Determine Certainty Program Framework of a Market Based Conservation Initiative for Longleaf Pine Habitat Improvements in Eastern North Carolina

Longleaf Pine Credit Supply Component Final Report
Component Report 3 of 6

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Executive Summary

This component of our Conservation Innovation Grant analyzed the potential supply of Longleaf pine habitat in Southeast North Carolina for an ecosystem based credit market using landowner surveys and economic analyses of rural land management alternatives.

Results from a logistic regression and a choice-based-conjoint (CBC) statistical analyses revealed that landowners were most influenced by program requirements such as contract length and legal obligation in a conservation contact. Short term contract agreements of 5 to 10 years were favored, as were the least land restrictions. Annual payments were somewhat less important than contract agreement or level of obligation, although higher payments were more desirable, as expected. The initial cost share rate and level of technical assistance were the least important factors affecting willingness to participate in Longleaf conservation programs. The presence of Longleaf pine on the landowner's property, previous participation in a FSA benefits program, a willingness to participate in a permanent easement to promote Longleaf pine, the amount required amount to accept a permanent easement, and ownership of 101 – 500 acres of forest positively impacted landowners' interest in a conservation credit program to promote Longleaf pine habitat. Conversely, persons who were unwilling to participate in a permanent easement were less interested.

The financial and capital budgeting analysis indicated that for Longleaf pine versus Loblolly pine, the incentive payment required for landowners to breakeven and plant Longleaf in the low intensity 2011 analysis at a 4% discount rate, was between $7 per acre and $83 per acre per year, not including establishment costs. If establishment costs of $306 were paid, Longleaf returns would exceed Loblolly returns for the higher site indexes and pine straw raking scenarios. Greater costs in our more intensive 2015 management scenarios resulted in annual incentive payment requirements of $66 to $496 per acre per year for Longleaf to break even and meet the 4% discount rate when converting agricultural land, which are prohibitive at the high end. However, if the initial year costs for mature forest conversion of Longleaf pine tree planting received a 50% cost share rate, required annual payment costs could decrease substantially. Also, if the very expensive $2000 to $2500 per acre shrub establishment practice were dropped, even the intensive Longleaf annual payment rates for mature and planted stands could decrease to less than $100 per acre per year, which is still within current Farm Bill program payment levels. Conversion of good quality agricultural crop land to Longleaf pine would be too expensive based on high 2011 crop prices, but for poor croplands and at current lower 2015 prices, conversion could be economically attractive, especially with prevailing cost share payments.

Introduction

This USDA Conservation Innovation Grant (CIG) project is designed to examine "Market Based Conservation Initiative for Longleaf Pine Habitat Improvements in Eastern North Carolina." This section of the report is a summary of that project with the component of assessing the possible supply of Longleaf pine forests that landowners could provide for Longleaf ecosystem habitat under various conservation market incentives. To draw from the proposals, this report examines two principal questions: (1) assess landowner willingness to supply habitat/species conservation; and (2) analyze the economics of alternative forest investments and the economic returns and opportunity costs for conservation management.

The supply component of the project built on our prior research on conservation programs to identify key components of a successful program. This work was continued with further surveys of landowners in the key counties to assess their willingness to plant Longleaf pine, work with nontraditional partners seeking habitat credits, interact with farm and forestry support agencies, gauge their knowledge of Endangered Species Act issues, and determine cost-share payment rates that might be required to foster credit creation. A map of the counties is shown below. We used one large survey and two statistical methods to examine the interest of landowners in participating in various conservation programs to create, enhance, or restore Longleaf pine ecosystems—a choice based conjoint (CBC) analysis and a regression analysis—as described below.

The economics of returns to setting aside lands for Longleaf pine conservation, or converting other lands to Longleaf, were also estimated in prior research, and updated in this component of the project. In order to increase Longleaf pine habitat, the credit buyers will need to make adequate incentive payments to make supplying credits as attractive when compared to other potential income from higher valued land uses. Economic analyses of Longleaf pine versus alternative land uses were made to estimate the "delta" required—the difference between economic value of current land uses and prospective land uses. This would provide the amount that would be needed to be paid for conservation payments required to increase the Longleaf pine ecosystem as compared to Loblolly pine or agriculture land uses.

Conservation markets need a supply of a product or service—landowners who will supply the service—and demand from some entity to buy the conservation good or service. In the case of conservation credit markets, private landowners may enter into temporary contracts or permanent easements directly with buyers or with brokers to create and ultimately supply credits to individuals, businesses or government entities seeking an investment opportunity, positive public relations coverage and/or to offset damages to the environment. Such agreements can vary in their provisions; however, they generally place stringent land management and legal requirements on the participant in return for financial compensation, regulatory assurances, and program assistance.

Private lands are crucial for ecosystem services and habitat conservation. In the United States, 914.5 million acres of land were classified as farmland (40% of the total area), and there were 2.1 million farms (USDA NASS 2014). In the lower 48 states, about 70% of the *total* land area is in private ownership, and about half of all the land is managed as cropland, pastureland, and rangeland by private landowners (Heard et al. 2000, cited in Gray and Teels 2006). Approximately 65% of *all* land in the United States is owned privately.

For the 766 million acres of *forest* land in all states, the public sector owns a greater share at 321 million ha (42%). There are 445 million acres of private forest land, or 58%, with about 10 million forest land owners. Private noncorporate owners hold 39% (298 million acres) of the nation's forest land and private corporate owners hold 19% (147 million acres). In the South, private non-corporate and family forest owners hold 60% of the forest land, and private corporate owners hold 27% (Oswalt et al. 2014).

Public assistance for natural resource conservation by individuals on private lands is an objective of government and nongovernment organizations, ranging from international, to national, to state, to local scales. There are literally thousands of financial and technical assistance programs and cooperative programs that provide economic incentives for sustainable use, conservation, and protection of natural resources, including land, water, fish and wildlife, forests, rangelands, and croplands.

Various conservation programs provide payments to encourage private landowners to perform conservation practices on their land. The structure of the payments required, contract of easement terms, and technical assistance required influence the enrollment in and success of the programs. Longleaf pine has become an important conservation

priority in the South in last decade or so, and we examined the economics and program characteristics that would encourage private landowners to plant or restore more Longleaf. Approximately 4.7 million acres of Longleaf pine (LLP) exist in the Southeast region, of which 61% are on private lands (ALRI 2014). Given these conditions, successfully promoting LLP habitat through the implementation of a credit market hinges on its widespread adoption by private, non-industrial landowners. LLP is most noted for its ability to provide habitat for the endangered red cockaded woodpeckers (RCW), but has many other broad biodiversity and ecosystem functions and values that would make it attractive as a credit market opportunity.

This section of the report is divided into three parts. First, we review current literature on landowner interest in conservation in southeastern U.S. Second, we analyze a survey conducted of landowners in 38 eastern North Carolina counties to examine how they prioritize provisions of a theoretical performance contract and the variables associated with interest in Longleaf pine (LLP) conservation. Finally, we evaluate three traditional income generating activities (LLP for timber, Loblolly for timber, and agriculture production) to better understand the level of compensation needed to attract market participants.

Brief Literature Review

Considerable research has examined landowner views and interest in conservation in the Southeast U.S. in North Carolina. Rodriquez et al. (2012) found landowners prefer contracts to permanent easements and while many were interested in protecting endangered species, it was the lowest priority among conservation issues. They also found interest in conservation was negatively correlated with age and positively correlated with past participation in conservation programs, positive perceptions of endangered species protection, and lower property requirement scores. Golden et al. (2012) studied North Carolina landowners and found that they are more likely to be interested in wildlife conservation if they resided on their property, hunt and/or have a family member that hunts and were younger and male.

Although the terms of conservation performance contracts may vary, they usually contain several common attributes including, but not limited to: length; legal obligation to maintain land during and after contract; financial assistance to help with establishment costs; incentive payments to compensate for potential loss in income; and level of

program assistance received prior to and during the contract period. Some research has used novel approaches to shed light on how landowners prioritize such conditions. For instance, Sorice et al. (2013) studied family-forest landowners in southeast U.S., using a choice model to determine preferences for participation in a program to protect the gopher tortoise. They found a strong aversion to strict regulatory programs, or ones that require permanent easements, or put landowners at risk of future regulation.

In general, conservation programs may provide contracts, which are temporary legal agreements between the program's managing agency and a landowner, and easements, which are permanent changes in the rights to use the land. Conservation contracts usually provide a specific cost-share payment for establishing a conservation practice, and usually have annual payments for maintaining those practices. The cost-share payment covers a portion of the costs that landowners incur when performing a practice, ranging from 50% to 100% depending on the needs, the practice, the state, and the type of landowner. The annual payments may occur for a decade or more for conservation contracts, where the landowner agrees to keep a practice in place for the duration of the contract. Landowners also may enter into a long term or permanent easement—which is a specific legal instrument that mandates they perform a practice or restricts their land use rights, and is registered on the title to their land. This may include some establishment costs, and then a fixed payment for the easement rights, usually as a lump-sum up-front payment (Cubbage et al. 2016).

Easement agreements are more expensive than conservation contracts, and less common, but still prevalent. Most landowners are apt to prefer short-term easements with payments for a fixed term, so they can break a contract if need be, or simply wait until it expires before changing the conservation practice or land use. However, landowners who truly want to protect and conserve their land use in perpetuity, and receive a greater payment for themselves, not their heirs, may prefer to sell their land with a permanent conservation easement, or just sell the conservation easement and retain the land (Cubbage et al. 2016).

Landowner Interest in Longleaf Conservation Programs

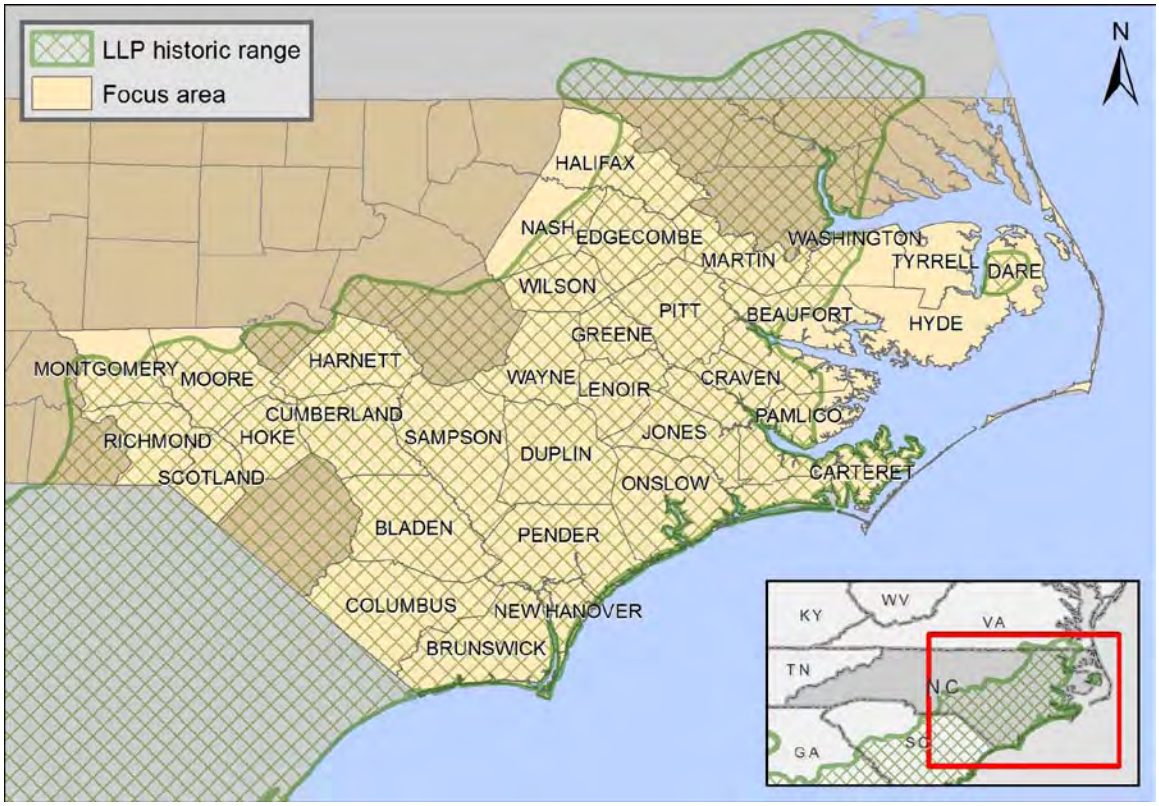
Per the objectives of this Conservation Innovation Grant, we used two broad methods to gauge the interest of landowners in establishing Longleaf pine conservation programs. First, we performed a survey of landowners to estimate their interest and the factors that

influenced that interest. Second, we calculated the economic returns to growing Longleaf pine versus Loblolly pine or agriculture crops. These efforts are described below.

Landowner Survey Methods

We conducted a survey of landowners in 38 counties in eastern North Carolina that fell within the historical Longleaf pine range as identified by the Longleaf Alliance strategic plan (Figure 1).

Figure 1. Map of Conservation Innovation Grant Longleaf Pine Project Area



Working with various forest and agriculture associations and cooperative extension agents, we developed a sampling list and frame composed of (1) individuals for whom the research team has secured personal email addresses, and (2) organizations who would rather not share internal information, but agreed to send our emails with links to the survey directly to landowners on our behalf. Many drafts of the survey were developed, reviewed by the project personnel, presented for discussion at CIG stakeholder meetings,

and revised for the final survey instrument. The surveys were reviewed by the NC State University Institutional Review Board and approved before sending them out.

Data were collected from respondents through a pre-tested questionnaire constructed and administered on an online server hosted and maintained by North Carolina State University. Approximately 1,000 survey requests we sent electronically and another 2,000 via regular postal service mail. These requests asked landowners to go to the web site to complete the survey, since part of the survey specifically required web replies. Our sample included 374 landowners (only 243 completed the entire survey) who owned forest, agriculture land or a combination thereof with acres ranging from less than 50 acres to more than 5,000 acres.

The survey consisted of two parts. First, it asked one open ended question (age) and 25 multiple choice questions related to respondents' demographics, land characteristics, interest in conservation programs and easements, having management plans, participation in the North Carolina deferred tax program based on agriculture, forestry or wildlife usage (present use value (PUV)), and using Natural Resource Conservation Service (NRCS) and Farm Service Agency (FSA) benefits/cost-share programs. We also included a question on their willingness to participate (WTP) and the amount required to participate (willing to accept: WTA) in making a permanent conservation easement. Table 1 summarizes the independent variables measured from the survey.

Table 1. Independent Variables Measured

Variable	Options
LL Cons Interest	Yes, No, I don't know
Currently has LLP	Yes, No, I don't know
Present Use Value Registered	Yes, No, I don't know
Receives FSA Benefits	Yes, No, I don't know
Receives NRCS Benefits	Yes, No, I don't know
Agriculture Management Plan	Yes, No, I don't know
Forest Management Plan	Yes, No, I don't know
Conservation Program for Ag Land	Yes, No, I don't know
Forest Management Plan, Who Helped	NC Forest Service, NC Wildlife Resources Comm, Consultant, Yourself, Other
Age	Years
Gender	Male, Female
Education	High School, Tech, Associates, Bachelors, Graduate
Acres Forest Owned	1-49, 50-100, 101-500, 501-999, 1,000-4,999, 5,000+
Acres Ag Owned	1-49, 50-100, 101-500, 501-999, 1,000-4,999, 5,000+
Income	<$24,999, $25-$49,999, $50-$74,999, $75-$99,999, $100,000+
WTP Perm Easement	Yes, No, Depends on Payments/Property Requirements, Not Sure
WTA Perm Easement	$500, $1,000, $2,000, $2,500, Other (please specify)

Statistical Analysis

We analyzed the data using regression analysis and conjoint-based choice analysis. Using these two methods provided a means to triangulate on landowner interest and opinions using two approaches, providing more robust results.

Regression Analysis.—We analyzed the data from the survey using SAS JMP Pro Version 12.0.1. First we developed a correlation matrix to examine the relationships of variables measured and identified those with a correlation coefficient with the variable Interest in a Longleaf Pine Conservation Program (LLPInterest) greater than 0.1. These were organized into four conceptual categories based on landowner's wealth, past participation in a benefits program, interest in participating in a future credit program, and land characteristics. We then ran separate Ordinary Least Squares (OLS) regressions taking the variable Interest in a LLPInterest as a function of all the others and recorded their parameter estimates and p-values.

Based on the OLS models and correlation matrices, we used the best selected variables in a logistic regression model using SAS JMP procedure Nominal Logistic to estimate those that had the most impact on LLPInterest—the likelihood that landowners would be interested in planting or restoring Longleaf pine.

The regression model forms then were:

Ordinary Least Squares:

$$P = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_3 X_n$$

Logistic Regression

$$P = \beta_o X_1^{\beta 1} X_2^{\beta 2} \ldots X_n^{\beta n}$$

Where:

P = willingness to participate in a Longleaf pine conservation program
X_i = various land and landowner characteristics

Choice-Based-Conjoint Analysis.—The second part of the survey required respondents to select an ecosystem credit program scenario among those presented in 12 choice tasks (a choice task consisted of two different randomly generated scenarios and one 'I don't know'). Table 2 shows the five attributes included in each scenario along with their descriptions and possible levels. This portion of the survey, or the choice-based-conjoint (CBC) analysis, was analyzed using Sawtooth Software version 8.2.0, Orem, UT. CBC poses questions in a way that reflects how people make choices and enabled us to examine landowners' underlying values and preferences as they relate to environmental, land use, and economic concerns.

Table 2. Attributes with Importance Scores and Descriptions

Attribute	Levels	Description
Contract Length	5, 10, 20, 30	Number of years required by contract
Obligation	None, Baseline, Full	Landowner's legal obligation to maintain habitat
Annual Payment	$25, $50, $75, $100	Payment per acre received by landowner
Cost Share	25%, 50%, 75%, 100%	Percent of $300/acre establishment cost
Assistance Level	None, Prior Consult, Full Consult	Outside help to manage the land under contract

Most of the choice-based-conjoint analysis values are self explanatory, including contract length, annual payment, cost share rate, and assistance level. Obligation covers how the landowner is to manage their land once the contract ends. It has three values: none means there are no restrictions; baseline would require continued management based on some identified level of wildlife animal or plant species abundance; and full would have landowner manage per contract terms until the endangered species is delisted. The cost share percentage represents the possible program benefits to provide financial compensation to establish the forest.

Landowner Survey Results

Descriptive Statistics.—Table 3 summarizes the descriptive statistics of the survey data. Respondents averaged 62 years of age and were predominately male (82%) and retired (42%) or employed full time off property (34%). Households with annual earnings of $50,000 and $100,000 and greater than $100,000 made up 46% and 39% of the sample, respectively. Some landowners resided outside of project area, but would have to owned land or attended conservation programs that in the area in order to be included in our survey.

Table 3. Descriptive Statistics for Survey Participants

Survey Participants	Completed (244) Started but did not complete (132)
Sex	Male (81.8%) Female (18.2%)
Employment	Full-time (33.6%) Part-time (3.1%) Unemployed (.4%) Disabled (1.3%) Retired (42.4%) Self-employed (19.2)
Education	<High School (.4%) High School/GED (12.8%) Vocational/Tech (10.7%) Associates (14.5%) Bachelors (37.2%) Graduate/Professional (24.4%)
Household Earnings	<$24,999 (4.6%) $25-49,999 (11.1%) $50-74,999 (23.6%) $75-99,999 (22.2%) $100,000+(38.4%)
Presence of LLP on Property	Yes (57.7%) No (28.3%) Not Sure (14%)
Forest Management Plan	Yes (67.9%) No (29.1%) Not Sure (3%)
Ag Conservation Plan	Yes (27.5%) No (60.4%) Not Sure (12.2%)
Present Use Value	Yes (68.1%) No (13.4%) Not Sure (18.5%)
FSA Benefits Program	Yes (52.1%) No (34.5%) Not Sure (13.4%)
NRCS Benefits Program	Yes (38.7%) No (50.4%) Not Sure (10.9)
County Participant Resides	B Bertie (.4%) Bladen (3%) Brunswick (1.7%) Carteret (1.7%) Cabarrus (.9%) Caswell (.9%) Columbus (1.7%) Craven (.4%) Cumberland (10.3%) Dare (.4%) Davidson (.4%) Duplin (2.6%) Halifax (.9%) Harnett (8.6%) Hoke (2.6%) Gatson (.4%) Guilford (.9%) Johnston (6%) Jones (1.3%) Lee (.4%) Lenoir (1.3%) Mecklenburg (1.3%) Montgomery (3.9%) Moore (11.6%) New Hanover (.4%) Onslow (2.6%) Pender (3.9%) Pitt (1.7%) Randolph (1.3%) Richmond (1.3%) Robeson (.4%) Sampson (6.5%) Scotland (1.3%) Union (.4%) Wake (3.9%) Watauga (.4%) Wayne (10.3%) Wilson (.9%)

A large share of respondents reported having Longleaf pine on their property (58%), a forest management plan (68%), PUV (68%) and to a lesser extent a conservation plan for their agricultural land (28%). Finally, 52% and 39% have participated in a FSA and NRCS benefits program, respectively. These are high rates of Longleaf forests and farm programs due to the fact that we obtained our survey samples from existing program participants. This may provide some upward bias in the landowners' willingness to participate in Longleaf programs, but was unavoidable in order to get an adequate sample at all.

Table 4 provides a breakdown of respondents by land ownership type. For instance, 80% of landowners with 1-49 acres of forest also own 1-49 acres of agriculture land. Similarly, 50% of landowners with 1-49 acres of agriculture land also own 1-49 acres of forest. However, there are very few large forest landowners that own large amounts agriculture land. But the large agriculture landowners tend to own large amounts of forest as well. One might expect this since the state is 60% forested, and forests will tend to rest in streamside zones, swamps, or hillsides on almost any farm in the state.

Table 4. Land Characteristics of Survey Participants

Forest Landowners by Acres with Agricultural Land							
Acres of Ag	1-49	50-100	101-500	501-999	1000-4999	5000+	
1-49	80%	33%	37%	26%	19%		
50-100	15%	39%	30%	26%	14%		
101-500	5%	26%	27%	32%	48%	100%	
501-999		2%	5%	11%	10%		
1000-4999			2%	5%	10%		
5000+							**Total**
Forest Owners with Ag / Total Forest Owners	59/84	51/69	60/92	19/23	21/29	2/2	**210/299 (70.2%)**

Agriculture Landowners by Acres with Forests							
Acres of Forest	1-49	50-100	101-500	501-999	1000-4999	5000+	
1-49	50%	16%	6%				
50-100	18%	36%	26%	13%			
101-500	23%	33%	32%	38%	25%		
501-999	5%	9%	12%	25%	25%		
1000-4999	4%	6%	20%	25%	50%		
5000+			4%				**Total**
Ag Owners with Forest /Total Ag Owners	95/103	55/57	50/50	8/8	4/4		**212/222 (95.5%)**

Regression Analysis.—Tables 5 and 6 provide information on the relationship of those variables that affected interest in Longleaf pine conservation programs (LLPInterest). The p-value measures the significance of the results, and generally those less than .05 are considered strong, between .1 and .05 significant, and greater than .1 weak. Since p-values can be very small, the statistical package provides a Logworth value which can help more clearly interpret the significance and, if necessary, graph the results (P-values and Logworths are inversely related). The Logworth estimator provides information about the magnitude of the variable and how much it positively or negatively impacts the dependent variable, in this case LLPInterest.

Table 5 shows that presence of Longleaf pine on the landowner's property, previous participation in a FSA benefits program (FSABenefits), a willingness to participate in a permanent easement to promote Longleaf pine (a yes or no answer, depending on the property requirements; variable WTP Depends on Property Requirements), the actual required amount to accept a permanent easement ($2,500), and ownership of 101 – 500 acres of forest positively impacted landowners' interest in a conservation credit program

to promote Longleaf pine habitat. Conversely, Table 6 shows that those less likely to be interested included persons who were unwilling to participate in a permanent easement.

Table 5. Positive Significant Variables, LLPInterest

Variable	P-Value	LogWorth	Est.
CurrentLLP (Yes)	0.00459	2.338	0.5154
WTA ($2,500)	0.01828	1.738	0.4983
FSABenefits (Yes)	0.03864	1.413	0.3805
WTP (Depends Property Req.)	0.04367	1.36	0.4917
Acres Forest (101-500)	0.10482	0.98	0.3374

Table 6. Negative LLPInterest Correlation

Variable	P-Value	LogWorth	Est.
WTP (No)	0.00006	4.23	-0.8093

These all make intuitive sense—existing program and FSA participants were likely to be interested in Longleaf programs as well, and higher payments for easements would encourage more participation. Owners with medium sized forest tracts of 101 to 500 acres were the most likely to be interested; small and large forest owners were not. However, ownership size of agricultural land had no effect on interest in program participation. Similarly, education, employment, income, and gender had no effect on landowners' interest in participation. Neither did having forest or farm management plans or being enrolled in PUV programs. NRCS program participation may have been influential as well, but less so than FSA use, so it was eliminated in the first OLS regressions in order to avoid a high correlation between independent variables in the logistical regressions.

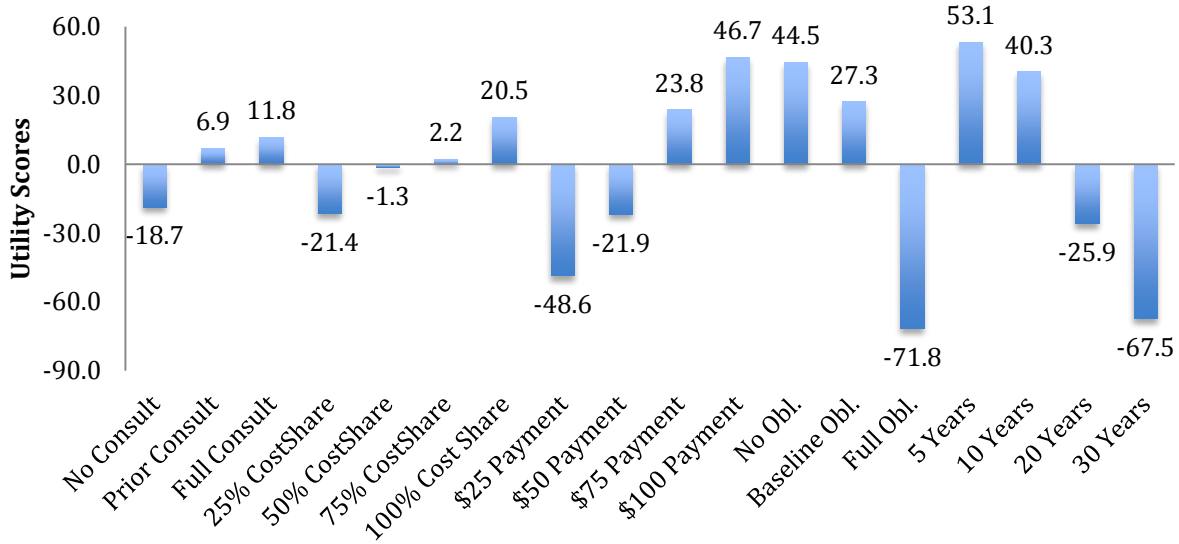
Choice-Based-Conjoint Analysis.—The CBC analysis provides insight into how landowners prioritize the program scenario attributes by assigning relative importance scores to each, as seen in Table 7. A higher score represents a greater value placed on the attribute by the respondents. Contract length, level of obligation and annual payments were identified as the most important factors to landowners. Conversely, cost share and technical assistance level both scored comparatively low.

Table 7. CBC Attributes with Importance Scores

Attribute	Score
Contract Length	28.40%
Obligation	25.90%
Annual Payment	20.80%
Cost Share	12.40%
Assistance Level	11.40%

This CBC analysis also enables us to examine how values within each attribute fared by providing total zero-centered utility values for each (only levels within an attribute can be compared), as seen in Figure 2. Again, higher scores represent a greater preference by the survey respondent. Generally speaking, there is a linear relationship as we move among the attributes' values. For instance, respondents showed a steady decreasing preference for greater contract lengths. Conversely, preference steadily increased with greater assistance levels, cost share percentages and incentive payment amounts. Obligation preference decreased slightly between no obligation and baseline obligations, but dropped radically for full obligation.

Figure 2. Utility Scores for CBC Attributes



Financial Analysis and Capital Budgeting for Alternative Investments

We performed another analysis of the interest that landowners might have in Longleaf pine using economic discounted cash flow analyses of potential investment returns for Longleaf versus Loblolly pine or agriculture crops. Glenn (2011) performed a financial and capital budgeting analysis of Longleaf pine management that we updated here for another perspective on landowner requirements to establish Longleaf habitat. This analysis examines managing for Red Cockaded Woodpecker habitat (LLP RCW) compared to managing Longleaf pine for timber (LLP Timber) in comparison to Loblolly pine for timber (Loblolly Timber) and agricultural crop production. The differences between Longleaf pine and the other two land uses provide an estimate of the discounted costs that a landowner would have to receive in order to shift from the generally more profitable uses to Longleaf pine.

In addition to the work by Glenn based on 2011 prices, we estimated new investment returns as well for more intensive Longleaf pine management alternatives and 2015 prices. We did not update the Glenn results for inflation, but that still should be less than 10% different than in 2015. Updating them without recalculating all the discounted cash flows would have been more arbitrary than keeping them in their original form. The management assumptions and results from Glenn were essentially a low intensity approach to Longleaf pine management, without any extremely detailed or expensive efforts to create perfect Longleaf ecosystem habitat for RCWs. The objective was mostly to plant and grow Longleaf, either for short (45 year timber) or long (80 year timber/RCW) rotations, with the presumption that the longer rotations would be most conducive to RCW. The 2015 estimates assumed a much higher level of management intensity, including understory restoration, foresters' fees, timber inventory, and timber marking. Thus this led to much higher costs, and less profits for Longleaf pine. The opportunity costs of growing Longleaf pine versus Loblolly or crops also were higher.

Management Assumptions, 2011

We defined the opportunity cost of implementing a land management regime to support Longleaf pine ecosystem credits as the transaction costs necessary to meet RCW habitat

requirements plus the foregone revenue from timber production or row crop agriculture. Assumptions on prescribed burning and thinning frequencies, as seen in Table 8, were based on literature review and discussions with Ron Myers from the North Carolina Forest Service (NCFS) in 2011. Although LLP Timber could be managed to accommodate lower amounts of RCW habitat and natural pine ecosystems, we assumed it was managed for maximum timber and thus ineligible for credits.

Table 8. Land Management Scenarios Examined for Discounted Cash Flow Analysis

Management Type	Rotation	Prescribed Burning	Thinning Schedule
Longleaf RCW	80 years	Every 5th year in years 45 to 80	40/60 years, 80ft2/60ft2 basal area
Longleaf Timber	40 years	Years 12 and 29	28 years, 80ft2per acre basal area
Loblolly Timber	25 yeas	NA	Year 7
Agriculture Crops	Every Year	NA	NA

Annual growth and volume for Longleaf were estimated using three Longleaf pine growth and yield models: NATYIELD (1986), Farrar (1985), and Lohrey and Bailey (1977). All three provided comparable yield curves, so we used NATYIELD because it was based on North Carolina data. It does have coefficients and yields similar to those specified by Lohrey and Bailey (1977). Land management practices and costs for Longleaf pine such as site preparation, tree planting, stand stocking and maintenance reflect prevailing practice rates and were taken from NCFS (2011). The first thinning contained 25% pulpwood and 75% chip-and-saw and the second thinning and final harvest contained 20% chip-and-saw, 50% sawtimber, and 30% large sawtimber.

Using a conventional Loblolly pine scenario, the thinning and harvest volumes and management regime were based on prior research by Siry et al. (2001) and Cubbage et al. (2012), which used the TAUYIELD growth and yield model. The planting rate was 600 trees per acre with a site index (SI) of approximately 80 feet at age 50. Thinning volume was 475 ft^3 per acre at age 17, comprised of 75% pulpwood and 25% chip-and-saw. The final harvest volumes were 2,225 ft^3 per acre at age 25, comprised of 23% chip-and-saw wood, 67% small sawtimber, and 10% large sawtimber.

Agriculture yields were based on model farm budgets for the Coastal Plain of North Carolina derived from NC State Cooperative Extension Service (2012, 2016) data for corn and soybeans. The average yields were 110 bushels of corn per acre and 35 bushels of soybeans per acre in both analyses, with corn selling for about $8 per bushel and beans for $12 per bushel in 2011. These returns assumed that farmers could plant the same field in corn or beans in perpetuity. This is of course not possible, but making a simulation with various crop rotations and returns would be even more difficult to understand and estimate.

The base 2011 crop analysis assumed constant excellent crop prices and good weather patterns, with no droughts, floods, hurricanes, or other disturbances. Prices since then also have dropped significantly. Thus for sensitivity analyses, we recalculated the returns for 2015, based on the latest (still only 2012) crop budgets and the 2015 Coastal Plain prices of $4.50 per bushel of corn and $8.50 per bushel of soybeans (USDA Agricultural Marketing Service 2016).

Thus the 2011 crop budget comparisons provide an upper range of possible crop yields and agriculture land profits. Mixed crop production systems and more typical wide weather variations would be more apt to reduce these agricultural land value estimates and opportunity costs than they would for timber and Longleaf pine in particular, which are much better adapted for weather stress. In addition, while timber prices fluctuate, and indeed were at a low level in 2011, crop prices have dropped in greater amounts since 2011, and have more price risk in free markets without government crop insurance subsidies.

Capital Budgeting Methods

We used a standard capital budgeting approach to assess the present value (PV) and Land Expectation Value (LEV) of each land management option to determine their economic values (Klemperer 2003, Wagner 2012). LEV provides a measure of the value of a management regime into perpetuity and allows one to compare multiple regimes with different time frames (e.g., 25 years of active Loblolly management vs. 80 years at a Longleaf stand). We used a 4% real discount rate, which is consistent with other forest economic and investment analyses that have examined Longleaf pine financial returns (Cubbage et al. 1989, Johnson 2011, Roise et al. 1991, Kessler et al. 1991, Row et al. 1981).

Calculated values were organized by Site Index (SI) at age 50 and pine straw value within each land management scenario. Longleaf pine SI 70 is representative of sites in the eastern coastal plain region and reflects realistic returns from good sites in North Carolina. Pine straw was assumed to be harvested every three years from ages 16 to 40. We used three pine straw revenue scenarios: (1) no harvest (zero value), (2) conservative value ($75/acre per harvest) and (3) moderate value ($125/acre per harvest), representing low to mid-range literature estimates and local pine straw sales in North Carolina (Dickens et al. 2012).

For comparison, Bladen Lakes State Park 2011 pine straw sales ranged from $150 to $300 per acre (Michael Chesnutt, personal communication), and are harvested almost every year. Thus we were relatively conservative in our estimates of pine straw value, but this should be more consistent with RCW habitat management in order to transition the stands from mixed timber and straw production into RCW conservation uses.

The LEV of LLP RCW was compared to those of LLP Timber, Loblolly Timber and agricultural crop production to determine the opportunity cost associated with adopting this land management regime. From this, we calculated the annual payment to landowners, in a theoretical 10-year contract, necessary to make them indifferent between LLP RCW and the other scenarios. This payment is equivalent to common conservation programs such as the Conservation Reserve Program (CRP). Rodriguez et al. (2012) identified ten years as the contract length that landowners preferred for conservation programs in counties in eastern North Carolina.

Financial Results, 2011

For the 2011 low intensity management analysis, the LEVs of LLP RCW and LLP Timber were calculated using the different pine straw values mentioned above, an $8 annual property tax, and stumpage prices averaged from 4th Quarter 2011 Forest2Market and Timber Mart-South reports that include $7.93/ton for pulpwood, $14.88/ton for chip-and-saw, $25.41/ton sawtimber and $56.32/ton for large sawtimber (Forest2Market 2011, Timber Mart-South 2011).

Table 9 compares the 2011 LEVs for Longleaf pine with a timber production focus and a RCW conservation at the selected 4% discount rate. It also shows the difference in the LEVs between the two scenarios, with a range of three pine straw production options. This difference between the returns then provides a net cost to grow Longleaf pine for RCW conservation. This total difference in the LEV amount was then converted to the value of a 10 year annual annuity contract, which is typical for Farm Programs like the Conservation Reserve Program (CRP).

Table 9. Longleaf Pine for RCW Habitat Opportunity Cost per Acre versus Longleaf Pine for Timber Production Revenue, 2011, 4% Discount Rate

Site Index	Pine Straw Value	LLP RCW LEV	LLP Timber LEV	Opportunity Cost LEV	10-year Contract Annual Payment
60	None	-$498	-$140	$358	$42
	Conservative	-$218	$105	$323	$38
	Moderate	-$54	$303	$357	$42
70	None	-$398	-$3	$395	$47
	Conservative	-$124	$243	$367	$44
	Moderate	$40	$441	$401	$48
80	None	-$283	$143	$426	$51
	Conservative	-$19	$387	$406	$48
	Moderate	$145	$585	$440	$52

This annual payment value would represent the “breakeven” opportunity costs and the annual payments necessary to make landowners equally willing to grow Longleaf pine for RCW conservation versus for timber production. Converting existing Longleaf stands to longer rotations is probably the easiest of the potential land use changes that owners may consider. It of course might take even greater annual payments to actually induce landowners to shift from existing Loblolly pine or agriculture systems to Longleaf pine systems.

To illustrate the opportunity cost comparison, at Site Index 70 with a conservative pine straw raking system, Longleaf for timber production would yield a LEV of $243 per ac; Longleaf for RCW habitat would “lose” $124 per acre. Thus the LEV opportunity cost would be $367 per acre, which would require an annual payment of $44 per acre for 10 years at a 4% discount rate to make the LLP RCW habitat regime as profitable as the LLP timber production regime.

One generic base level LEV was calculated for planted Loblolly pine timber, Site Index 80, 25 year rotation. Loblolly pine would not have a pine straw component. We used the same prices as Longleaf pine for each product class, and a $242 establishment cost, $8 annual tax, $103 income at Year 17 from thinning and $1,305 income at year 25 from harvest. Table 10 compares the LEVs of the LLP RCW and the base Loblolly Timber scenarios, their opportunity costs and the required payments to landowners under a 10-year contract.

Again, an example helps clarify the opportunity cost concept for Loblolly pine versus Longleaf pine for RCW habitat. Loblolly pine had an LEV of $221 per acre; conservative Longleaf, SI 70 had a LEV of -$124 per acre. Thus the net difference is $325 per acre, which converts to a ten year annual payment of $71 per acre at the 4% discount rate.

Table 10. Longleaf Pine RCW Opportunity Cost per Acre versus Loblolly Pine for Timber Production with an LEV of $201 per Acre, 2011, 4% Discount Rate

Site Index	Pine Straw Value	LLP RCW LEV	Opportunity Cost LEV	10-year Contract Annual Payment
60	None	-$498	$699	$83
	Conservative	-$218	$419	$50
	Moderate	-$54	$255	$30
70	None	-$398	$599	$71
	Conservative	-$124	$325	$39
	Moderate	$40	$161	$19
80	None	-$283	$484	$58
	Conservative	-$19	$220	$26
	Moderate	$145	$56	$7

The best case agricultural scenarios assumed average North Carolina Coastal Plain crop returns for corn and soybean farms each year into perpetuity, with annual profits of $67.57 and $159.92 per acre, respectively (NCSU 2012). As noted, these assumptions were optimistic and assumed that farmers would get average yields, maintain the current high crop prices, and encounter no weather or climate issues. LEVs for corn and soybeans were $1,757 and $4,158 respectively using 2011 prices, indicating opportunity costs of between nearly $2,000 to more than $4,000 per acre to make LLP RCW returns equal to agriculture returns when direct costs are included.

These best case agricultural returns are much higher than the highest Longleaf pine versus Loblolly pine forestry opportunity cost of $699 per acre. However, this would be a theoretical upper bound of the opportunity costs for crop farming given there are few sites in North Carolina that grow corn or beans forever.

As one more recent comparison, net crop returns based on the much lower 2015 prices would be approximately $42 per acre for corn and $26 per acre for soybeans. Capitalized in perpetuity at the 4% discount rate, these would be values of $1050 per acre for corn and $650 per acre for soybeans. Thus these opportunity costs between a $-124 for Longleaf pine and corn would be $1174 per acre; for soybeans it would be $774. These are obviously less daunting than in 2011.

Poorer agriculture land, or even quite common variations in weather, would reduce these theoretical annual crop returns greatly, and might make at least even marginal agricultural lands in North Carolina more possible to convert to forestry or to Longleaf pine using incentive payments. A more detailed analysis of dozens of different agriculture crop rotation, weather, and price fluctuations would be necessary to examine these prospects.

Marginal agricultural lands may be more attractive for conversion to RCW habitat. An economic analysis of marginal farmland in North Carolina found that between 2007 and 2012 both corn and soybean crops generated negative returns, averaging annual losses of -$174 per acre for corn and -$41 per acre for soybeans (Cubbage et al., 2012). If these losses were repeated annually, as the positive returns were repeated in the simplified agricultural analysis, they would lead to LEVs of -$4,524 to -$1,066 per acre. These findings would be even worse in 2015. Thus when compared with annual risks and potential losses from agricultural crops, forestry investments can produce suitable positive investment returns on poor agricultural sites that may not be as fertile or that are more susceptible to drought and flooding. In fact, for poor agricultural lands and current 2015 prices, Loblolly pine and even Longleaf pine would be more profitable in the long run than corn or beans, even without cost share payments.

Sensitivity Analysis: Changes in Stumpage Prices and Cost Share Payments, 2011

A sensitivity analysis was conducted to examine the effect of timber prices on the opportunity costs for Longleaf RCW habitat scenario. The preceding analyses are based on timber prices from fourth quarter of 2011, which were at modern historical low levels for the southern U.S. Thus we increased stumpage prices by a factor of 1.5; this increased the conventional Loblolly LEV to $635 per acre (compared to $201). Longleaf timber prices also were increased, but one would need to wait longer to realize these returns than for the shorter rotation Loblolly pine.

Table 11 presents the 2011 Longleaf pine LEVs, opportunity costs, and payments. Although the value of each Longleaf pine investment improved with higher timber prices, the difference between it and the conventional Loblolly income, and thus the opportunity cost, grew because timber became a more important part of total revenues than pine straw, and the Loblolly timber revenues occurred sooner.

Again, for the Conservative SI 70 example, Longleaf RCW LEV was $11 per acre; the Loblolly base LEV was $635 per acre; the opportunity cost was $624 per acre; and the ten year annual payment required was $74 per acre. This pattern could be expected to emerge for LLP Timber as well given that proportional timber revenues would outpace fixed pine straw revenues. Pine straw prices could increase as well, although we did not analyze this because they were at historic high prices, not low ones like timber.

Table 11. Longleaf Pine RCW Opportunity Cost per Acre versus Loblolly Pine for Timber Production, with an LEV of $635 per Acre, 4% Discount Rate, Timber Prices of 1.5 Times more than in 2011

Site Index	Pine Straw Value	LL RCW Habitat LEV	LEV Opportunity Cost	10-year Contract Annual Payment
60	None	-$382	$1,017	$121
	Conservative	-$129	$764	$91
	Moderate	$36	$599	$71
70	None	-$233	$868	$103
	Conservative	$11	$624	$74
	Moderate	$176	$459	$54
80	None	-$61	$696	$83
	Conservative	$170	$465	$55
	Moderate	$334	$301	$36

North Carolina provides state and federal cost share programs that offer financial assistance for planting Longleaf pine. These programs can have a tremendous impact on financial returns, especially when compared to Loblolly pine since its cost share rate is lower. An example of such a program is USDA's NRCS Environmental Quality Incentives Program (EQIP) that has cost shared up to 100% of establishment and maintenance activities for Longleaf pine (USDA NRCS 2012a, 2012b). Assuming a minimum payment from EQIP, the opportunity cost between Longleaf and Loblolly pine was greatly reduced and in many cases disappeared.

Table 12 presents opportunity cost and payments when a cost share of $306 per acre, to cover establishment costs, is included. The same SI 70 Longleaf conservative pine straw case would then have a positive LEV with cost share payments of $195 per acre, versus the Loblolly base case of $201 per acre. Thus the RCW Longleaf LEV opportunity cost would be only $6 per acre, or essentially require no annual conservation payment (e.g., $1 per year for 10 years).

In fact, landowners would receive a conservation payment of $50 per acre or so for 10 years in the EQIP program, generating a LEV of $456 per acre at 4% discount rate. So Longleaf for RCW habitat actually would become a much preferred alternative to Loblolly pine—$450 per acre better in fact with the EQIP cost share payment and annual payments. This helps explain why landowners have been eager to enroll in the Longleaf

programs for planting Longleaf pine, and the EQIP program has been fully enrolled of even oversubscribed when it has been available.

Table 12. Longleaf Pine RCW Opportunity Cost per Acre with $306 per acre Cost Share Payment for Planting versus Loblolly Pine for Timber Production with an LEV of $201 per Acre, 2011, 4% Discount Rate

Site Index	Pine Straw Value	LL RCW Habitat LEV	LEV Opportunity Cost	10-year Contract Annual Payment
60	None	-$178	$379	$45
	Conservative	$102	$99	$12
	Moderate	$266	NA	NA
70	None	-$79	$280	$33
	Conservative	$195	$6	$1
	Moderate	$359	NA	NA
80	None	$36	$165	$20
	Conservative	$301	NA	NA
	Moderate	$465	NA	NA

[1]NA- In several cases the Longleaf pine LEV with establishment costs being paid now exceed Loblolly pine's LEV ($201) and opportunity cost is not applicable.

Management Costs and Present Values for RCW Habitat, 2015

Managing Longleaf pine stands specifically for RCW habitat require specific practices and their associated costs vary depending on site conditions. This analysis of a higher intensity of management with 2015 costs compared two more scenarios: (1) artificial replanting on agricultural lands—such as shown above for the 2011 input costs and prices—and (2) conversion of existing mature stands.

Practices Required for Longleaf Pine Conversion or Existing Stand Management.— Our high intensity scenarios for converting agriculture lands into Longleaf pine habitat for RCW or for managing mature existing stands that have a Longleaf pine component for RCW were significantly more involved. For conversion from agriculture, there were seven distinct management steps, including:

- Scalping, burning and applying broad-spectrum herbicides to eliminate Bermuda grass, fescue, or whatever common field grass is growing on the site;

- Machine or hand planting (associated costs include seedlings, labor and the periodic application of herbicide while planting);

- Prescribed burns, herbicide treatments or both until trees grow out of their grass stage and obtain height (it may be necessary to do two prescribed burns and one application of herbicides after planting, but before age five);

- Introducing fire on a rotational basis when trees begin to average 2.5 to three feet in height and over 1.5 inches in diameter (one fire per stand every three years until year 75);

- Conducting understory restoration (old agricultural fields are usually void of original native understory plants);

- Conducting two to three thinnings, timber marking and inventorying every 10 to 15 years; and

- Depending on landowner characteristics and preferences,

    - Hiring a forester (for larger landowners) or retaining a consultant, based on the amount of work required and the skill of the forester;
    - Hiring a third party contractor to track, monitor and inventory RCWs to meet the requirements of US Fish and Wildlife Services; and/or
    - Maintaining such things as roads and gates, property taxes, and boundary marking.

In contrast to planting bare fields, converting mature stands with the target age class structure (assumed here to be 75 years old with 45 to 75 square feet of basal area per acre), or potential for it, requires less intensive management activities. On the other hand, replanting cutover forest sites requires more management activities to clear a site and prepare it for planting.

Appendix 1 provides a list of the activities required to convert agriculture land for RCW habitat (assumed to occur in year 50) and to maintain mature stands at a basal area of 60 sq. ft. /acre; their associated descriptions for low and high intensity management regimes; and their associated cost estimates for each of the practices required, at a high and low end of the range for those costs.

Discounted Cash Flow Value of Costs.—Table 13 provides a breakdown of both the present value of costs to convert agricultural land and the LEV to manage mature forests into perpetuity. It also provides the LEV for annual fees that occur in both management scenarios.

Table 13 values were calculated using the same 4% real discount rate to determine the total value of converting, then managing, agricultural lands into RCW habitat into perpetuity. The conversion cost is added to the discounted cost of managing mature forests in order to calculate the total present value of the costs for our analysis for costs in 2015. Also, for comparison, the costs of management discussed in the previous section from the low intensity approach modeled in 2011 are included.

Note that the costs for intensive management that were assumed for the 2015 analysis were far greater than the low intensity management scenarios analyzed in 2011. The costs for more frequent prescribed burns, earlier stand treatments, more herbicide treatments, and especially the $2000 to $2500 per acre understory restoration costs in 2015 scenarios were extremely expensive. Note that if one did not spend the extra funds to plant and restore the understory, the costs in 2015 would be less, at $884 per acre at the low input cost levels and $1364 per acre for the high cost levels. However, all of these costs are still much more than just planting Loblolly pine, which is probably less than $400 per acre at most for the initial costs, and requires less burning and no understory establishment costs to establish and maintain a stand.

Using the basic low intensity/low costs scenarios we employed for the 2011 analysis, the present value of the costs for converting agricultural land to Longleaf pine stands was $548 per acre at the 4% discount rate. The costs to manage the mature forests then was $447 per acre, discounted to the first year of that mature forest analysis. Thus the combined cost of these scenarios—converting it Longleaf pine, then managing it from that point on (50 years) into perpetuity—would be $665 per acre. Note that the $665 per acre is less than the sum of the above two components, because it is the discounted sum of $548 per acre, already to year 0, plus the $447 per acre discounted from year 50 back to year 0 (e.g. $548 +$447/$(1.04)^{50}$).

Table 13. PV and LEV for Costs to Convert and/or Manage Land for RCW Habitat, 4% Discount Rate

Activity	PV Costs/acre, 2011 (Low Intensity)	PV Costs/acre, 2015 (High Intensity)	
		Low Price	High Price
Converting Land from Agriculture			
Scalping	$40	$40	$60
Herbicide Site Preparation	$80	$80	$120
Pre-plant Prescribed Fire	$20	$20	$30
Longleaf Seedlings	$80	$80	$200
Planting Labor	$40	$40	$60
Herbicide Treatments	None	$50	$70
Early Stand Treatments	$34	$99	$144
Prescribed burns	$14	$139	$209
Understory Restoration	None	$2,000	$2,500
Timber Marking	$14	$14	$20
Timber Inventory	None	$97	$97
Managing Mature Forests			
Prescribed Burns	$92	$160	$240
Herbicide Treatments	None	$104	$156
Timber Marking	$29	$29	$36
Timber Inventory	None	$75	$120
Annual Costs			
Forester Fee	$100	$100	$175
Land Maintenance Fee	$125	$125	$175
RCW Monitoring	$100	$100	$150
PV Cost to Convert Agricultural Land*	**$548**	**$2,884**	**$3,860**
LEV Cost to Manage Mature Forests	**$447**	**$694**	**$1,053**
LEV Cost to Convert Agricultural Land and Manage it into Perpetuity**	**$665**	**$3,036**	**$4,088**
LEV Cost to Replant a Cutover Site with Longleaf Pine & Manage into Perpetuity**	**$800**	**$3,121**	**$4,196**

*Excludes RCW Monitoring Cost

**To calculate this, the costs for managing mature stands were discounted 50 years and then added to the conversion and uniform costs

Required Incentive Payments.—The capital budgeting analysis for 2011 discussed above indicated that the LEV for managing forests for Longleaf pine timber, including both management cost and timber revenues, compared to Loblolly pine timber ranged from $56 to $699 per acre. For agriculture, the 2011 differences between Longleaf pine and optimistic agriculture returns were $1,757 to $4,158 per acre. These results led us to conclude then that landowners were very unlikely to convert average quality agriculture

land to forest land. The 2015 data indicate that crop production profits decreased substantially, reducing the differences between agricultural and Longleaf pine returns for the low intensity scenario to about $900 to $1200 per acre.

Based on our input cost data for individual practices, total costs for management of existing mature stands ranged from $447 per acre for low intensity management in 2011 to $1,053 per acre for high cost, high intensity management. Converting agricultural land was more expensive and ranged from $548 per acre in 2011 to $3,860 per acre in 2015. The LEV for replanting cutover forest sites was slightly higher, ranging from $800 in 2011 to $4,196 per acre in 2015.

The net discounted benefits of the timber and pine straw harvests for Longleaf pine forest rotations in 2011 were $156 per acre (Glenn 2011). Subtracting these returns from the total costs in Table 13 provides an estimate of the LEV of costs plus returns for restoring or establishing Longleaf pine habitat for the 2011 and 2015 scenarios. Note that the greater costs shown for 2015 are mostly caused not by price differences, but rather by a more expensive set of practices, including shrub establishment and more frequent burning and herbicide applications.

Table 14 then summarizes the calculations we made and the annual incentive payments that would be required to pay the opportunity cost between the current land use and converting those lands to Longleaf pine under our low intensity and high intensity management regimes.

So, the bottom line of Table 14 is that high costs for Longleaf establishment will require greater incentive payments to break even. The low intensity management regime with annual cost share payments and a 50% establishment cost rate, which has fewer management inputs and costs, might require incentive payments of about $27 to $79 per acre per year for 10 years to establish and grow Longleaf pine. In addition, converting mature forests also might possibly have incentive payments that are reasonable, ranging from $27 to $98 per acre per year for 10 years plus 50% of establishment costs.

Table 14. Annual Incentive Payments Required to Pay the Opportunity Cost Between the Current Land Use and Converting those Lands to Longleaf Pine

Management Scenario	**Low Intensity**	**Hi Intensity/ Low Price**	**Hi Intensity/ High Price**
	- - - - - $/acre - - - - -		
LEV of Costs/Scenario			
Mature Forest	447	694	1053
Ag Land Conversion	665	3036	4088
Cutover Forest Replanting	800	3121	4196
LEV of Costs + Longleaf Pine Returns of $156			
Mature Forest	291	538	897
Ag Land Conversion	509	2880	3932
Cutover Forest Replanting	644	2965	4040
Required Incentive Payment for 10 Years at 4% Discount Rate			
Mature Forest	36	66	111
Ag Land Conversion	63	355	485
Cutover Forest Replanting	79	366	498
Cost Share Payments			
Mature Forest Burn + Herbicide Base Costs	70	70	105
Cost Share Rate at 50% of Initial Base Cost	35	35	53
Establishment Costs in Year 0	300	2300	2800
Cost Share Rate at 50% of Establishment Costs	150	1150	1400
Required Incentive Payment for 10 Years at 4% Discount Rate + 50% Cost Share			
Mature Forest	27	58	98
Ag Land Conversion	44	213	312
Cutover Forest Replanting	79	366	498
Annual Payment Multiplier at 4% Times Cost =		0.123290944	

The high intensity management regimes, even with payment of 50% of establishment costs, would require much greater annual incentive payments, ranging from $213 to $498 per acre per year. Establishing the understory is by far the greatest expense in these costs,

at the initial costs of $2000 to $2500 per acre. Not performing understory establishment, however, would lop off $250 to $300 per acre per year of the required payments for low intensity and high intensity management, respectively. These annual payment costs would also then be less than $100 per acre per year in all but the high intensity, high cost regime.

Increasing Existing Longleaf Pine Habitat in Mature Stands

As noted before, prior to European settlement, Longleaf pine occupied approximately 92 million acres (37 million hectares) of the Southeast U.S., of which 74 million acres were Longleaf dominant and 18 million acres were mixed-species stands. Such activities as agriculture, open range grazing by livestock, logging, production of turpentine and elimination of naturally occurring wildfires have reduced this amount by approximately 97% over the last 400 years (Frost 1993). The current Forest Inventory and Analysis (FIA) data can be accessed to estimate the actual Longleaf pine areas now, using the EVALIDator forest inventory data set building tool (USDA Forest Service 2015).

We used EVALIDator to estimate the amount of Longleaf pine habitat within the counties covered by the landowner survey. There are approximately 191,500 acres of Longleaf pine (sampling error of 16.05%). Table 15 provides a summary of old growth forest that could be suitable for RCW habitat and converted as mature forests with the treatments described above. This includes both Longleaf pine types and for Loblolly pine types for age classes between 41 and 80 years old. The Longleaf estimates do have considerable variability, but the standards errors are approximately 20% or less.

Table 15. Mature Longleaf and Loblolly Forest Types in the 38 Study Counties, 2015

Forest Type/Age	41-50 Years	51-60 Years	61-70 Years	71-80 Years	Total
	- - - - - - - Acres - - - - - -				
Longleaf Types	35,481	64,685	21,427	52,713	174,306
Loblolly Types	247,366	229,431	129,838	109,114	715,749
Total	282,847	294,116	151,265	161,827	890,055

Source: EVALIDator 2016. Longleaf type data include Longleaf pine, Slash pine, Longleaf pine/oak, and Pond pine. Loblolly type data include Loblolly pine and Loblolly pine/hardwood.

These data indicate that there are about 174,000 acres of mature Longleaf forest types within the 38 landowner survey counties that could be improved for red cockaded woodpecker (RCW) habitat. Similarly, there are about 716,000 acres of mature Loblolly pine forest types. These two types would then total about 900,000 acres of potential older growth stands that could be useful for RCW habitat in the 38 counties. Most scientists believe that old Loblolly pine also could serve as adequate, if not ideal, habitat for RCWs if that were the primary purpose of habitat restoration. This would provide a much greater total area for RCW opportunities. However, if one were seeking to establish the full range of ecosystem benefits provided by Longleaf, there are fewer mature forest to work with.

One could also estimate the costs of these different treatments times their number of acres times the cost of conversion to estimate a supply curve for converting mature stands. In fact, we also could do the same for estimating the total acres of Loblolly pine forests in the region, total Longleaf pine forests, and total agriculture land. The study proposal indicated that we would do this, but in the end the result was astronomical, so we have eschewed reporting these details. For reference, the 38 counties had a total of (EVALIDator 2015, USDA NASS 2015):

Forest land	4,242,055 acres
Longleaf pine forest land	191,523 acres
Loblolly pine forest land	2,950,424 acres
Farm Land	3,588,032 acres
Total Farm and Forest Land	7,830,087 acres

The total estimated cost of converting all the mature lands and replanting all the longleaf and loblolly pine lands and all the agriculture land literally totaled more than $30 billion, which is of course far beyond any reasonable cost that could be subsidized in 38 counties by the Farm Bill or other private programs. So maybe the bottom line on the land area/supply is that there is plenty of land in the counties that could be restored or converted to Longleaf ecosystems if landowners were interested, land management hurdles could be overcome, and adequate inventive payments could be made.

Longleaf Supply Discussion

Environmental credit markets are voluntary programs that engage private landowners through economic incentives in order to promote habitat conservation. Their success largely depends on the ability of policy makers, landowners, extension agents, or perhaps credit brokers to understand and accommodate the participants' needs and craft payments and contracts accordingly. This component of our CIG grant provides a multifaceted analysis of the supply side of a potential ecosystem based credit market to promote Longleaf pine habitat in Southeast U.S.

In brief, our results indicate that previous experience in cost-share benefit programs and specific landownership traits may lead to greater interest in a conservation credit program to promote Longleaf pine. Both the logistic regression and choice based conjoint (CBC) statistical analyses revealed that landowners are very concerned about program requirements such as contract length and legal obligation in a conservation contact. This makes intuitive sense because landowners seldom want to tie up their land with permanent easements to restrict their opportunity to sell part or all of their land for a profit, or bequeath it to their heirs. Much of the sampled population was at or near retirement and may be concerned with inheritance in particular. Some may still prefer to conserve the land into perpetuity, but that was less common based on our sample.

The CBC analysis also revealed the relative role that key factors play in encouraging participation. Short term contract agreements were favored, with 5 and 10 year contracts each being the most highly rated of all factors identified, and 30 year agreements being the least favored. No obligation and the baseline obligation were acceptable; increasing obligations were not. Annual payments were somewhat less important than contract agreement or level of obligation, and higher payments were more desirable as expected. The initial cost share rate and type of assistance were the least important factors affecting willingness to participate in Longleaf conservation programs. More technical assistance

and higher cost share rates were favored, but had a much smaller CBC attribute score payments, obligations, or contract length.

The surveys and statistical analyses revealed that agricultural land size, farm/forest plans, and present use valuation were not statistically important factors determining interest in a new Longleaf pine program. Nor were age, gender, income, education significant. Some "lack" of significance of planning and demographic factors may be due to sample bias toward assisted and engaged landowners. This is mostly good news. Program factors we can control are key to getting landowners to enroll. Demographics not problematic. Thus we mostly need to find interested landowners, with medium forest owners as better prospect, and get the policy right and funding levels high enough to attract landowners, while minimizing the legal obligations and length of commitment required.

The financial and capital budgeting analysis expanded on this by providing insight into the opportunity cost of managing for conservation as compared to timber or agriculture production. For Longleaf pine versus Loblolly pine, the incentive payment required for landowners to plant Longleaf in the 2011 analysis at a 4% discount rate, was between $7/acre and $83/acre per year, not including establishment costs. If establishment costs of $306 were paid, Longleaf returns would exceed Loblolly returns for the higher site indexes and pine straw raking scenarios.

Costs were much more expensive for the more intensive 2015 Longleaf economic analyses, being several times greater than the low intensity 2011 costs. The 2015 analysis also examined costs to convert mature pine forests to high quality Longleaf or even Loblolly habitat for open grown pine conditions that would favor RCW habitat. The 2015 intensive management costs ranged from $694 to $1053 for conversion of mature forests to open grown systems, up to $4196 for planting cutover forest sites. The required incentive payment for these management regimes would be $66 to $496 per acre per year, which are prohibitive at the high end. However, if the initial year costs for mature forest conversion of Longleaf pine or for tree planting received a 50% cost share rate, required annual payment costs could decrease somewhat. And last, if the very expensive shrub establishment practice were dropped, even the intensive Longleaf annual payment rates for mature and planted stands could decrease to less than $100 per acre per year, which is at least in the Farm Bill Program ballpark.

Limitations and Conclusions

The project findings discussed above help clarify the current program and economic factors that affect landowners in converting their forest or farm land into longleaf pine habitats. Various assumptions in the analyses, or broader regional economic, macroeconomic, and social factors could affect these conclusions, so bear mentioning.

The findings suggest that the low intensity establishment and management costs such as we found in 2011 could be used first to get Longleaf plantations in the ground. The higher 2015 high intensity approaches are more expensive, but could be acceptable with high enough cost share payments. Shrub establishment is the biggest cost by far in our 2015 analyses. So perhaps one could use low intensity approaches such as analyzed in 2011, and get the trees established first. Landowners could even rake pine straw in the initial years in order to generate and income and attract them to Longleaf, then convert to conservation uses later in the stand life. In 30 or 40 years, one could come back and work on shrub establishment as part reforestation of more mature stands. This could break up the costs into manageable components, for landowners and for government programs.

One microeconomic caveat is that we used a standard 4% real discount rate (4% greater than inflation) in our economic analyses of comparisons, which should be pretty good based on comparable stock market and average agriculture returns in North Carolina. However, if landowners used a higher alternative rate of return, it would probably take a higher cost share rate and annual payments for Longleaf to break even with other uses. On the other hand, lower discount rates would tend to favor Longleaf land uses more. A related microeconomic change in the returns due to increased pressure for short rotation Loblolly pine or hardwood crops to supply fiber for wood pellets also could make conversions to Longleaf less attractive based on higher opportunity costs.

The microeconomics of fast grown timber for wood pellets presages a broader issue for a host of macroeconomic factors or exogenous shocks that could alter our project findings. Longleaf investments, like any others that occur for 40 years are subject to technology and social changes that are impossible to predict. Thus to ensure the Longleaf habitat is maintained in face of these shifts, we might suggest that efforts to make sure that it can yield financial returns to landowners—such as pine straw, RCW payments, or stacking

some other benefits—is important. In the long run, there is good reason to believe that Longleaf could prosper more because of its adaptability to warmer climates and fire, and even extend its range in the future. These long run factors all might suggest that efforts for long term easements and opportunities for credit stacking should be favored more if there are limited funds and enough willing landowners to commit for longer time periods.

The location and additional value of any lands enrolled also would be important. We talk about conservation credits in the policy component of this report. If a credit ranking system is developed, setting minimum conservation benchmarks and priorities for selecting the best lands—e.g., large areas, near existing RCW colonies—would be important. Even for more traditional incentive programs, these location and habitat characteristics could be incorporated more in making funding decisions.

As noted, restoring old growth stands or establishing new stands without a new shrub component have the best Longleaf financial returns. Purposeful shrub establishment, however, is of course more likely to produce a broad range of ecological and biodiversity benefits. Reviewers noted that species such as Southern hognose snake or Carolina gopher frog are likely to require broader ecological systems than a Longleaf pine straw stand. Thus the higher payments should be used if possible to achieve broad ecosystem benefits soon, rather than just planting Longleaf trees with the hope for natural brush regeneration sometime in the future.

Longleaf might offer other benefits not directly measured in this study. Voluntary incentive programs provide a potentially effective means of encouraging environmental conservation among private, non-industrial landowners. Compared to Loblolly pine or crops, it provides a different income stream and markets for risk reduction purposes; it may prosper more in droughts or even floods; and it provides broad ecosystem benefits. It also does provide pine straw, and can produce higher returns than the conservative estimates we used here. It also can produce superior timber and poles that fetch higher prices than those we used.

Our specific results also can be complemented by knowledge of existing landowner behavior. Landowners have been more than willing to enroll in Farm Bill and state Longleaf pine planting programs, and our findings help suggest preferred contract, payment, and assistance factors. While it is anecdotal, it appears that a recent increase in

tree planting in the South also has a much larger Longleaf pine component than in the past.

As noted, the economic analyses estimated the annual payments and initial cost share rates that represent "breakeven" opportunity costs and the annual payments necessary to make landowners equally willing to grow Longleaf pine for RCW conservation versus for timber production. Converting existing Longleaf stands to longer rotations is probably the easiest of the potential land use changes that owners may consider. It might take even greater annual payments to actually induce landowners to shift from existing Loblolly pine or agriculture systems to Longleaf pine systems, and we could not estimate what the range of that "Longleaf adoption premium" actually is.

However, since landowners are planting lots of Longleaf under the current incentive programs, it might suggest that our 4% discount rate and those incentive programs are already approximating an acceptable level of cost share payments. If so, it is again just more funding that is needed, at least for the landowners in the current segment of the Longleaf habitat supply curve. Like any economic supply, it is probable that higher payments will be needed do landowners at the high price segment of the supply curve, who are not presently considering planting or restoring Longleaf.

Other practical factors—such as likelihood that Longleaf is harder to plant and manage then Loblolly, or that agriculture returns on poor lands have such huge variations and much higher risk—may also have large negative or positive impacts on economic decisions to whether to plant or restore Longleaf. Program delivery and implementation also will. Getting the message right, making applications easy, and providing certainty to landowners that any program strings will not escalate all are important factors that could provide fodder for future projects.

We will continue this line of innovation grant analyses, and work with government and nongovernment agencies and landowners to evaluate and deliver their conservation programs for Longleaf and other open grown pine systems. We would welcome comments and suggestions regarding our findings and conclusions as well.

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Appendix 1. Management Activity Descriptions and Associated Costs for Low and High Intensity Management Regimes, 2015

Activity	Low Intensity Activity Description	High Intensity Activity Description
Converting Land from Agriculture		
Scalping	Initial one time cost at $40/acre	Initial one time cost, from $40 to $60/acre
Herbicide Site Preparation	Initial one time cost at $80/acre	Initial one time cost, from $80 to $120/acre
Pre-plant Prescribed Fire	Initial one time cost at $20/acre	Initial one time cost, from $20 to $30/acre
Longleaf Seedlings	Initial one time cost at $80/acre	Initial one time cost, from $80 to $200/acre
Planting Labor	Initial one time cost at $40/acre	Initial one time cost, from $40 to $60/acre
Herbicide Treatments	None	Initial one time cost, from $50 to $70/acre
Early Stand Treatments	Burns in years 3 and 5 at $20/acre	Herbicide treatment in year 2 (from $70 to $100/acre), burns in years 3 and 5 (from $20 to $30/acre)
Prescribed burns	Every 5 years, starting in year 5 and ending in year 75, at $20/acre	Every 3 years, starting in year 5 and ending in year 74, from $20 to $30/acre
Understory Restoration[1]	None	Initial one time cost (from $2,000 to $2,500/acre)
Timber Marking	Once in year 40 and 60 at $40/acre	Once in year 40 (from $50 to $75/acre) and again in year 60 (from $40 to $50/acre)
Timber Inventory	None	Once every 13 years, starting in year 13 at $70/acre
Converting Land from Timber		
Site Preparation Burn	Initial one time cost at $40/acre	Initial one time cost, from $40 to $55/acre
Drum Chop	Initial one time cost at $100/acre	Initial one time cost, from $100 to $130/acre
Herbicide Site Preparation	Initial one time cost at $80/acre	Initial one time cost, from $80 to $120/acre
Longleaf Seedlings	Initial one time cost at $80/acre	Initial one time cost, from $80 to $200/acre
Planting Labor	Initial one time cost at $40/acre	Initial one time cost, from $40 to $60/acre
Early Stand Treatments	Burns in years 3 and 5 at $20/acre	Herbicide treatment in year 2 (from $70 to $100/acre), burns in years 3 and 5 (from $20 to $30/acre)
Prescribed burns	Every 5 years, starting in year 5 and ending in year 75, at $20/acre	Every 3 years, starting in year 5 and ending in year 74, from $20 to $30/acre
Herbicide Treatments	Every 10 years up to year 70 at $50	Every 10 years up to year 70, from $50 to $75/acre
Understory Restoration[1]	None	Initial one time cost (from $2,000 to $2,500/acre)
Timber Marking (three times)	Once in year 40 and 60 at $40/acre	Once in year 40 (from $50 to $75/acre) and again in year 60 (from $40 to $50/acre)
Timber Inventory (every 13 years)	None	Once every 13 years, starting in year 13 at $70/acre
Managing Mature Forest		
Prescribed Burns	Every 5 years at $20/acre	Every 3 years, from $20 to $30/acre
Herbicide Treatments	None	Every 10 years, from $50 to $75/acre
Timber Marking	Every 22 years at $40/acre	Every 22 years, from $40 to $50/acre
Timber Inventory	None	Every 13 years, from $50 to $80/acre
Annual Costs		
Forester Fee	Annual fee at $4/acre	Annual fee, from $4 to $7/acre
Land Maintenance Fee	Annual fee at $5/acre	Annual fee, from $5 to $7/acre
RCW Monitoring	Annual fee at $4/acre	Annual fee starting in year 50, from $4 to $6/acre

1 - This practice may not be necessary in all fields.

Activity and cost data provided by the North Carolina Forest Service. Costs are estimates based on certain land characteristics and are likely to vary from site to site