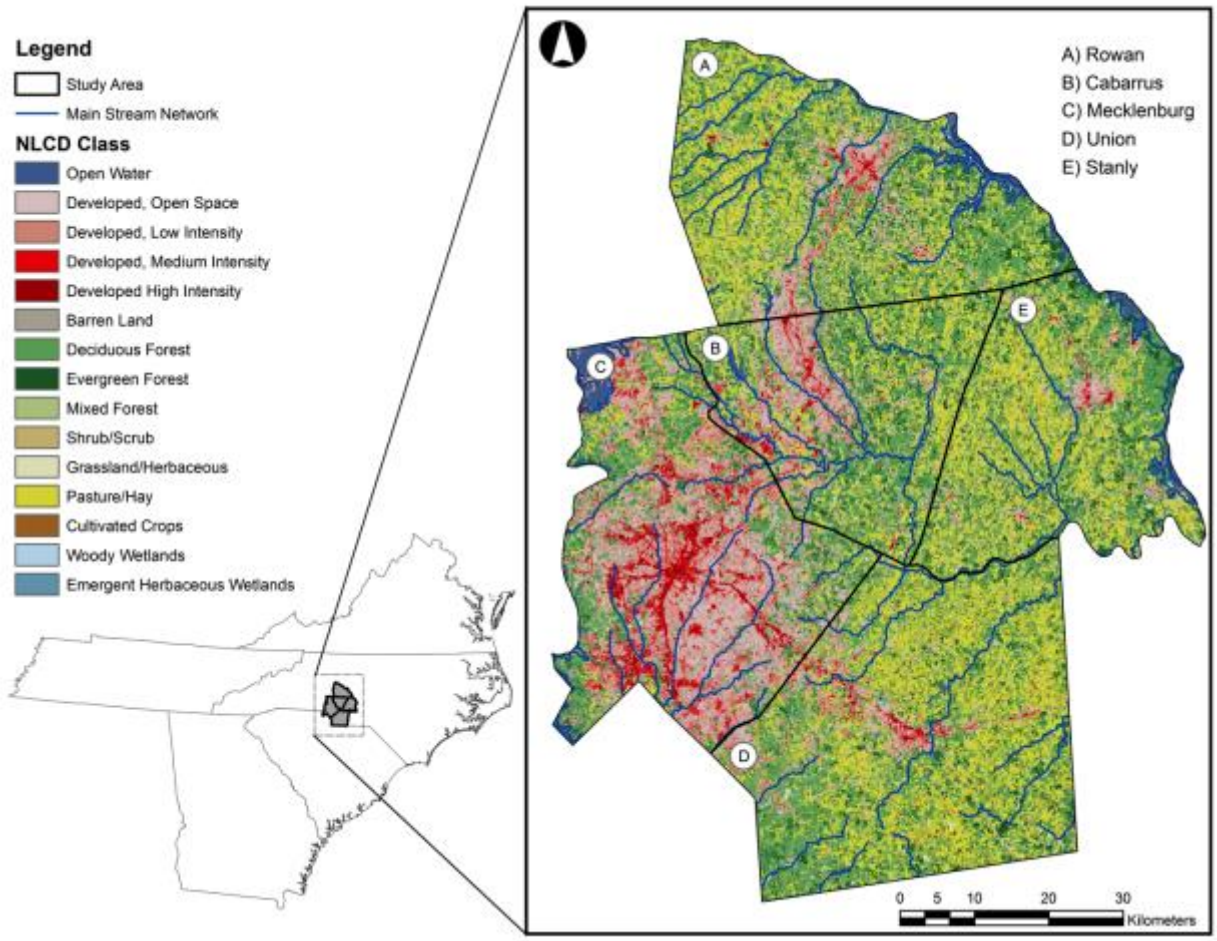

Figure 1. Study area (the counties included in the study are labeled A-E in the map inset; NLCD refers to the USDA Forest Service's National Land Cover Dataset).

Payment for Woodland Carbon Storage

Due to increased concerns about global climate change associated with carbon emissions, programs have emerged that will pay landowners for the carbon stored by their wooded land. These programs are often aimed at forest owners since forested land removes carbon from the atmosphere and stores it in plant materials and soils. When participating in these programs, a written forest management plan is required that limits use of the wooded land for other activities and prohibits clearing of trees or participation in other payment programs for the duration of the contract. These types of 'payment for carbon storage' programs can be administered by a private company, a state agency, or a federal agency. Participation in these programs requires signing formal contracts, which vary in length from 5-30 years, in return for an annual per acre payment to the landowner.

We are interested in whether or not you would be willing to participate if such a program if it was available in your area. **Please evaluate each of the following nine scenarios and indicate whether or not you would participate in the program based on those hypothetical conditions.**

Scenario	Contract Length	Annual Payment	Program Administration	Would you participate?
1	15 Years	$50 per acre	State Agency	YES ☐ NO ☐
2	30 Years	$25 per acre	State Agency	YES ☐ NO ☐
3	5 Years	$25 per acre	State Agency	YES ☐ NO ☐
4	5 Years	$5 per acre	Federal Agency	YES ☐ NO ☐
5	15 Years	$5 per acre	State Agency	YES ☐ NO ☐
6	15 Years	$25 per acre	Federal Agency	YES ☐ NO ☐
7	5 Years	$50 per acre	Private Company	YES ☐ NO ☐
8	30 Years	$5 per acre	Federal Agency	YES ☐ NO ☐
9	15 Years	$25 per acre	Private Company	YES ☐ NO ☐

☐ I would not participate in any of these programs

Why not? _____

Figure 2. Discrete choice survey question.

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