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Allocation versus completion: Explaining the distribution of the Forest Development Program fund in North Carolina

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ABSTRACT

The Forest Development Program (FDP) is a nationally renowned state-administered cost-share assistance program for forest landowners in North Carolina, primarily funded through taxation on primary forest products across the state. While the demand for FDP cost-share funds often exceeds available resources, over one-fourth of annual allocations on average go unused, due primarily to application cancellations and the divergence of actual costs and treated acres from the amounts approved originally. This study evaluates various factors related to the utilization of allocated funds based on actual cost-share fund usage data in the last six years. Results suggest that FDP applications associated with the piedmont region, shearing and chemical site preparation, hand-planting activities, and larger applied acres are more likely to be completed as defined in the initial application. The methods and findings of this study provide useful insights to administrators of other similar public incentive programs. The need for similar analyses evaluating the utilization of public funds will likely grow as state and federal governments increasingly rely on incentive programs to meet ambitious goals in conservation and sustainable management of natural resources.

1. Introduction

Governmental programs in the form of financial incentives to promote natural resource management and conservation are widespread globally. For example, governments within the Organization for Economic Co-operation and Development (OECD) spent $280 billion (USD) in 2005, a major increase from the negligible expenditures in 1986, supporting agriculture, production systems, and environmental services in the form of direct payments and preferential tax programs (Hajkowicz and Collins, 2009). Federal financial incentive programs for private forests in the United States (U.S.) averaged $596 million per year (2015 dollars) from 2010 to 19 (Frey et al., 2021). In part, this is a recognition of the fact that forests provide many ecosystem services that benefit the public but usually do not generate direct, market-based monetary compensation for landowners. As such, governmental funds will be needed to reach socially optimal levels of conservation as long as markets for ecosystem services remain limited with significant barriers to entry.

Incentive programs in the United States frequently involve some action by landowners, such as conducting approved forest management activities, in order to receive payments. The process for a private forest landowner to receive a financial incentive payment from a government agency varies from program to program, but generally involves several steps: landowner application, agency approval and fund allocation, landowner and service provider actions, agency verification, and payment. As this process progresses through time, the situation of the landowner, agency, service provider, or overall market may change. Furthermore, the landowner and agency may not have full information at the application and approval stage. Therefore, there is a degree of uncertainty in payment levels at the early stages, which leads to uncertainty in program budgeting and outcomes.

This occurrence has been documented in the U.S. Environmental Quality Incentives Program (EQIP) and state cost-share programs in Kentucky, South Carolina, and North Carolina (Cattaneo, 2003; Chizmar et al., 2021). For instance, approximately 25% to 40% of the yearly budget for North Carolina's Forest Development Program (FDP) is not paid to landowners within the funding period (Fig. 1), which is sometimes called "slippage funds" (North Carolina Forest Service [NCFS], 2014; NCFS, 2015; NCFS, 2016; NCFS, 2017; NCFS, 2018; NCFS, 2019b). These slippage funds are an inefficiency as they typically cannot

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be used to fund additional applications until the next funding period, potentially delaying the implementation of management and conservation practices. In fact, the unused funds may not be realized by FDP administrators for one to two years after approval, at which time the FDP administrators initiate contact with the applicants for an update. After this period, unused allocations are rolled into the next funding period to be redistributed to new cost-share applicants.

The main purpose of this study is to examine the factors associated with the fuller utilization of allocated funds under the FDP program in NC. More specifically, we investigate the accomplishments of the FDP applications funded between 2015 and 2020 and, through four predictive models, and explore which attributes are correlated with the greater implementation of allocated cost-share dollars. The modeling framework used in this study may be adapted and applied to other limited-budget public incentive programs to evaluate which characteristics drive their ability to meet their objectives, which the literature identifies as a growing need (Keene and Pullin, 2011).

Several past studies attempted to identify evidence of capital substitution of private investment by public dollars, primarily through the use of survey data (Cohen, 1983; Boyd, 1984; de Steiguer, 1984; Brooks, 1985; Royer, 1987; Lee et al., 1992; Hardie and Parks, 1996). While subsidizing reforestation efforts that might have occurred without assistance is a consequence of concern for some, capital substitution is relatively innocuous in its impacts on timber prices. We also did not have access to a primary survey to assess determinants impacting landowner behavior on private forestlands. As such, this study differs from past research by utilizing extensive administrative data from approved applications to examine the factors associated with the fuller utilization of cost-share allocations.

The Trillion Trees (2020) global mission also makes this study especially timely. The mission will require the U.S., as well other nations, to increasingly rely on forest incentive programs to meet the proposed reforestation goal: re-grow, save from loss, and better protect one trillion trees around the world by 2050 (Trillion Trees, 2020). At the national level, the 2018 Farm Bill was projected to outlay approximately $60 billion to support both commodity and conservation programs from 2019 to 2023 (USDA Economic Research Service [ERS], 2020). At the state-level in the U.S., programs such as the FDP will be needed in addition to federal efforts to meet the country's ambitious goal (Chizmar et al., 2021).

2. North Carolina's forest development program

2.1. Program background and history

The FDP has supported private investment in forest management on over 1.3 million acres since state legislation established the program in 1977 (NCFS, 2020a). The NC Forest Service (NCFS) administers the FDP as the state's forestry gateway program: landowners enroll for the financial benefits but learn about water quality and forest health through implementation of recommended management practices (NCFS, 2019a). The FDP compensates landowners through direct reimbursements known as cost-share payments (Mehmood and Zhang, 2002; Cubbage et al., 2020) to address barriers to investment efforts such as limited capital and cash flow in the initial years of the investment (Haines, 1995; Granskog et al., 2002). Table 1 presents a timeline of the program history.

Subsidized management activities expanded from tree planting over time to include site preparation and timber stand improvement practices (North Carolina Division of Forest Resources, 2009). Beginning in 1987, the administrators of the FDP were authorized to designate a portion of

Table 1
Forest development program timeline.

Fiscal year	Description
1979	First year of Forest Development Program and beginning of waiting list
1984	Trial for "tree planting only" special allocation and decreased cost-share rate to 50%
1985	Decreased cost-share rate again to 40% and established maximum prevailing rates
1987	Special allocations allotted permanently for "plant-only" and Mountain region projects
1992	No state appropriations
1993	No state appropriations
1994	Cost-share rates for longleaf pine, hardwoods, and wetland species increased to 60%
2007	Non-recurring special allocation of $600,000
2008	Funding for forest stand improvement practices available for request
2009	Last year of state appropriations
2017	One-time allocation of $75,000 and unused reserve funds pay-off waiting list
2019	Waiting list reinitiated and moved to lottery-based distribution
2020	First year of lottery and allocations weighted by district economic distribution

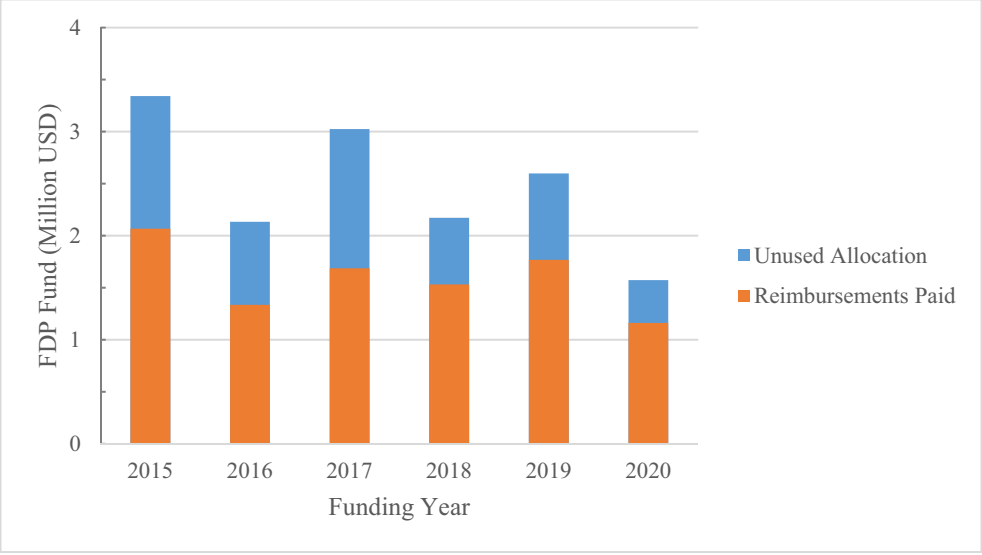

Fig. 1. Forest development program reimbursements and unused allocations.

the funding available for cost-share allocations to two special funds for activities (1) that include planting-only, and not site preparation or timber stand improvement, practices and (2) that are located in the mountain region of North Carolina (North Carolina Division of Forest Resources, 2009). Other projects not qualifying for the one of the two special funds listed above must compete within the general fund.

Further, the FDP's cost-share rate decreased from 60% to 40% in 1984 to serve more landowners. The FDP administrators later raised the cost-share rate back to 60% for higher priority species including longleaf and shortleaf pines and hardwoods. Fiscal year (FY) 1984–1985 also saw the inception of maximum "prevailing rates" which function as a practice- and region-specific cap on eligible cost-share reimbursements, based on market costs for services (North Carolina Division of Forest Resources, 2009).

The FDP, originally funded through a combination of general state appropriations and a tax on harvested wood products in NC, stopped receiving general state funding after FY 2008–2009, except for a payment of $75,000 in 2016 used to fund the landowner projects on the waiting list (NCFS, 2019a). The timber assessment monies and unused slippage funds supply more than $2 million annually on average for new projects (Table 2). Recently for the FY 2019–2020, the provider changed the winner selection method from on a first-come, first-served basis to random lotteries for each district in an attempt to more fairly distribute the limited budget (NCFS, 2019b).

A 2009 FDP Continuation Review Report advised the program requires $1.4 million in addition to the tax on wood products and unused slippage funds to assist all cost-share applicants (North Carolina Division of Forest Resources, 2009). The program is estimated to have substantial economic impact in the state economy. Koesbandana (2017) estimated that the $4.2 million spent jointly in 2012 by the government and private landowners increased total industry output by approximately $12.5 million and total value added by almost $7.5 million.

2.2. Authorization and payment processes

Annually, the FDP provides funds for new forest management projects while continuing to disburse payments for previously approved projects (NCFS, 2019a). Landowners each year may apply for new management projects on at most 100 acres with a maximum reimbursement payment of $10,000, regardless of practice or region (NCFS, 2017). Applications include characteristics relating to the landowner, location of forest, and management practice. Approved applications are allocated funds through one of three pools on two different cycle schedules: base, tree planting-only, and mountain. For example, for the FY 2019–2020, the enrollment period for projects paid through the base and mountain funds was March 4 to May 31, whereas the enrollment window for plant-only projects was August 19 to October 18 (NCFS, 2019b).

Projects in the mountain region of NC, as opposed to the piedmont and coastal plain regions, are funded through the mountain fund first (Fig. 2). Landowners that apply for cost-share funds to cover tree-planting activities only, not in combination with other management practices, are paid through the plant-only fund first. Site preparation and timber stand improvement projects located primarily in the coastal plain and piedmont regions of the state are paid through the base fund. However, all applications approved during the FY 2016–2017 were paid through the base fund only, in addition to the one-time payment of $75,000 from the state, as there were no special allocations for mountain and plant-only projects that pay period (Table 2) (NCFS, 2016).

Cost-share allocations for management activities are calculated by multiplying the number of acres requested in the application by the prevailing rate of the practice published annually by the NCFS by district and management intensity (NCFS, 2020b). Following application approval and allocation of cost-share funds, landowners have one to two years to complete the work featured in the application. Then, landowners must report the actual cost and acreage of the work once completed to the NCFS in the form of an invoice to receive a reimbursement. The addition of prevailing rates changed the reimbursement amount to the lesser of two options: (a) cost-share percentage multiplied by the consumer invoice or (b) the product of the cost-share percentage, unitary costs, and the treated acreage. Although infrequent, applicants that underestimate their needs may request additional funding from FDP administrators (i.e., landowners require a higher prevailing rate or would like to be reimbursed for more acres than included in the application).

Table 2
Forest development program annual budgets by fund (base, mountain, and plant-only).

Fiscal year	Base	Mountain	Plant-only	Total
	Million dollars			
FY14–15	1.39	0.25	0.75	2.39
FY15–16	0.98	0.25	0.75	1.98
FY16–17[a]	2.38	0	0	2.46[b]
FY17–18	1.28	0.25	0.50	2.03
FY18–19	1.16	0.25	0.75	2.16
FY19–20	1.39	0.25	0.50	2.14

[a] All approved applications paid through base fund, no special allocations.
[b] State appropriation of $75,000.

3. Methodology

3.1. Theoretical framework

In this analysis, FDP administrators distribute cost-share allocations and reimbursements to applicants willing to expend upfront effort, or expenditures, to complete approved forest management practices. In past years, FDP cost-share allocations were not fully utilized within the same funding period, delaying approval of other applications for cost-share funds, and thus the forest-based benefits that would have been produced if the cost-share funded activity would have been completed. This is in part due to project cancellations where the landowner does not follow-up with the FDP administrators for a reimbursement payment following project completion. Also, for finalized applications, reimbursements may be less than their allocations if (a) the landowner performed the work on fewer acres than originally approved and/or (b) the landowner paid a lower actual price than the prevailing rate set by the FDP administration at NCFS.

Project execution may vary by forest management practices, funding pool, region, landowner classification, cost-share rate, number of applied acres, year, and other factors. For example, burning activities may be more likely than other practices to be cancelled or not fully executed as the practice requires specific weather conditions and liability regulations (Parajuli et al., 2019). This may be further exacerbated for burning as well as other activities in applications with multiple applied practices (i.e., combinations of planting, site preparation, and timber stand improvement activities). Applications with multiple practices are generally funded through the base and mountains fund. Whereas applications paid through the plant-only fund are unique such that they only include tree planting activities not combined with other site improvement activities. Logistic regressions performed by Cattaneo (2003) suggested that the likelihood of contract withdrawal from the Environmental Quality Incentive Program (EQIP) is significantly and positively related to the number of practices included in applications.

In addition, forests in the coastal plain and mountain regions generally require higher levels of management intensity than the piedmont region, due primarily to soil characteristics (NCFS, 2020b; Chizmar et al., 2019). For instance, mechanical site preparation activities to keep seedlings above high-water tables may be more likely to be completed in the coastal plains than the other regions. Likewise, mechanized activities in the mountain region may be less likely to be

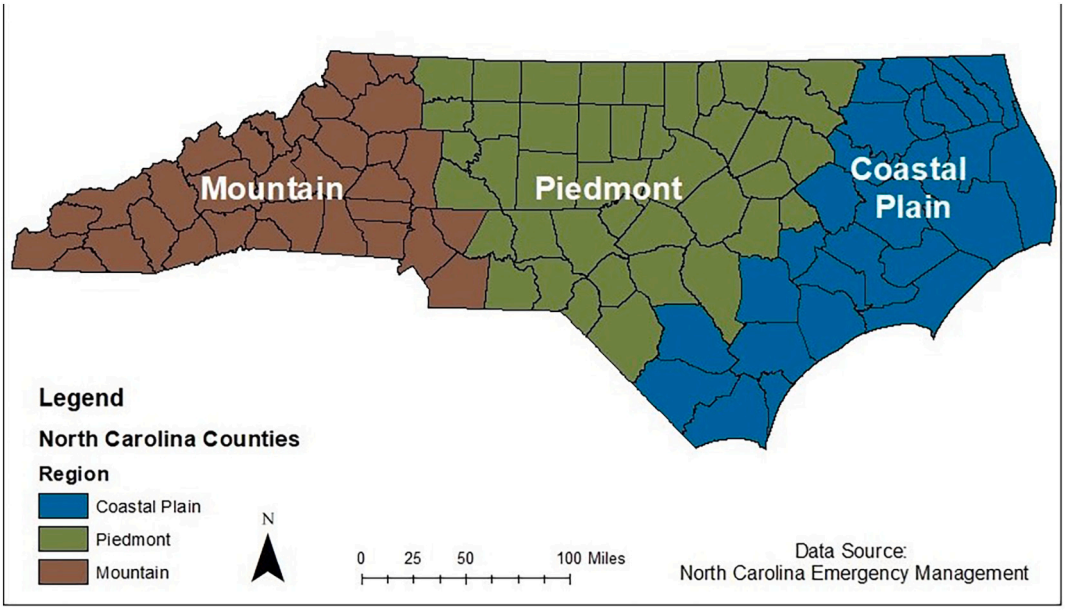

Fig. 2. Map of North Carolina and its regions.

completed due to steep, rocky slopes. For this reason, prevailing rates vary by districts to reflect differing needs and site characteristics. However, these prevailing rates may be set too high for certain practices and/or locations, which could help explain the underuse of cost-share allocations. Many of the regional variables used by Cattaneo (2003) were significant determinants of cost-share program participation and practice withdrawal.

Furthermore, landowner classification as well as the number of acres featured in the application may help determine cost-share project completion. Non-corporate landowners owning less acres may have less access to technical knowledge (Butler et al., 2021). Similarly, the number of acres included in an application may signify economies of scale. That is, that larger treatment acreages imply larger landholdings, which may be associated with greater levels of resources than landowners that apply for funding on fewer acres. Accordingly, forestry practices on larger tracts may attract lower costs per acre than treatments on smaller acreages, suggesting that they may be more likely to pay less than the established prevailing rates. Cattaneo (2003) also found that the variables representing total farmland acreage and cropshare acreage were significantly and negatively related to application withdrawal.

Not to mention, practices with a higher cost-share rate may be more likely to be completed than activities with a lower rate, simply due to higher expected payouts. In the context of the FDP, this suggests that practices covered under the 40% cost-share rate may be less likely to be completed as specified in the application than practices covered under the alternative, higher cost-share rate of 60%. Hardie and Parks (1996) found the proportion of shared costs to be a significant, positive determinant in pine reforestation behavior on non-industrial private forestland.

The cost-share rate may also represent a landowner's ability to execute practices by species since the higher rate is associated with higher priority species (e.g., longleaf pine, wetland species, and hardwoods). Landowners that value conservation may be more willing to complete activities that protect higher priority forest ecosystem (Watson et al., 2013). Nonetheless, landowners that are profit-driven may be more willing to complete activities related to loblolly pine, which are covered under the 40% category, if they believe the additional cost-share assistance is not enough to compete with the higher net revenues expected from loblolly pine production.

Finally, the FDP budget varies year to year depending on the tax assessment on timber products and the realization of slippage funds from past years (North Carolina Forest Service [NCFS], 2014; NCFS, 2015; NCFS, 2016; NCFS, 2017; NCFS, 2018; NCFS, 2019b). FY 2016–2017 is an outlier in the data since there were no special allocations and the State appropriated a one-time payment to landowners waiting for application approval. FY 2019–2020 is also significant in that it was the first funding period that allocated funds according to random lotteries for each fund in each of the 13 NCFS districts. Prior, applications were approved statewide on a first-come, first-served basis for each of the three funds, when available. It is reasonable to assume that funds distributed on a first-come, first-served basis favor applicants that are organized and have high access to knowledge of the program. For this reason, projects funded before FY 2019–2020 may have been more likely than those funded after the change to be completed.

3.2. Empirical models

The models utilized in the literature to analyze private forest management build from foundations in microeconomics, investment theory, profit maximization and cost minimization, and utility theory (Royer, 1987; Sills and Abt, 2003). Within these frameworks, landowners seek to maximize the net benefits produced from private forests subject to multiple constraints such as income and wealth, access to public incentives, and land characteristics including acreage. Past studies hypothesized that reforestation is influenced by market characteristics, management practice costs, nontimber values, and the availability of public programs (Sills and Abt, 2003).

Cattaneo (2003) first recognized the potential implications of moral hazard throughout the cost-share reimbursement process for the federal EQIP. More specifically, Cattaneo (2003) evaluated the impact of factors such as conservation practice, acreage, time, and cost-share percentage on the likelihood of withdrawal from an approved EQIP project. The study then estimated the impact of project withdrawal on net conservation benefits utilizing the EQIP allocation ranking system: an index of conservation practices ranked by their environmental benefits (Cattaneo, 2003).

We consequently assumed that the NCFS wishes to maximize the likelihood of funding applications that will be completed (finalized) with the full utilization of the initially allocated amount. In other words, the NCFS wishes to minimize slippage funds, the difference between reimbursement payments and approved allocations. We also interpret

this as the NCFS maximizing the use of the fund on the most acres of forestland parallel to Cattaneo (2003) and the net benefits from payments for conservative projects under the EQIP.

We developed four models to examine characteristics that help explain the fuller allocation of cost-share payments. Model 1 assesses the propensity of completion of those who have signed up for and are given FDP funds within the approved time frame:

$$prob(Finalized) = f(Z_i) \quad (1)$$

where Z_i is a vector of locational, ownership category, treatment, and fiscal year characteristics. All the variables included in *Zi* are described in Table 3. It is important to note that the practices in finalized applications may or may not have been completed as specified in the approved application, in terms of treated acreage and the associated per unit costs. The dependent variable in Model 1, *Finalized*, is a binary variable that equals 1 when an application status is completed or finalized and 0 otherwise.

Model 2 was formulated to capture the implementation rate, or extent of completion, of cost-share funded management practices:

$$CSratio = f(Z_i) \quad (2)$$

The model relates the application characteristics to the ratio of actual reimbursements to original allocations. The implementation rate, denoted as *CSratio*, is influenced by the cost landowners were charged to complete approved practices and the number of acres to receive the treatment as allocations and reimbursements are the product of treatment acreage, unitary costs, and the cost-share rate.

The dependent variable in Model 2, *CSratio*, is a ratio bounded between 0 and 1, inclusive, which represents total cost-share reimbursements equal to or greater than their originally approved allocations. The ratio equals 0 for total cancellations where no reimbursement is paid, 1 for reimbursements that match their original allocations, and values between 0 and 1 when an applicant received a reimbursement less than the allocation approved in the application.

Table 3
List of variables with descriptions.

Variable	Description
Dependent	
Finalized	Binary variable: equals 1 when the status of an application is final, or completed, and 0 for cancelled
CSratio	The ratio of cost-share funds reimbursed to allocated funds, takes values [0,1]
CostRatio	The ratio of actual labor costs to NCFS prevailing rates, takes values [0, 4.67]
AcreRatio	The ratio of completed acres to applied acres, takes values [0.03, 10]
Independent	
Base	Binary variable: equals 1 for applications paid through the base fund and 0 for applications paid through special allocations
Piedmont	Binary variable: equals 1 for applications in the piedmont region and 0 for applications in the coastal plain and mountain regions
MtnRegion	Binary variable: equals 1 for applications in the mountain region and 0 for applications in the coastal plain and piedmont regions
NonCorp	Binary variable: equals 1 for non-corporate landowners and 0 for corporate landowners
CSburn	Binary variable: equals 1 for burning activities and 0 otherwise
CSshear	Binary variable: equals 1 for K-G, V-Blade/shearing activities and 0 otherwise
CSbed	Binary variable: equals 1 for double-bedding activities and 0 otherwise
CSchemSP	Binary variable: equals 1 for chemical site preparation activities and 0 otherwise
CSpine	Binary variable: equals 1 for pine hand-planting activities and 0 otherwise
CScontain	Binary variable: equals 1 for hand-planting of containerized longleaf and 0 otherwise
CSchem	Binary variable: equals 1 for chemical release activities and 0 otherwise
lnAcre	Integer variable that is the log transformation of the number of acres allocated cost-share funds
CS40	Binary variable: equals 1 for projects with 40% cost-share rate and 0 for projects with 60% cost-share rate
Year	Categorical variable: equals 1, 2, 3…, 6 for projects funded in 2015, 2016, 2017 …, 2020, respectively

Consequently, we developed Models 3 and 4 to separate the multiple influences, costs and acres, on the implementation rates of cost-share funded management practices. Model 3 regresses the application characteristics on the ratio of actual costs per acre to the approved prevailing rate, *CostRatio*:

$$CostRatio = f(Z_i) \quad (3)$$

The outcome variable in Model 3, *CostRatio*, is a ratio of the actual costs per practice, as reported in applicant invoices, to approved prevailing rates from finalized applications. *CostRatio* data had values between 0 (cancellations or work performed at no cost) and 4.67, inclusive. A value of 1 would suggest that a landowner paid the prevailing rate and those less (more) than 1 signify the landowner paid less (more) than the prevailing rate.

Likewise, Model 4 relates characteristics of applications to *AcreRatio*, the ratio of completed acres to approved acres:

$$AcreRatio = f(Z_i) \quad (4)$$

AcreRatio, is a ratio of the acreage completed by the applicant to the acreage originally approved in their application, taking values inclusively between 0 (cancellations) and 10.0. Landowners may request additional cost-share funding if they underestimate the acreage they are able to treat, this was the case with 36 applications. We only observed the outcome variables in Models 3 and 4 when applications are finalized as the FDP administrators are unaware of how practices are completed when applicants do not follow-up with an invoice.

3.3. Estimation methods

In this study, we estimated Model 1 using the logit regression approach. We performed a fractional response regression, a quasi-likelihood estimation approach first developed by Papke and Wooldridge (1996), to estimate Model 2. We estimated Models 3 and 4 via the tobit model approach in an attempt to separate the factors influencing actual reimbursement payments, the NCFS allocation/reimbursement strategy and the landowners' ability to execute management practices as approved by the NCFS. The tobit estimation method allows us to specify observations of cancelled applications, outcome variables with values of 0, as unobserved. Interestingly, Model 4 left-censored two fewer observations than Model 3 due to landowners reporting completion of activities at a cost of $0 (i.e., the landowners performed the work themselves or were not charged for the service). We calculated robust standard error estimates, Huber-White sandwich estimates (StataCorp, 2019), for each of the independent variables.

3.4. Data

We obtained the data about FDP applications and reimbursements from the NCFS. The database provided by the NCFS included 8326 applications funded between 2015 and 2020. Application status is classified as either finalized ($n = 6027$), cancelled ($n = 1782$), or open ($n = 517$). We excluded open applications, leaving 7809 observations. We estimated each of the models excluding years with open applications, represented by *Year* = 4, 5, *and* 6 in the study, to test for potential selection bias from purposefully excluding open application and robustness. Results from the restricted dataset, excludes funding years 2018–2020, were analogous to the dataset including observations from the last three funding years. Table 4 lists all variables along with their summary statistics and their expected relationships with the dependent variables in Models 1–4. We omitted the variable associated with hand-planting of containerized longleaf pine seedlings, *CScontain*, after testing for multicollinearity among variables.

Of the 7809 finalized and cancelled applications, 1932 applications are funded in 2015; 1191 applications in 2016; 1440 applications in

Table 4
Summary statistics of all variables and expected results of estimated coefficients for Models 1–4.

Variable dependent	Mean	Std. dev.	Min	Max	Expected results			
Finalized (1)	0.77	0.42	0	1				
CSratio (2)	0.61	0.36	0	1				
CostRatio (3)	0.66	0.43	0	3.22				
AcreRatio (4)	0.67	0.41	0	10				
Independent					**(1)**	**(2)**	**(3)**	**(4)**
Base	0.71	0.46	0	1	(−)	(?)	(?)	(−)
Piedmont	0.64	0.48	0	1	(+)	(?)	(?)	(+)
MtnRegion	0.12	0.32	0	1	(?)	(?)	(?)	(?)
NonCorp	0.87	0.34	0	1	(−)	(?)	(+)	(−)
CSburn	0.06	0.24	0	1	(−)	(?)	(?)	(−)
CSshear	0.04	0.20	0	1	(?)	(?)	(?)	(?)
CSbed	0.03	0.18	0	1	(?)	(?)	(?)	(?)
CSchemSP	0.17	0.37	0	1	(?)	(?)	(?)	(?)
CSpine	0.40	0.49	0	1	(?)	(?)	(?)	(?)
CScontain	0.04	0.20	0	1	(?)	(?)	(?)	(?)
CSchem	0.05	0.22	0	1	(?)	(?)	(?)	(?)
lnAcre	3.50	0.78	0	4.65	(+)	(?)	(−)	(+)
CS40	0.94	0.23	0	1	(−)	(?)	(?)	(−)
Year[a]	3.13	1.68	1	6	(+)	(?)	(?)	(+)

[a] Base value: Year = 6 (year 2020).

2017; 1187 applications in 2018; 1317 applications in 2019; and 742 applications in 2020. Applications, both finalized and cancelled, average 43 acres per applied practice. The six management practice variables featured in the models capture activities from 5893 applications. This includes 487 burning practices, 322 K-G Blade/shearing activities, 253 double-bedding practices, 1319 chemical release (site preparation) treatments, 3101 pine hand-planting practices, and 411 chemical release (timber stand improvement) treatments.

Reimbursements for 6783 applied practices are requested by non-corporate landowners. The remaining 1026 applications for forest management practices are associated with corporate landowners. Most applications are finalized or cancelled within the same funding period ($n = 7712$); however, 94 and 3 applied practices received a one-year and two-year extensions, respectively. Allocations for cancelled and finalized applications average $1900 per applied practice, whereas payments for finalized applications are $1583 per applied practice on average.

The mean of the dependent variable *Finalized* (0.77) indicates that on average, 77% of applications are completed or finalized and the remaining 23% are cancelled, whereas the mean of the dependent variable *CSratio* (0.61) suggests that on average, reimbursements amount to 61% of total allocations. Furthermore, the mean of the outcome variable *CostRatio* (0.66) suggests that on average, actual costs are less than the prevailing rates approved by the NCFS. Lastly, the mean of the dependent variable *AcreRatio* (0.67) implies that on average, 67% of approved acres receive the proposed treatments.

4. Results

4.1. Model 1: Logistic (finalized)

We interpret the estimated coefficients for each of the independent variables in Model 1 as the relationship between the characteristics and finalized applications (Table 5). The following factors are positively associated with the likelihood of a funded application being finalized: piedmont and mountain regions; K-G Blade/shearing, double-bedding, chemical release (both site preparation and timber stand improvement), and pine hand-planting activities; and the applied acreage. Positive coefficients on binary variables signify the characteristics associated with values of 1 have higher probabilities than the alternative characteristics (values of 0) to be positively associated with the dependent variable. For example, positive coefficients on the piedmont and mountain region variables indicate that applications from the piedmont and mountains are more likely than applications from the coastal plain to be finalized.

Table 5
Regression results for all models.

	(1)	(2)	(3)	(4)
	Logit – finalized	Fracreg logit – CSratio	Tobit A– CostRatio	Tobit B – AcreRatio
Base	−0.71***	−0.38***	−0.10***	−0.11***
	(0.10)	(0.05)	(0.02)	(0.02)
Piedmont	0.47***	0.26***	0.08***	0.10***
	(0.07)	(0.05)	(0.02)	(0.02)
MtnRegion	0.29*	−0.03	0.00	0.05*
	(0.13)	(0.07)	(0.02)	(0.02)
NonCorp	−0.25**	−0.23***	−0.08***	−0.06***
	(0.09)	(0.05)	(0.02)	(0.02)
CSburn	−0.97***	−0.83***	−0.28***	−0.28***
	(0.12)	(0.09)	(0.04)	(0.04)
CSshear	0.42**	0.39***	0.10**	0.07*
	(0.15)	(0.10)	(0.04)	(0.03)
CSbed	0.43**	0.35**	0.08	0.07
	(0.16)	(0.11)	(0.04)	(0.04)
CSchemSP	0.76***	0.38***	0.10***	0.15***
	(0.10)	(0.06)	(0.02)	(0.02)
CSpine	0.59***	0.59***	0.20***	0.12***
	(0.08)	(0.05)	(0.02)	(0.02)
CSchem	0.47***	0.00	−0.02	0.13***
	(0.14)	(0.08)	(0.03)	(0.03)
lnAcre	0.43***	0.28***	0.09***	0.10***
	(0.04)	(0.02)	(0.01)	(0.01)
CS40	−0.48***	−0.48***	−0.15***	−0.10**
	(0.13)	(0.09)	(0.03)	(0.03)
15.Year	−0.62***	−0.50***	−0.15***	−0.12***
	(0.13)	(0.07)	(0.02)	(0.02)
16.Year	−0.69***	−0.49***	−0.14***	−0.12***
	(0.13)	(0.07)	(0.02)	(0.02)
17.Year	−0.97***	−0.67***	−0.19***	−0.21***
	(0.13)	(0.07)	(0.02)	(0.02)
18.Year	−0.24	−0.12	−0.02	−0.04*
	(0.14)	(0.07)	(0.02)	(0.02)
19.Year	−0.10	−0.06	−0.01	−0.00
	(0.13)	(0.07)	(0.02)	(0.02)
Constant	0.83***	0.31*	0.54***	0.42***
	(0.23)	(0.14)	(0.05)	(0.05)
N	7809	7809	7809	7809

Standard errors in parentheses.
Binary alternative representations: special funds; coastal plain region; corporate landowners; other management practices; 60% cost-share rate.
Base year 2020: 20.Year or Year = 6.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

Conversely, the subsequent characteristics are negatively correlated with the likelihood of a funded application being finalized: base-fund; non-corporate landowners; burning activities; 40% cost-share rate; and applications funded between 2015 and 2017. The negative sign on the variable *noncorp* implies that non-corporate landowners are less likely than corporate landowners to finalize applications. The 2018 and 2019 funding-year variables are not significantly different from the base year 2020. The magnitude of the marginal impacts on *finalized*, in absolute terms, range from 4% to 15% for the significant determinant variables (Table 6). For instance, funding applications from the piedmont region, as opposed to the coastal plain, would increase the likelihood of completion by 7%, whereas applications paid through the base-fund would decrease the probability by 11%.

4.2. Model 2: Fractional response regression (CSratio)

The variables signifying the piedmont region, hand-planting of pine species, and the site preparation practices modeled outside of burning (K-G Blade/shear, double-bedding, and chemical release) are more likely than their respective alternatives to be related to applications that

Table 6
Marginal analysis for Models (1) and (2).

	(1)	(2)
	Logit – finalized	Fracreg logit – Csratio
Base	−0.11***	−0.08***
	(0.01)	(0.01)
Piedmont	0.07***	0.06***
	(0.01)	(0.01)
MtnRegion	0.05*	−0.01
	(0.02)	(0.02)
NonCorp	−0.04**	−0.05***
	(0.01)	(0.01)
CSburn	−0.15***	−0.18***
	(0.02)	(0.02)
CSshear	0.07**	0.09***
	(0.02)	(0.02)
CSbed	0.07**	0.08**
	(0.03)	(0.02)
CSchemSP	0.12***	0.08***
	(0.02)	(0.01)
CSpine	0.09***	0.13***
	(0.01)	(0.01)
CSchem	0.07***	0.00
	(0.02)	(0.02)
lnAcre	0.07***	0.06***
	(0.01)	(0.01)
CS40	−0.08***	−0.11***
	(0.02)	(0.02)
15.Year	−0.09***	−0.11***
	(0.02)	(0.01)
16.Year	−0.10***	−0.11***
	(0.02)	(0.02)
17.Year	−0.15***	−0.15***
	(0.02)	(0.02)
18.Year	−0.03	−0.03
	(0.02)	(0.02)
19.Year	−0.01	−0.01
	(0.02)	(0.01)

Standard errors in parentheses.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

will be fully implemented (Table 5). The variable associated with the number of approved acres also is positively correlated with the dependent variable *CSratio*. On the other hand, the variables representing applications associated with the base fund; non-corporate landowners; burning for site preparation; a 40% cost-share rate; and the 2015, 2016, and 2017 funding years are all negatively related to *CSratio*. The variables signifying chemical release for timber stand improvement (*CSchem*) and the 2018 and 2019 funding years are insignificant moderators with respect to the base practice and year variables. The magnitude of the estimated marginal effects associated with the significant factors range from 5% to 18% in absolute terms (Table 6).

4.3. Model 3: Tobit (CostRatio)

The variables associated with the piedmont region; K-G Blade/shearing, chemical release (site preparation), and pine hand-planting activities; and the applied and allocated acreage are positively related to the ratio of realized unitary costs to the approved prevailing rates (Table 5). Furthermore, the variables inversely related to *CSratio* are also negatively correlated with *CostRatio*: *Base*, *NonCorp*, *CSburn*, *CS*40, 15. *Year*, 16. *Year* and 17. *Year*. We interpret the coefficients estimated using the tobit approach similar to the results from ordinary least square regressions. To illustrate, an approved application from the piedmont region, as opposed to the coastal plain, increases the expected cost ratio by 0.08 or 8% (Table 5). The estimated coefficients range in magnitude from 8% to 28% in absolute terms. The variables representing chemical release for timber stand improvement and applications funded in 2018 and 2019 are not significantly different from other forest management practices and applications funded in 2020, respectively.

4.4. Model 4: Tobit (AcreRatio)

Results from the tobit estimation of Model 4 suggest that *AcreRatio* is positively associated with the piedmont and mountain regions, chemical release activities (both site preparation and timber stand improvement), pine hand-planting practices, and applied acreage (Table 5). In contrast, the completed: applied acre ratio is negatively related to the base fund, non-corporate landowners, burning treatments for site preparation, a 40% cost-share reimbursement rate, and the 2015, 2016, 2017, and 2018 funding years. In absolute terms, the values of the coefficients range from 4% to 28%. *CSshear*, *CSbed* and 19. *Year* are not significantly different from other management practices and the FY 2019–2020, respectively.

4.5. Pairwise comparison of cost-share practices

Table 7 displays the results from testing the null hypothesis that the difference between the coefficients on the cost-share practice variables listed under the "Term 1" columns are not significantly different from the estimated coefficients on the practice variables listed under the "Term 2" column. Applications for burning site preparation activities are significantly less likely than applications featuring the other cost-share practices evaluated in the study to be finalized and fully utilize allocations. Meanwhile, K-G Blade/shearing and double-bedding site improvement activities are more likely than chemical release (TSI) treatments to fully implement allocations but less likely than pine hand-planting practices. Interestingly, chemical release (SP) activities are more likely than chemical release (TSI) activities to be finalized and fully implemented. However, chemical (SP) practices are less likely than pine hand-planting practices to fully utilize allocations due to costs that are less than the prevailing rates on average. Lastly, pine hand-planting practices are more likely than chemical release (TSI) to fully utilize allocations and pay at the least the prevailing rate.

5. Discussion

Activities that are funded through the FDP base fund include mainly site preparation and timber stand improvement activities in the coastal plain and piedmont regions. Base-funded applications may also include (1) planting practices when they are combined with other management activities and (2) practices in the mountain region (i.e., when there are no available resources in the mountain fund). Results from the estimated models suggest that practices funded through the base fund are less likely than those financed through special funds to be finalized and reimbursed as specified in the approved application, thus confirming our expectations. This could be due to the number of activities in each application since our results imply that site preparation (other than burning) and timber activities are positively associated with the probability of funding projects that will fully utilize their allocations, at least of the practices analyzed.

Our results also indicate that project applications located in the piedmont and mountain regions are more likely than those in the coastal plain to be finalized and executed on at least the applied acreage (Table 5). In contrast to our expectations, applications from the piedmont region are likely to include a higher implementation rate as well as a higher cost: prevailing rate ratio than those from the coastal plain. Projects from the mountain region are determined to be not significantly different than applications from the coastal plain in terms of the extent of project implementation and the ratio of realized costs to the approved prevailing rate. These findings may be due in part to soil and site characteristics typical in the different regions, although, future studies should explore additional factors that may explain these differences such as access to service foresters and providers.

In addition, our results confirm our expectations that non-corporate

Table 7
Linear differences between estimated coefficients on cost-share practice variables.

Term 2	Model	Term 1				
		CSburn	CSshear	CSbed	CSchemSP	CSpine
CSshear	1	−0.22*** (0.03)				
	2	−0.27*** (0.03)				
	3	−0.39*** (0.05)				
	4	−0.35*** (0.04)				
CSbed	1	−0.22*** (0.03)	0.00 (0.03)			
	2	−0.26*** (0.03)	0.01 (0.03)			
	3	−0.36*** (0.05)	0.03 (0.05)			
	4	−0.35*** (0.05)	0.00 (0.04)			
CSchem-SP	1	−0.27*** (0.02)	−0.05* (0.02)	−0.05 (0.03)		
	2	−0.27*** (0.02)	0.00 (0.02)	−0.01 (0.02)		
	3	−0.38*** (0.04)	0.01 (0.03)	−0.02 (0.04)		
	4	−0.42*** (0.03)	−0.07* (0.03)	−0.07 (0.04)		
CSpine	1	−0.25*** (0.02)	−0.03 (0.02)	−0.03 (0.03)	0.03 (0.02)	
	2	−0.31*** (0.02)	−0.04* (0.02)	−0.05* (0.02)	−0.05*** (0.01)	
	3	−0.48*** (0.04)	−0.09** (0.03)	−0.12** (0.04)	−0.10*** (0.02)	
	4	−0.40*** (0.03)	−0.04 (0.03)	−0.04 (0.04)	0.03 (0.02)	
CSchem	1	−0.23*** (0.02)	−0.01 (0.03)	−0.01 (0.03)	0.05* (0.02)	0.02 (0.02)
	2	−0.18*** (0.02)	0.09** (0.03)	0.08** (0.03)	0.08*** (0.02)	0.13*** (0.02)
	3	−0.26*** (0.04)	0.13** (0.04)	0.10* (0.04)	0.12*** (0.03)	0.22*** (0.03)
	4	−0.41*** (0.04)	−0.06 (0.04)	−0.06 (0.04)	0.01 (0.03)	−0.01 (0.03)

Standard errors in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

landowners, including individuals, estates, trusts, and LLC., are less likely than corporate landowners to finalize their applications and receive full reimbursements. Some state program administrators argue that corporations should not receive financial assistance (Chizmar et al., 2021); further, corporate landowners with extensive forestland acreage may not be as attracted to apply for cost-share assistance for activities on at most 100 acres or which total to at most $10,000 per year. Conversely, others advocate for the inclusion of corporations in programs similar to the FDP which has been funded solely through the forest industry for the last several years (Thomas and Zaporozhets, 2017).

In contrast to our expectations, our estimations of Model 3 indicate that non-corporate landowners are more likely than corporations to pay a cost lower than the prevailing rate. While lowering the prevailing rates is a potential remedy to align reimbursements with their allocations as well as spread the limited funds across more applications, the action may also negatively influence the execution of cost-share practices, in terms of acreage. The FDP administrators may want to assess the rates or payments non-corporate landowners are willing to accept before canceling or not fully executing a cost-share application as these landownerships constitute the majority of private forestland in NC (Oswalt et al., 2019).

Furthermore, we attempted to control for economies of scale through the inclusion of an acre variable. Similar to our hypothesized relationships, the results suggest that higher acreage is correlated with a higher propensity of project completion and reimbursements that align with their allocations. A survey of the landowners in the data set could provide the information needed to estimate models which control for total landholdings and access to specialized knowledge and labor. This would help the FDP administrators understand elements related to economies of scale that lead to discrepancies between non-corporate and corporate landowners.

Burning practices are the only activities included in the study that are negatively related to each of the four dependent variables. Burning for site preparation was also found to be statistically different from the other practice variables (Table 7). Prescribed burning in forest management, when done under improper conditions, carries the risk of harm and danger to the forest, nearby properties and structures, and human lives. Poor weather conditions for a controlled burn and a lack of capacity to safely apply fire has been documented in the literature to impede implementation of controlled burning (Parajuli et al., 2019).

Similarly, activities with a 40% cost share rate are less likely than activities with a 60% cost-share rate to be completed as specified in the application, as we expected to be the case. The 40% cost-share rate primarily includes loblolly pine activities, whereas the 60% cost-share rate incentivizes management of higher priority species: longleaf pine, shortleaf pine, hardwoods, and wetland species. Conifers in NC typically perform better than hardwood species on lower-quality soils such as those common in the coastal plain (Megalos et al., 2019). The performance and economic returns of different species relative to soil characteristics and required management could help explain this discrepancy. Landowner objectives and preferences may also help account for differences in the execution of activities related to various tree species.

Counter to our expectation, the year variables representing 2015, 2016, and 2017 are associated with a lower probability than those in 2020 of funding finalized applications that fully implement their allocation. The 2018 funding year applications are also less likely than those funded in 2020 to be completed on all applied acres. In addition to year effects, the negative value of the coefficients may indicate that applications funded on a first-come, first-served basis are less likely than those funded through the lottery system to be finalized and fully utilize the allocated funds. The literature recognizes the importance of allocation decision-making in public incentives for conservation; however, it is divided over which method is most efficient in maximizing environmental and economic benefits (Cattaneo, 2003; Kilgore et al., 2007; Perez, 2008).

6. Conclusion

Since 1978, the NC FDP program continues to attract more demand for funds than can be supplied by the wood products tax assessment in NC. Program administrators are interested in adapting the program to maximize the number of acres subsidized within the present budget constraints. For the FY 2019–2020, FDP administrators began weighting allocations to districts in NC according to their contributions to the tax assessment on harvested wood products and selecting prospective applications through lottery systems (one in each district). This study provides observations on application characteristics such as location, ownership classification, and management practice to aid program administrators in decision-making and adaptive management.

Our results suggest that the following characteristics increase the likelihood of funding activities that will be completed on all intended acres and at costs that are at least the prevailing rates: the piedmont region, K-G Blade/shearing activities, chemical release (site

preparation) treatments, pine hand-planting practices, and larger applied acreages. Conversely, findings from the four estimated models indicate that projects associated with the following factors are expected to have lower rates of completion and implementation due to costs less than the prevailing rate and fewer completed than applied acres: base fund, non-corporate landowners, burning practices (site preparation), activities with a 40% cost-share rate, and applications funded between 2015 and 2017.

Nations around the world have enacted policies that support the production of environmental goods and services since the environmental movement of the 20th century. Accordingly, governments and donor institutions require greater attention and understanding of the effects of these programs for accountability and adaptive management purposes. Program evaluations of incentive policies, such as the analysis performed in this study on underused cost-share funds, provide frameworks for assessing the performance of the program, which is especially crucial under a constrained budget situation (Keene and Pullin, 2011). The forest cost-share programs of the U.S. South have traditionally acted as model policies for the nation (Mehmood and Zhang, 2002). The analysis performed in this study may be also applied to evaluate other public incentive programs, especially those that do not have access to socioeconomic data as well as resources to implement a primary survey.

This study has some notable caveats worth discussing. The research outlined in this paper is specific to the North Carolina FDP and may not be generalizable to all incentive programs. The program administrators of the FDP maintain rich datasets, much of which was made available to the study investigators. Incentive programs in other jurisdictions, whether local, state, regional, or federal, may not offer such detailed historical data, preventing replication of our methodology. Furthermore, the fund allocation problem we analyze may not be a concern to administrators of governmental programs that allocate benefits according to a different strategy.

Consequently, future research should include a survey of cost-share program participants to determine if the FDP induces forest management and how the program impacts wood supply and markets, if at all. A subsequent analysis should group applied practices by application and landowner, if possible, to control for repeat applicants. That would also allow us to isolate the effect of landowners applying for more than one practice in order to model their ability to execute each additional cost-share funded practice with respect to the region of the application, treatment characteristics, and fiscal year.

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Declaration of Competing Interest

We, all authors, declare that there is no conflict of interests regarding the publication of this paper in Forest Policy and Economics. The findings and conclusions in this publication are those of the authors and should not be construed to represent any official USDA or U.S. Government determination or policy.

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