ASSESSING THE EFFECTIVENESS OF PROPERTY TAX INCENTIVE PROGRAMS IN CONSERVING FORESTS IN GEORGIA

by

SAGAR GODAR CHHETRI

(Under the Direction of Yanshu Li)

ABSTRACT

Private forests account for more than 90% of the forestland in Georgia. They provide vital economic products, essential environmental and ecological benefits, and abundant opportunities for recreation. Maintaining and enhancing the profitability of private forests is critical to ensuring sustainable provision of the multiple benefits provided by these forests. Prudent forest landowners may consider conducting more intensive forest management and exploring nontimber income to improve the profitability. However, many private forest landowners experience pressure from the high costs of forest maintenance, including timberland property tax.

The Georgia legislature introduced several property tax incentive programs to provide tax relief among landowners and conserve forestland. The Conservation Use Valuation Assessment (CUVA) and Forest Land Protection Act (FLPA) programs are the major incentives available to Georgia forest landowners. Nevertheless, the effectiveness of the programs in conserving forestland has been frequently questioned by researchers and various stakeholders since their inception.

To address these issues, first, this dissertation conducted a literature review on assessments of the effectiveness of state property tax incentive programs for forest landowners in the U.S. Measures of program effectiveness, factors affecting landowners' participation, and methodologies were synthesized. Most existing studies were conducted at the aggregate levels. A study with more fine-grained information would provide more insight. Second, forest attributes of parcels enrolled and not enrolled in the CUVA/FLPA programs were compared for a selected list of counties in Georgia. The attributes included variables that had market, tax, and spatial information available at the parcel and county levels. Furthermore, a multilevel logistic regression model was used to analyze the effects of various factors on a parcel's enrollment in the CUVA/FLPA programs. The results indicated that the CUVA/FLPA programs promote the conservation of large tracts of forestlands but are limited in conserving forestlands with higher land values. Third, the dissertation presented the results from a survey of practicing consulting foresters regarding major forest management activities and the associated costs for family landowners in Georgia. The study provides first-hand information on forest management costs and implications on profitability for Georgia family forest landowners.

INDEX WORDS: Forest conservation, effectiveness, multilevel logistic regression, costs, enrollment, forest management activities, Georgia, landowners, state property tax incentive programs

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DEDICATION

I would like to dedicate this research to my parents, Mrs. Maiya Devi Godar and late Mr. Hemkul Godar.

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CHAPTER 1

INTRODUCTION

The United States (US) is home to 7.5% of the world's forestlands, with some 766 million acres of land, of which 521 million acres is timberland. According to the United States Forest Service (USFS), timberland is defined as forestland capable of producing in excess of 20 cubic feet per acre per year. Approximately 42% of the US forestlands (320 million acres) are owned by more than 10 million individual and family forest landowners (Oswalt & Smith, 2014). In addition, corporate companies, partnerships, and tribes own approximately 14% of US forestlands. Most private forest landowners are found in the South, as are approximately 81% of privately owned forestlands. Moreover, the South is home to 40% of the nation's timberland, which is why the South is often referred to as the "wood basket" of America (Oswalt & Smith, 2014).

In particular, the Southern state of Georgia has the highest amount of commercially available forestland, with approximately 22 million acres (Brandeis et al., 2014). Georgia is also known as the number one forestry state in the United States (Georgia Forestry Commission, 2021). Approximately 65% (24.7 million acres) of the state is forested, 98% of which is timberland. Georgia's forests are a mix of both hardwood (53%) and softwood (45%) tree species (Brandeis et al., 2014). Oak-hickory and loblolly-shortleaf forest types are the most dominant among the hardwood and softwood groups, respectively. Forests in Georgia are equally important for wildlife species, wetland conservation, and watershed protection. Since more than 81% of

Georgia's forestlands are owned by private landowners, their large tracts of private forests are important for wildlife abundance, movement, and diversity (Oswalt & Smith, 2014). Moreover, these forests provide clean air and water, carbon repositories, spaces for recreation, and life-enhancing products (Oswalt & Smith, 2014). Thus, these forests are socially, economically, and ecologically significant.

Private forest landowners own 90% of Georgia's forestlands (Georgia Forestry Commission, 2015). Private forestland contributes a considerable share of state's timber supply and provide many non-timber benefits. According to the USFS's National Woodland Owner Survey (NWOS), the most common objectives of owning forestland are for beauty, wildlife habitat, nature protection, and timber production. Landowners take monetary and non-monetary benefits from their forestland. To maximize benefits, landowners would invest their money in forest management (Godar Chhetri et al., 2019). The common forest management activities include site preparation, planting, prescribed burning, timber stand improvement, and protection against fire and insects. The cost associated with forest management activities can vary greatly depending on the level and nature of the management activity (Arano & Munn, 2004). However, property tax is an inevitable component of the costs to landowners. The study found that property tax is the topmost concern of private forest landowners in Georgia (US Forest Service, 2015).

In addition, due to population growth, urbanization, and development activities, Georgia's forestlands are increasingly under the pressure of being converted to other uses. Furthermore, disturbances such as fire, insects, diseases, and invasive species have severely affected Georgia's forestlands (Brandeis et al., 2014) . Although the literature indicates that Georgia's forest area has been relatively stable since 1910, this stability

does not mean that the forest quality or attributes have remained unchanged (Brandeis et al., 2014). One of the drivers of these issues is property taxes. Studies have found that a high tax burden contributes to landowners' decision to subdivide their forestland (Butler et al., 2010; Stone & Tyrrell, 2012). In addition, numerous studies (Brockett et al., 2003; Poudyal & Hodges, 2009; Sampson & DeCoster, 1997) have found that property tax burden is an important factor that influences landowners' decision to sell their forestland as well as their choices regarding forest management regimes (Dennis & Sendak, 1992; Rathke & Baughman, 1996). To address the aforementioned issues, Georgia has introduced several property tax incentive programs among landowners to protect property owners from being pressured by the property tax burden to convert their land from agricultural use (including forestry use) to residential or commercial use (Georgia Department of Revenue, 2021) and promote forestland conservation.

Three interrelated objectives guided this research, forming the five chapters of this dissertation. First, the study examined the literature on state property tax incentive programs aimed at promoting forestland conservation in the US. Second, the effectiveness of two major property tax incentive programs in conserving forests of Georgia is assessed by comparing the attributes of enrolled and nonenrolled forest parcels and constructing a multilevel logistic regression model to identify and quantify the effects of a range of factors associated with forest parcel enrollment in the preferential property tax programs. Third, a survey was conducted on consulting foresters to determine recent common forest management activities and the associated costs for family forest landowners in Georgia. The results from this study could be used to estimate net revenue

and costs of timberland investment for the valuation of timberland for property tax purposes.

Following this introduction, Chapter 2 reviews the literature related to state forest tax incentive programs across the US. Online search engines such as Google Scholar and Web of Science were used. This chapter compiles the objectives, scope, research methodology, major findings, and policy recommendations of each study reviewed. Chapter 3 compares the attributes between forestlands that are enrolled versus nonenrolled in property tax incentive programs in Georgia. In addition, it quantifies and identifies the factors associated with forest parcels in these programs. The chapter concludes with policy implications and recommendations. Chapter 4 illustrates common forest management practices and their associated costs in Georgia. The results are given separately by physiographic region in Georgia due to regional differences in forest types, prevalent management regimes, and timber prices. The results provide a snapshot of the intensity and costs of forest managements of private forest landowners in Georgia from the perspective of the surveyed consulting foresters. The chapter concludes with policy recommendations. Finally, Chapter 5 briefly summarizes and concludes the dissertation.

1.1 References

Arano, K. G., & Munn, I. A. (2004). Non-industrial private forest landowners' forest management activities and expenditures in Mississippi, 1998-2000 data. Forest and Wildlife Research Center, Bulletin FO249， Mississippi State University，Mississippi State, MS. 13 p.

Brandeis, T. J., McCollum, J., Hartsell, A., Brandeis, C., Rose, A. K., Oswalt, S. N., Vogt, J. T. J., & Marcano-Vega, H. (2016). Georgia's forests, 2014. Resource Bulletin SRS-209. US Department of Agriculture, Forest Service, Southern Research Station, Asheville, NC. 78 p.

Brockett, C. D., Gottfried, R. R., & Evans, J. P. (2003). The use of state tax incentives to promote forest preservation on private lands in Tennessee: An evaluation of their equity and effectiveness impacts. *Politics & Policy*, 31(2), 252-281. doi.org/10.1111/j.1747-1346.2003.tb00148.x

Butler, B. J., Hewes, J. H., Catanzaro, P., Greene, J. L., & Kilgore, M. A. (2010). Effects of federal, state, and local tax policies on family forest owners: technical report. US Department of Agriculture Forest Service/Univesity of Massachusetts Amherst, Family Forest Research Center, Amherst, MA. 74 p.

Dennis, D. F., & Sendak, P. E. (1992). An empirical study of enrollment in Vermont's use value appraisal property tax program. *Canadian Journal of Forest Research*, 22(9), 1209-1214.

Georgia Department of Revenue. (2021). *Table of conservation use land values*. https://dor.georgia.gov/table-conservation-use-land-values [accessed on 11/10/2021].

Georgia Forestry Commission. (2019). *Georgia Forest Facts*. https://gfagrow.org/advocate/numberone/ [accessed on 11/24/2021].

Georgia Forestry Commission. (2021). *The #1 forestry state in the nation*. https://gfagrow.org/advocate/numberone/ [accessed on 11/24/2021].

Godar Chhetri, S., Gordon, J., Munn, I., & Henderson, J. (2019). Comparison of the timber management expenses of non-industrial private forest landowners in Mississippi, United States: Results from 1995–1997 and 2015. *Environments*, 6(9), 107.

Oswalt, S.N., & Smith, W.B. (2014). US forest resource facts and historical trends. General Technical Report FS-1035. US Department of Agriculture, Forest Service, Southern Research Station. Knoxville, TN. 63 p.

Poudyal, N. C., & Hodges, D. G. (2009). Property taxation and rural land values: Their effect on private forestland ownership structure in Texas. *Land Use Policy*, 26(4), 1100-1105.

Rathke, D. M., & Baughman, M. J. (1996). Influencing nonindustrial private forest management through the property tax system. *Northern Journal of Applied Forestry*, 13(1), 30-36. https://doi.org/https://doi.org/10.1093/njaf/13.1.30

Sampson, R. N., & DeCoster, L. A. (1997). Public programs for private forestry. American Forest.

Stone, R. S., & Tyrrell, M. L. (2012). Motivations for family forestland parcelization in the Catskill/Delaware watersheds of New York. *Journal of Forestry*, 110(5), 267-274. doi.org/10.5849/jof.11-015

US Forest Service. (2015). Who owns America's trees, woods, and forests? Results from the U.S. Forest Service 2011-2013 National Woodland Owner Survey. NRS-INF-31-15. US Department of Agriculture, Forest Service, Northern Research Station, Newtown Square, PA. 12 p.

CHAPTER 2

STATE FOREST TAX INCENTIVE PROGRAMS AND FOREST CONSERVATION: A LITERATURE REVIEW[1]

[1] [1] Godar Chhetri, S & Li, Y. To be submitted to [Forest Policy and Economics]

Abstract

Property tax is consistently among the major concern for private forest landowners in the US and is also identified as one of the driving forces behind forest parcelization and fragmentation. All 50 states have some kind of state preferential tax incentive programs to provide property tax relief to private forest landowners and slow the conversion of forestland into developed use. Whether these programs are effective in achieving their goals has been of great concern to many concerned stakeholders and been the focus of a number of studies. This paper compiles and analyzes the relevant literature related to assessment of the effectiveness of state preferential property tax incentive programs in the US. The reviewed studies vary greatly by geographic scope, time frame, research method, evaluation criteria, data resolution, and final results. With a few exceptions, the studies generally suggest that the state preferential property tax programs make contributions towards conserving forests. However, the effectiveness of these programs in conserving forests under intense development pressure is shown limited. Despite the mixed results, number of landowner participation and acreage of enrolled forestland in programs were major criteria in evaluating the effectiveness of the property tax incentive programs. Factors prevent landowners from participating in the programs include lack of awareness, shift in tax burden, strict program requirements, and penalty for breach. Furthermore, previous studies have overlooked several variables that might influence landowners' decision to participate in such programs. Thus, comprehensive parcel-level research is required for a better understanding of the effectiveness of state preferential tax incentive programs.

Keywords

State property tax incentives, effectiveness, forestland, NIPF landowners

2.1 Introduction

Forestland comprises approximately 751 million acres of the United States land area (U.S. Forest Service, 2008). Most (56%) US forestland is privately owned (U.S. Forest Service, 2008). Of this private land, 62% is owned by families/individuals, and the remaining is owned by corporations, conservation organizations, and others (U.S. Forest Service, 2008). Private lands are critical for beauty and scenery, providing habitat for wildlife, nature protection (U.S. Forest Service, 2008), investment or income, family legacy, farming and ranching (Bengston et al., 2011), and buffering nature reserves (Wright, 1998). However, private forests have been under pressure from urban development and increased property taxes. Property taxes are listed among the top concerns of private forest landowners (Butler et al., 2010). High property taxes reduce the profitability of timber investment. Property tax burden is found to be an essential factor that influences the landowners' decision to sell their forestland (Brockett et al., 2003; Poudyal & Hodges, 2009; Sampson & DeCoster, 1997). Landowners need to pay property tax annually. However, it may take several decades for them to conduct a timber harvest and receive income from the timber sale (Wicker, 2002). The income could be quite limited if the forestland is owned primarily for aesthetics and recreational purposes. This cash-flow issue has been faced by many private forest landowners. The property tax issue becomes more acute for owners of forestland being under intense development pressure (Kimbell, 2010). Studies have found that property tax is one of the major drivers leading to forest parcelization and fragmentation. (Butler et al., 2010; Poudyal & Hodges, 2009; Stone & Tyrrell, 2012). Property taxes could also influence the use and management of private forests (Dennis & Sendak, 1992; Rathke & Baughman, 1996). High property taxes lead some landowners to timber harvesting before optimal harvest

age and convert of forestland to more economically profitable land uses (Cubbage & Wear, 1994). A reduction in property taxes may provide an incentive for private landowners to retain their forestland and support sustain provision of public benefits from the forests. Therefore, all 50 states have adopted some sort of preferential property tax incentive programs to respond to the need. Although each program may have its specific objectives and goals, property tax relief and forest preservation are usually listed among the goals. Current-use programs are the most popular type of the state property tax incentive programs. Under current-use programs, forestland is assessed and taxed at its current uses (forestry or agricultural uses) rather than at its market value (Hickman & Greene, 2015). With current use programs, enrolled forest owners pay lower property taxes. These programs have evolved from encouraging timber production to forest multiuse (Egan, 1997) and focus not only on timber but also the importance of forestland for wildlife habitats, recreation, watershed protection (Egan, 1997), and ecosystem health (Clendenning & Stier, 2002).

Numerous studies have found that current use programs are intended to preserve timberland and open space (Kingsley, 1995), slow the pace of development (Anderson, 1993; Maker et al., 2014), prevent the conversion of forestland to commercial and residential use (Williams et al., 2004), protect unique recreation resources (Haas, 2011), and reduce forestland tax (Hickman & Crowther, 1991; Rathke & Baughman, 1996). Nonetheless, a few other studies have shown that these programs demonstrate minimal effectiveness in preventing the conversion of timberland into other land uses (Malme, 1993) and often fail to protect forestland (Dennis & Sendak, 1992; Hibbard et al., 2003). Program effectiveness has been evaluated through various measures, including eligibility

requirements, characteristics of enrolled forestland, landowners' attitude, and net tax amount saved by enrolled landowners. Previous research has generally focused on one or a few of these factors, but rarely all simultaneously. Addressing each of these factors requires expertise in different domains. Nevertheless, compiling and summarizing all information on the effectiveness of current use programs will be valuable to stakeholders.

The purpose of our study was to review the literature regarding the effectiveness of state current use programs with a focus on forest conservation. The review will identify major evaluation criteria used to assess the effectiveness of the current use programs in achieving their conservation goals and knowledge gaps in current research. The information will be used to develop a conceptual model for estimating factors that affect forest parcels' enrollment in the current-use programs in Georgia. In the following section, I examine the history and trends of current use programs across the United States. I then review existing studies on the effectiveness of state preferential property tax programs, with particular attention to their objectives, scope, and methodology. That section is followed by an exploration of the major findings of the studies. Finally, the paper concludes with discussion, conclusion, and policy recommendations.

2.2 State Current Use Programs for Forestland

Every state has certain types of current use programs, whose attributes and eligibility requirements help determine enrollment. Provision of minimum/maximum acreage, enrollment periods, withdrawal penalties, written forest management plans, and prejudices between private and corporate landowners are some aspects that hinder the enrollment of forestland in such programs. Some states have a certain minimum acreage requirement to participate in current use programs. One study found that the land eligible

to enroll in such programs would be increased by 5% if the size requirement were reduced to five acres (Kingsley, 1995). Certain programs might waive the minimum requirement for landowners who generate a minimum income level (Hibbard et al., 2003). Similarly, the enrollment period varies from two (New Jersey and Utah) to 50 years (Wisconsin). However, in some states, landowners are able to renew the covenant for more time. These minimum sizes and periods improve program efficiency by reducing the per-acre administration fees and achieving economies of scale.

Landowners may also feel at risk due to the provision of withdrawal penalties. Approximately 81% of current use programs in the United States have established penalties for withdrawal from preferential tax incentive programs (Butler et al., 2010). The calculation of penalties depends upon the county and specific program[2]. The penalties constitute the difference between the owed taxes with and without the program, plus the interest rate[3]. Furthermore, 54% of these programs require a forest management plan, which provides landowners with forest management guidelines. Many landowners pay a fee to hire consulting foresters to prepare a management plan, which raises the question of whether landowners with low income are equally able to hire such professionals. Requirements such as a forest management plan, which could necessitate the hiring of an outside professional, might prevent many forest landowners from participating in current use programs.

[2] Assessed in two ways, the breakeven point and penalty versus profit.
[3] The interest rate and taxes owed in a given time period vary by state and provision of the preferential tax incentive program

2.2.1. History and Trends of State Current Use Programs

Policymakers and planners have introduced a broad array of policy tools to produce and maintain public goods on private forestland (Bengston et al., 2004). Property tax incentive programs represent one such tool and have been established for nearly a century in the US. In 1914, Massachusetts became the first state to pass legislation to reduce the property tax for private forest landowners (Hibbard et al., 2003; Rozman, 1942) to enhance forest management and ensure the future timber supply (Locke & Rissman, 2012; Sendak & Dennis, 1989). However, only 1% of the country's private forestland was enrolled under a special tax program by 1960 (Williams, 1961). This low enrollment was due to inadequate attention from state incentive programs to nonindustrial private forest (NIPF) landowners with objectives other than timber production (Marler & Graves, 1974). During the 1960s, many states passed preferential assessment laws for farms and forests (Jacobson & McDill, 2003). These programs have gradually evolved from a timber focus and have adopted recreation, wildlife habitat, watershed protection, and aesthetic purposes (Egan, 1997). Throughout the 1990s, all 50 states passed some form of state property tax incentives for forestland. At present, a total of 38.5 million US landowners, owning 210 million acres of forestland, agricultural land, and open space, are enrolled under some kind of tax incentive program (Kilgore et al., 2017).

2.2.2. Objectives of the Programs

As of 2021, each US state had some sort of current use program for forestland, and many have multiple programs available for forest landowners. Tax incentive programs focus primarily on forestland, followed by open space, agricultural land, and habitat conservation. Each state program varies by scope and name (Table 1).

Table 1: Scope of the state preferential tax incentive programs

Region	State	Program legal/common name	Program goals
North	Connecticut	Current use	Conservation
	Delaware	General property tax program	Conservation
		Commercial Forest Plantations	Timber production
		Forest Preservation Program	Conservation
	Illinois	Forest Management Plan	
		Conservation Stewardship	
		Transition Percentage Assessment	
		Land enrolled in Conservation Programs	
	Indiana	Classified Forest & Wildlands Program	Conservation, woodland and wildlife stewardship
	Iowa	Agricultural real estate	
		Forest and fruit-tree reservations	Forest reservation and fruit-use
	Maine	Tree Growth Tax Law	Conservation, tax saving
	Maryland	Forest Conservation and Management	Conservation, timber production, welfare of the State
		Forest Management Plan Program	Timber production
	Massachusetts	Chapter 61-Forestry	Conservation, keeping undeveloped land
		Chapter 61A-Agriculture	Conservation, keeping undeveloped land
		Chapter 61B-Open Space and Recreation	Long-term land management
	Michigan	Commercial Forest Tax Program	Conservation, tax saving
		Qualified Forest Program	Conservation,
	Minnesota	Managed Forest Land	Promotion of sustainable forest management
		Sustainable Forest Incentive Act	Long-term forest protection
	Missouri	Forest Cropland	Encourage forestry, fire prevention

	New Hampshire	Forest Land, Forest Land with Documented Stewardship	Conservation, preservation of open space
	New Jersey	Farmland Assessment Program	Preservation of open space
	New York	Forest Tax Law (480-a)	Conservation
		Forest and reforested lands (Fisher Act)	
	Ohio	Current Agricultural Use Program	Timber production
		Ohio Forest Tax Law	Timber production
	Pennsylvania	Clean and Green Program	Conservation, tax saving
	Rhode Island	Farm, Forest and Open Space Tax Program	Conservation, welfare of the State
	Vermont	Agricultural & Managed Forest Use Value Program	Timber and agricultural production, conservation, tax saving, equitable tax
	West Virginia	Managed Timberland Program	Timber production
	Wisconsin	Managed Forest Land Program	Tax saving
		Forest Crop Law Program	Sustainable forest management
South	Alabama	Current use value	Timber and forest products production
	Arkansas	Timberland	Forestland protection
	Florida	Green Belt Program	Conservation
	Georgia	Agricultural Preferential Assessment	Tax saving, conservation
		Conservation Use Assessment	Tax saving, conservation
		Forest Land Protection Act	Tax saving, conservation
	Kentucky	Current Use Tax	Tax saving
	Louisiana	Use Value	Timber production
	Mississippi	Current Use Tax	N/A
	North Carolina	Forestry Present Use Valuation Program	Tax saving
		Wildlife Conservation Land Program (WCLP)	Conservation
	Oklahoma	Agricultural Land	N/A
	South Carolina	Agricultural Use Land	Tax saving
	Tennessee	Greenbelt Law	Preservation of open space

	Texas	Timberland for Productivity Appraisal Classification	Timber production
		Restricted Use Timberland Classification	Conservation
	Virginia	Forestry Land Use	Conservation, Preservation of water source, preservation of open space
Rocky Mountain	Arizona	General Property Tax Program	
	Colorado	Forest Ag	Conservation
	Idaho	Bare Land and Yield Tax	Tax saving
		Productivity Tax System	Tax saving
	Kansas	Agricultural Land	Production, soil conservation
	Montana	Forest Lands Tax	Forest protection, encouragement of reforestation
	Nebraska	Greenbelt	Continuation of agriculture and horticulture
	Nevada	Agricultural Land Classification	Conservation of agricultural lands
		Open Space Classification	Preservation of open-space lands
	New Mexico	General Property Tax Program	Conservation
	North Dakota	Forest Stewardship Property Tax	Financial incentive, conservation
	South Dakota	General Property Tax System	N/A
	Utah	Farmland Assessment Act Greenbelt Act	Tax saving
	Wyoming	Managed Timberland Program	Tax saving
Pacific Coast Region	Alaska	General Taxation Exemption	Tax saving
	California	Timberland Production Zone, Open Space Land	Conservation, timber, and other forest product production
	Hawaii	Native Forest Dedication	Conservation
		Commercial Agricultural Use Dedication	Timber production
		Tree Farm Development	Timber production
	Oregon	Forestland Program	Tax saving

	Small tract forestland option	Tax saving, accommodation of small-woodland owners
Washington	Designated Forest Land	Forestland protection
	Open Space Timberland	Timber production

Note. N/A=Not available

2.3 Review Methodology

An extensive review of peer-reviewed journals, technical reports, research bulletin, and other working papers was conducted dealing with current use programs implemented in the US. The review was mainly concerned with compiling the objectives, scopes, results, findings, and policy recommendations of the previous studies. The search algorithm included a two-tier of keywords. The first tier of keywords included "property tax incentive program." The second tier of keywords was "forestland enrollment," "landowner's participation," "effectiveness," "United States," and "forest conservation." We only considered articles for review if the keywords appeared in either the title, topic, or abstract of the paper. We used a database called "Web of Science" and "Google Scholar" to find literature. Web of Science and Google Scholar are the largest databases of different scientific fields that are often used for searching the literature (Guz & Rushchitsky, 2009). Altogether, I found 938 articles with the keyword in the body of text and 78 articles with the keywords in the title. After cleaning up, I used 55 papers for this review.

2.4 Results

2.4.1. Geographic Scope

The selected studies on current use programs and their geographic scope examined in this work are shown in Table 2. These studies focused mostly on county-

level to nationwide programs and on the east coast. Their objectives and scope are summarized in Table 2 below.

Table 2: Selected previous studies on current use programs for forestland

Study	Year	Scope (County, state, region)
King (1963)	1963	Wisconsin, three counties (Marinette, Oconto, and Waupaca)
Hickman (1982)	1982	Tennessee: 45 counties (20 participating counties and 25 nonparticipating counties)
Chang (1982)	1982	Nationwide
Gayer (1987)	1987	Virginia, 20 counties or cities
Sendak and Dennis (1989)	1989	Vermont, statewide comparisons
Hickman and Crowther (1991)	1991	East Texas, 43 easternmost counties or districts
Dennis and Sendak (1992)	1992	Vermont
Malme (1993)	1993	Nationwide
Anderson (1993)	1993	Nationwide
Sendak and Huyler (1994)	1994	Vermont
Kingsley (1995)	1995	22 municipalities
Rathke and Baughman (1996)	1996	Minnesota
Parks and Quimio (1996)	1996	New Jersey
Costello (1997)	1997	Western Oregon (19 counties) and Alabama
Newman et al. (2000)	2000	Nine counties in North Georgia
Wagner et al. (2002)	2002	New York, 11 counties and 78 townships
Clendenning and Stier (2002)	2002	Nationwide
Brockett et al. (2003)	2003	Tennessee: Franklin County
Jacobson and McDill (2003)	2003	Pennsylvania, state level
Hibbard et al. (2003)	2003	Nationwide
Williams et al. (2004)	2004	Three counties in southeastern Tennessee
Cushing (2006)	2006	23 states (Oregon, Washington, Alabama, Mississippi, Georgia, Florida, Tennessee, South Carolina, North Carolina, Louisiana, Virginia,

		Arkansas, Idaho, Texas, New York, Pennsylvania, Michigan, Kentucky, West Virginia, Minnesota, Maine, and Wisconsin)
Kilgore et al. (2007)	2007	Nationwide
Eckhoff et al. (2007)	2007	Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming
Polyakov and Zhang (2007)	2007	Louisiana, state level
Poudyal and Hodges (2009)	2009	Texas
Butler et al. (2010)	2010	Nationwide
Kimbell et al. (2010)	2010	Nationwide
Fortney et al. 2011	2011	Statewide
Haas (2011)	2011	Maine: 8 counties
Udayanganie (2012)	2012	New Hampshire, 231 towns
Meng and Zhang (2013)	2013	Georgia
Ma et al. (2014)	2013	36 states
Maker et al. (2014)	2014	Vermont, four counties (Chittenden, Washington, Caledonia, and Essex)
Kilgore et al. (2017)	2017	Nationwide
Meier et al. (2019)	2019	National assessment
Hickman (n.d.)	N.A.	Nationwide

2.4.2. Stated Objectives in Previous Studies

Several studies have been carried out to assess the effectiveness of tax incentive programs, which has primarily been measured through protection of forestland (Malme, 1993; Williams et al., 2004) and promotion of the ecosystem in private lands (Clendenning & Stier, 2002). Many studies have also analyzed the effects of use-value assessment on land-use decisions (Anderson, 1993), tax burden on landowners (Hickman, 1982; Hickman & Crowther, 1991), tax revenue (Rickenbach & Saunders, 2009), and

sustainable forest management (Kilgore et al., 2017; Maker et al., 2014; Udayanganie, 2012). Other studies have been conducted to compare the similarities and differences among programs in different states (Ma et al., 2014) and characteristics of enrolled and nonenrolled forestland (Sendak & Dennis, 1989). Various studies have identified factors that affect landowners' decisions regarding participation in the programs, such as property tax rates, landowners residential distance to the nearest city, and land value (Fortney & Arano, 2010; Udayanganie, 2012). Further, Kingsley (1995) used the enrolled forest acreage as an indicator of program participation. Wagner et al. (2002) examined whether the state property tax incentive programs act as a substitute or complement for zoning on protecting forestland and encouraging active forest management.

2.4.3. Methods Used in Previous Studies

Previous studies have used varying methods of data collection and analysis to examine the effectiveness of current use programs that can be broadly categorized under two methodological approaches: i) survey approach and ii) econometric modeling. Basically, the survey approach studies provide the attitude, motivations, and level of knowledge and awareness about the current use programs among landowners. However, econometric models quantify the factors that affect forest landowners and forestland in participating in the current use programs.

2.4.3.1. Survey Approach

Most of the studies were empirical studies based on observation and experience. Mail surveys of landowners (Dennis & Sendak, 1992; Fortney et al., 2011; Maker et al., 2014; Rathke & Baughman, 1996; Williams et al., 2004) and program administrators (Butler et al., 2010; Kilgore et al., 2007; Ma et al., 2014) were major sources for data

collection. One survey asked landowners to identify their level of awareness and perceptions of preferential tax incentive programs to aid in identifying eligible and ineligible forestland (Kingsley, 1995). Similarly, surveys of administrators aided in identifying their perceptions regarding the effectiveness of tax incentive programs. However, the response rates varied between landowner and administrator surveys, with a higher response rate for administrators (97%; Ma et al., 2014) than for landowners (22%; Williams et al., 2004). The main reason for the high response rate from administrators was likely the prior provision of information about the survey via telephone. In addition, state-level departments of revenue (Haas, 2011; Hickman, 1982; Newman et al., 2000; Udayanganie, 2012), a national woodland owner dataset (Meier et al., 2019), and state-level departments of natural resources (Rickenbach & Saunders, 2009; Sendak & Hyuler, 1994) were other sources for data collection. Department of Revenue data included tax rate, tax levies, rollback taxes, area of forestland enrolled in programs, property location, owners, stand data, and an assessed value of the taxable property. These data were analyzed with simple descriptive statistics in several studies (Ma et al., 2014; Newman et al., 2000; Rathke & Baughman, 1996; Sendak & Huyler, 1994).

2.4.3.1. Econometric Models

Researchers have commonly used econometric models to specify the statistical relationship between dependent and explanatory variables. Probit and logistical models are frequently used regression models to identify the factors affecting the probability of enrollment in current use programs and provide information on whether the explanatory variables are statistically significant to the probability of program enrollment. For instance, using such modeling, researchers have explored the change in probability of

enrollment for each one-unit change in the associated exogenous variable, such as income, education, and objective of forest ownership (Williams et al., 2004). Additionally, marginal effects were calculated to examine the predicted probability of enrollment change associated with changes in the explanatory variables (Fortney et al., 2011). Several studies about current use programs employed a probit model (Williams et al., 2004), generalized least squares (Parks & Quimio, 1996), logistic regression model (Fortney et al., 2011; Rathke & Baughman, 1996), multiple linear regression model (King, 1963), conditional logit and two-level nested logit models (Polyakov et al., 2007), land development model (Anderson, 1993), or binary choice model (Dennis & Sendak, 1992) to analyze the data.

2.4.4. Criteria Used to Measure Program Effectiveness

Major criteria used to evaluate the effectiveness of the state's preferential tax incentive programs included landowners' awareness level regarding incentive programs, administrators' attitude, proportion of eligible forestland enrolled in such programs, and reduced landowner tax burden.

2.4.4.1. Landowner Awareness

Awareness of tax incentive programs is often the first step for landowners in making their decision about program participation. Thus, landowner awareness was one of the criteria used in many studies to measure program effectiveness. Specifically, landowner awareness of the merits and demerits of such programs and their ability to enroll was investigated. Studies by Williams et al. (2004) and Butler et al. (2010) used this criterion to measure program effectiveness. For instance, if forest landowners have no information about current use programs, there is little to no probability of their

enrollment in such programs. Additionally, landowners' level of awareness determines their attitude towards current use programs. Therefore, one study also employed landowners' attitude towards current use programs to assess their effectiveness (Fortney et al., 2011).

2.4.4.2. Number of Enrolled Landowners

The number of landowners participating in the program is another major tool for evaluating program effectiveness (Rathke & Baughman, 1996; Williams et al., 2004). This criterion is easier to use when a higher number of enrollments is the indicator of program success. However, the number of enrolled landowners might also increase due to the parcelization of forestland.

2.4.4.3. Acreage of Enrolled Forestland or Percentage of Eligible Lands Enrolled

The enrollment of forestland in current use programs is also considered an indicator of program effectiveness. With this criterion, a higher proportion or percentage of eligible lands enrolled in the programs indicates a more successful implementation. The percentage of eligible land enrolled in such programs was used by Maker et al. (2014) and Butler et al. (2010). Both studies found that less than half of eligible forestland were enrolled in current use programs. The percentage change in the total area of private forestland was also used as an a indicator of program effectiveness (Ma et al., 2014). Ma et al. (2014) further found that the largest percentage of forestland decline (21.2%) occurred in California, whereas private forestland increased by approximately 41% in Iowa from 1997 to 2007.

2.4.4.4. Forestland Characteristics

The existence of large tracts of forestland enrolled in the program and not converted to other land uses over time can be considered as indicating the success of tax incentive programs to some extent, largely because forestland enrollment could delay conversion into other land uses. The characteristics of lands enrolled in the program, such as the size of forest tracts and land productivity, were also used as effectiveness indicators (Newman et al., 2000). Similarly, the availability of various forest products, such as trees per acre and saw-timber volume, of lands enrolled in such programs were also criteria in one study (Sendak & Dennis, 1989). This type of criterion could reflect program effectiveness, to some extent, if these programs encourage landowners to become active forest managers. Ma et al. (2014) used a change in average forest size enrolled in current use programs during two periods as a criterion to assess program effectiveness.

2.4.4.5. Forest Management Plan

The presence of a written forest management plan is another requirement for enrollment in many programs and was also used by several studies as a criterion to evaluate program success. Although the presence of forest management is not necessarily a perfect indicator of sustainable forestland management, it can be used as a surrogate indicator (Ma et al., 2014).

2.4.4.6. Tax Savings

As one of the objectives of current use programs is to reduce the tax liability for forest landowners, the effectiveness of these programs can be measured by whether the landowners participating in them reduce their forestland tax owed. This criterion was

used by several studies (Haas, 2011; Rathke & Baughman, 1996). Despite the benefits of reduced tax liability for landowners, however, the government loses tax revenue through such programs (Gayer, 1987). In most cases, these taxes shift to other property owners. The balance between tax relief and revenue effect is the best way to measure program effectiveness. Various studies have employed the equitable distribution of the tax burden for low-income landowners and underdeveloped land as indicators (Brockett et al., 2003; Sendak & Dennis, 1989). Brockett et al. (2003) compared the average tax burden and average tax reduction for low-income landowners. The difference in tax burden and reduction determines programs' effectiveness in reducing forest landowners' tax burden and increasing their tax savings. Additionally, if the current use program significantly lowered the property tax on forest land, it achieved its goal (Sendak & Dennis, 1989).

2.5 Findings of Previous Studies

2.5.1. Proportion of Eligible Forestland Enrolled

Studies carried out in New Hampshire (Kingsley, 1995) and Georgia (Newman et al., 2000) showed that a significant portion of the eligible forestland in these states were enrolled in current use programs. Forest enrollment ranged from 4 to 94% by county in Virginia (Gayer, 1987) and from none to 82% in Alabama (Flick et al., 1989; Malme, 1993). During the 1990s, forestland enrollment in such programs grew rapidly (Dennis & Sendak, 1992). However, one somewhat recent study found that enrollment in current use programs is low (Wolde et al., 2016).

2.5.2. Landowner Participation

The exact number of participants in tax incentive programs is unclear and is not reported uniformly because forest landowners may enroll their forestland in more than

one program and may enroll several separate parcels as a single property (Kilgore et al., 2017). Nonetheless, several studies have attempted to estimate the rate of participation in these programs by using county tax assessor data. The number of landowners enrolled in such programs was low in Tennessee (Williams et al., 2004). In contrast, a survey conducted of forest landowners in East Texas indicated their interest in participating in a current use program (Hickman & Crowther, 1991). In a recent study, an estimated 3.85 million landowners were participating in tax incentive programs (Kilgore et al., 2017).

2.5.3. Landowners' Attitude Towards Property Tax Incentive Programs

Many landowners lack knowledge about the benefits of enrolling in tax incentive programs. They frequently do not know about the provision of current use valuation programs at the county or state levels. Previous studies have found unfamiliarity with programs (Hickman, 1982), low awareness levels (Williams et al., 2004), and a lack of clarity about all aspects of such programs among forest landowners (Fortney et al., 2011). Forest landowners often had not even heard about these programs. Other reasons for a lack of enrollment included confusion with program minimum requirements, withdrawal penalties, and benefits. This type of confusion was mostly observed in the South, where program requirements were also the least restrictive (Butler et al., 2010). Landowners' position, views, and satisfaction levels regarding preferential tax incentive programs must be considered.

One study (Brockett et al., 2003) found no significant difference in landowners' forest management behavior between participants and nonparticipants. Specific landowner behaviors, such as hiring consulting foresters and investing in timberland, reflect active forest management on the part of forest landowners. Active forest

management includes the implementation of forest management activities and the generation of income from these activities. Landowners who engaged in harvesting activities were more likely to enroll in tax incentive programs (Sendak & Huyler, 1994). Moreover, active forest managers were more likely to enroll in such programs (Meier et al., 2019). Participants in tax incentive programs were more likely to sell timber and timber stand improvements (Rathke & Baughman, 1996). Additionally, enrolled forestland were less likely to be used for hunting purposes (Meier et al., 2019). However, it remains unclear whether tax incentive programs motivate landowners to be more active forest managers or whether enrolled landowners are already actively managing their forest land.

2.5.4. Socioeconomic Profiles of Participating and Nonparticipating Landowners

The objective of land ownership, economic status, education, and social factors are all important in determining landowners' decisions on land use conversion. Education is positively correlated with enrollment in preferential tax incentive programs (Meier et al., 2019). Some studies have found that formal (university degree) and informal (forestry-related training and knowledge) education plays a crucial role in landowners' enrollment in such programs. Educated landowners may have more awareness and/or knowledge of the benefits of these programs. Since education and income are highly related among forest landowners (Chhetri et al., 2018), higher income among landowners is positively correlated with their program enrollment (Meier et al., 2019). Population density, absentee landownership, population growth rate, and property tax rate are some social factors that determine the conversion of land use. However, none of the variables

(total population, population density, and percentage of the urban county population) were significant in one study (Meier et al., 2019).

2.5.5. Characteristics of Enrolled and Nonenrolled Forestland

Parcel size, spatial location, forest type, and land productivity classes are identified as important variables to consider when assessing the effectiveness of tax incentive programs. For example, only about 20% of private forest landowners in Pennsylvania are eligible for the state's current use program (Jacobson & McDill, 2003). This lower participation may be because many smaller and larger parcel sizes are excluded due to specific program requirements. Due to the minimum acreage requirement for enrollment and economies of scale, many forestland parcels enrolled under preferential tax incentive programs are relatively large (Dennis & Sendak, 1992; Kingsley, 1995; Meier et al., 2019; Newman et al., 2000). This trend indicates that the programs help conserve large and intact forestland, which generally have more value in providing wildlife habitat (Meier et al., 2019) and ecosystem services (Kilgore et al., 2017) than smaller, isolated parcels.

The effectiveness of the current use programs is quite limited for parcels with high development pressure (Malme, 1993) because the tax savings from these programs are trivial compared to the economic benefits from potential development uses. Moreover, lands under development pressure are prone to land use conversion. Nonetheless, Udayanganie (2012) found that forest landowners were more inclined to enroll in an incentive program for parcels located closer to town (in that study, Manchester, New Hampshire). Thus, the distance of forestland to the city can have both

positive and negative effects on program enrollment, depending on the rate of development and average land value of the areas in question (Udayanganie, 2012).

2.5.6. Tax Savings for Enrolled Forest Landowners

One study found that preferential tax incentive programs reduced the property taxes for eligible landowners in some northern states (Maine, New Hampshire, New York, and Vermont) (Haas, 2011). Landowners also perceived a tax savings of between 1% to 75% after enrolling their forestland in such programs (Fortney et al., 2011). The degree of tax reduction also varied by county and by forest type in Virginia (Gayer, 1987). While counties with rapidly expanding suburbs experienced the most significant decrease in tax for non-forestland, counties with relatively small populations had the lowest tax reduction in forestland (Gayer, 1987). The benefits of tax reduction for forest landowners, however, do come at a cost. For example, the Virginia state government experienced a loss of approximately 39% of potential tax revenue due to program participation (Gayer, 1987). Furthermore, the tax burden on ineligible and nonparticipating properties increased by 17% (Hickman & Crowther, 1991).

2.5.7. Consensus/Controversy

Although preferential tax incentive programs protect forestland from conversion to some extent, enrollment is concentrated among a relatively few landowners because of program requirements. Most programs stipulate minimum and maximum parcel sizes, so landowners must own a certain amount of land to be eligible for enrollment. For example, landowners must own at least 0.5 acres in Maui County, Hawaii, to participate (Butler et al., 2010). This minimum limitation varies by state and across types of preferential programs. Some programs have been found to encourage forestland parcelization by

providing a tax break for upscale developments with houses on 10+-acre lots (Jacobson & McDill, 2003). Due to increased property tax and urbanization, there is increasing forest fragmentation and parcelization in some states (LaPierre & Germain, 2005). The combination of forest parcelization and the minimum acre requirement prevents many landowners from enrolling their forestland in current use programs. Many landowners perceived preferential taxation as an expensive method (Malme, 1993). Moreover, incentive programs can create property tax inequalities among landowners. Many landowners who are not participants in such programs have suffered an increased tax burden.

Preferential tax incentive programs also attempt to address the sustainability of the ecosystem. However, due to the lack of cross-boundary forest management regimes and provisions for native species and their habitats, some programs fail to achieve ecosystem management (Clendenning & Stier, 2002). Many studies have found that incentive programs do not demonstrate clear evidence of preventing or slowing the pace of development in forestland (Jacobson & McDill, 2003). Moreover, these programs are not always effective in retaining forestland as forested (Meier et al., 2019). Although these programs encourage silvicultural practices, they often fail to maintain sustainable forest management regimes (Maker et al., 2014).

2.5.8. Constraints on Landowners' Enrollment in Tax Incentive Programs

In the studies included in this review, landowners had several reasons for choosing not to participate in tax incentive programs, including lack of awareness, newness or unfamiliarity of the programs, confusion, and rigid program requirements. Due to landowners' misinterpretation or misunderstanding of such programs, these

programs fail to demonstrate their advantages clearly to the landowners. There is a considerable knowledge gap among landowners about program requirements such as withdrawal penalties and their working mechanisms. In cases where landowners breached the contract associated with program participation, penalty calculation methods were difficult and unclear, and many landowners needed assistance with this paperwork (Cushing, 2006).

2.5.9. Research Gaps

Several studies have suggested needed research on program effectiveness. Future studies should focus on landowners' motivation for land ownership and enrollment, land use change due to these programs, and ownership structure. Such studies should focus on landowners' awareness, attitudes, and perceptions of these programs (Ma et al., 2012; Newman et al., 2000; Williams et al., 2004). Almost all previous studies have been carried out at the county and state levels. A study using parcel-level spatial information would contribute to the literature on the effectiveness of the state property tax incentive programs. Additionally, empirical research requires longitudinal studies to observe the behavior of the system over time (Sendak & Dennis, 1989).

In addition to new research, routine review and reevaluation of incentive programs are necessary to evaluate their success (Hickman, 1982). A systematic evaluation that includes cost-benefit analysis and contingent valuation can evaluate program effectiveness (Eckhoff et al., 2007). Similarly, periodic and regular monitoring of the forest characteristics of both enrolled and unenrolled forestland is necessary to assess program benefits (Dennis & Sendak, 1992; Gayer, 1987). Many studies excluded numerous variables that can help measure program effectiveness. Comprehensive

research should thus be conducted at the parcel level that includes numerous variables such as forestland productivity, objectives of forest landowners (King, 1963), and land use change (Polyakov et al., 2007) and incorporates spatial information on forestland (Parks & Quimio, 1996).

This paper found no studies that illustrated the influence of forest types (e.g., hardwood, pine, and mixed) and objectives of owning forestland (e.g., business, investment, recreation, and conservation) on participating in an incentive program. These factors are important to incorporate into models because they may prompt or hinder forest landowners from participating in such programs. In addition, it is important to analyze the trend of forestland and to monitor the changes in forest conditions in targeted areas (e.g., near water bodies, biodiversity hotspots, and fragile land).

2.6 Discussion

Current use programs have been somewhat effective in achieving program goals. Studies have used various indicators to determine the effectiveness of state tax incentive programs, including number of participating forest landowners, proportion of forestland enrolled in these programs, rate of conversion of forestland into other development land use, percentage change in forest cover, landowners' awareness of programs, and forest landowners' willingness to enroll. Studies have suggested that such programs have slowed the rate of land conversion to developed land use in Wisconsin (Anderson, 1993) and New Hampshire (Udayanganie, 2012). However, it remains difficult to determine whether these programs actually retard development activities in forestland, and it is impossible to disentangle the effects of the tax incentive programs from other forces changing forestland ownership. To determine whether such programs exert an impact on

land conversion, it is necessary to know the rate of conversion had they not been launched. Tac incentive programs attempt to address sustainability, structural diversity, ecosystem health, and societal needs (Clendenning & Stier, 2002), but they are not a long-term solution to conserve forestland because the covenant period for the programs is not permanent; landowners can review their commitment every ten years.

Previous studies have reported that current use programs are not widely utilized (Hickman, 1982; Williams et al., 2004). Moreover, many studies have shown that tax incentive programs have not reached their full efficacy due to a lack of landowner knowledge, administrative difficulties, strict program requirements, forestland location, and landowners' attitudes (Fortney & Arano, 2010; Hibbard et al., 2003; Jacobson & McDill, 2003; Maker et al., 2014; Meier et al., 2019; Williams et al., 2004). These findings suggest that landowners have not been fully or effectively informed about such programs. For example, many landowners have claimed that incentive programs are biased and generally favor landowners with larger forest tracts, which indicates that the assessors or administrators failed to clarify the program requirements and structure to these landowners.

Several studies have identified various factors that influence forest landowners' decision to enroll in preferential tax incentive programs, particularly landowners' attitudes and policy attributes. One study grouped these factors into internal (program characteristics) and external (related to human activities) factors (Ma et al., 2014)

2.7 Conclusions

This paper identified and compiled the major studies that focus on the effectiveness of current use programs applicable to forestland in the United States. The

majority of studies identified sociodemographic and forestland characteristics that influence the enrollment of forestland in these programs. In addition, the minimum requirements of such programs also affect forestland enrollment. Most importantly, no study used parcel-level data and geospatial information to examine effectiveness. Therefore, it is necessary to carry out a study incorporating the influential missing variables, such as forestland distance to streams and/or water resources, cities, biodiversity hotspots and/or protected areas, as well as soil class, to determine the effectiveness of current use programs in achieving their goals.

2.8 Recommendations of the Existing Literature

Based on the findings of the studies examined herein, the literature provided recommendations for both policymakers and researchers. While formulating policies, policymakers must focus on the simplicity of the process of enrolling forestland. It is recommended that policies should be flexible, understandable, and appropriate for landowners (Butler et al., 2010). It is also suggested to develop less expensive policies such as nonexclusive agricultural zoning and installment purchase financing of development rights (Malme, 1993). Reducing paperwork and providing clear techniques for forestland assessment for landowners and county tax assessors might play an important role in the creation of reasonable policies (Fortney et al., 2011).

In addition to the assessment methodology, the policies themselves should be inclusive of a wide range of forest landowners. Structurally and procedurally sound policies and programs should be established (Ma et al., 2014) and should address different forest types with slow and fast growth rates. Special programs for landowners with slow growth forests and relatively high taxes should also be developed (Cushing,

2006). These special programs might include an environment for carbon trade and a market for other ecosystem services such as water quality protection (Hickman, 2007). Most programs focused only on agricultural and timber resources. As a result, many open spaces, farmland, and forestland below minimum acreage cannot be enrolled. It is also necessary to incorporate the protection of native ecosystem integrity (Brockett et al., 2003) and open space in areas of high development pressure (Kingsley, 1995). Furthermore, some programs had a constant penalty rate regardless of the duration of enrollment, meaning that landowners who have been enrolled longer in an incentive program are treated the same as those with shorter enrollments, which results in inequities. Therefore, it is suggested that the withdrawal penalty should diminish with the length of enrollment (Udayanganie, 2012). Policies should clearly articulate program goals, complement other programs, and demonstrate their advantages for landowners (Hibbard et al., 2003). Finally, policies should establish good collaboration and coordination between state- and federal-level tax incentive programs.

Many studies' recommendations focused on increasing landowners' awareness, knowledge, and familiarity with incentive programs. Extension programs should be developed that increase landowners' awareness of their state's preferential tax incentive program(s) and, in turn, increase their participation (Meier et al., 2019; Williams et al., 2004). Similarly, proper communication between policymakers and landowners should be established. The creation of education programs among landowners should be encouraged (Haas, 2011). Various training, meetings, workshops, and conferences can be organized. Activities can be facilitated by government foresters. One study showed that increasing the presence of service foresters and design programs that represent all

landowners can increase landowners' awareness of land management possibilities and their likelihood of enrollment in incentive programs (Kilgore et al., 2007).

2.9 References

Anderson, J. E. (1993). Use-value property tax assessment: effects on land development. *Land Economics*, 69(3), 263-269. doi.org/10.2307/3146592

Bengston, D. N., Asah, S. T., & Butler, B. J. (2011). The diverse values and motivations of family forest owners in the United States: an analysis of an open-ended question in the National Woodland Owner Survey. *Small-Scale Forestry*, 10(3), 339-355. doi.org/10.1007/s11842-019-09423-7

Bengston, D. N., Fletcher, J. O., & Nelson, K. C. (2004). Public policies for managing urban growth and protecting open space: Policy instruments and lessons learned in the United States. *Landscape and Urban Planning*, 69, 271–286.

Brockett, C. D., Gottfried, R. R., & Evans, J. P. (2003). The use of state tax incentives to promote forest preservation on private lands in Tennessee: An evaluation of their equity and effectiveness impacts. *Politics & Policy*, 31(2), 252-281. doi.org/10.1111/j.1747-1346. 2003.tb00148.x

Butler, B. J., Hewes, J. H., Catanzaro, P., Greene, J. L., & Kilgore, M. A. (2010). Effects of federal, state, and local tax policies on family forest owners: technical report, US Department of Agriculture Forest Service/University of Massachusetts Amherst, Family Forest Research Center, Amherst, MA. 74 p.

Chang, S. J. (1982). An economic analysis of forest taxation's impact on optimal rotation age. *Land Economics*, 58(3), 310-323. doi.org/10.2307/3145939

Chhetri, S. G., Gordon, J. S., Munn, I. A., & Henderson, J. E. (2018). Factors influencing the use of consulting foresters by non-industrial private forest landowners in Mississippi. *The Forestry Chronicle*, 94(3), 254-259. doi.org/10.5558/tfc2018-038

Clendenning, J. G., & Stier, J. C. (2002). Ecosystem management and preferential property taxes for forestland in the United States. *Forstwissenschaftliche Beiträge* 27, Zurich, Switzerland 47 p.

Costello, S. T. (1997). Analysis of the efficiency, equity, and adequacy of a forest site value tax. Dissertation Virginia Polytechnic Institute and State University, Blacksburg, VA. 97 p.

Cubbage, F., & Wear, D. (1994). Can nonindustrial private forest landowners make up the shortfall in timber production from national forests? *In Proceedings: Foresters together: meeting tomorrow's challenges.* Society of American Foresters National Convention. November 6-10. Indianapolis, IN. 421-426.

Cushing, T. L. (2006). A comparison of the relative reduction in land expectation value due to taxation of private forest land in the United States. (Doctoral dissertation) University of Georgia, Athens, GA. 148 p.

Dennis, D. F., & Sendak, P. E. (1992). An empirical study of enrollment in Vermont's use value appraisal property tax program. *Canadian Journal of Forest Research*, 22(9), 1209-1214. doi.org/10.1139/x92-161

Eckhoff, M., Mackes, K., & Reader, T. (2007). Assessing state-sponsored tax incentive programs for nonindustrial private forest landowners in the western United States. *Western Journal of Applied Forestry*, 22(4), 253-260. doi.org/10.1093/wjaf/22.4.253

Egan, A. F. (1997). From timber to forests and people: a view of nonindustrial private forest research. *Northern Journal of Applied Forestry*, 14(4), 189-193.

Flick, W. A., Krietemeyer, S. W., & Hickman, C. A. (1989). Current-use assessment in Alabama. Bulletin 600, August 2009. Alabama Agriculture Experiment Station, Auburn, AL.

Fortney, J., & Arano, K. G. (2010). Property taxes and forests in West Virginia: a historical review. *Small-Scale Forestry*, 9(1), 67-80. doi.org/10.1007/s11842-009-9102-6

Fortney, J., Arano, K. G., & Jacobson, M. (2011). An evaluation of West Virginia's managed timberland tax incentive program. *Forest Policy and Economics*, 13(1), 69-78.

Gayer, P. D. (1987). Financial impact of current-use assessment of forest land in Virginia. Research Paper SO-240. US Department of Agriculture, Forest Service, Southern Forest Experiment Station, New Orleans, LA. 10 p.

Guz, A. N., & Rushchitsky, J. J. (2009). Scopus: a system for the evaluation of scientific journals. *International Applied Mechanics*, 45(4), 351-362.

Haas, J. L. (2011). The impact of taxation on Land Expectation Value and sustainable forest management in the Northern Forest states. (Thesis). State University of New York College of Environmental Science and Forestry, Syracuse, NY. 160 p.

Hibbard, C. M., Kilgore, M. A., & Ellefson, P. V. (2003). Property taxation of private forests in the United States: A national review. *Journal of Forestry*, 101(3), 44-49. doi.org/10.1093/jof/101.3.44

Hickman, C. A., & Crowther, K. D. (1991). Economic impacts of current-use assessment of rural land in the east Texas pineywoods region. Research Paper. SO-261. US Department of Agriculture, Forest Service, Southern Forest Experiment Station, New Orleans, LA. 10 p.

Hickman, C. (n.d.). Property taxes and the loss of private forests. Issue Paper. US Department of Agriculture, Forest Service, 18 p.

Hickman, C. A. (1982). Property tax impacts of current-use assessment of forest and other rural land in Tennessee. Research Paper SO–180. US Department of Agriculture, Forest Service, Southern Forest Experiment Station, New Orleans, LA. 17 p.

Hickman, C. A., & Greene, J. L. (2015). Property tax. In: Forests and Forestry in the Americas: An Encyclopedia. In: Cubbage, F.W. (Eds), Society of American Foresters and International Society of Tropical Foresters. http://64.78.1.15/index.php/Main_Page [accessed on 04/21/2021]

Jacobson, M., & McDill, M. (2003). A historical review of forest property taxes in Pennsylvania: Implications for special forestland tax programs. *Northern Journal of Applied Forestry*, 20(2), 53-60. doi.org/10.1093/njaf/20.2.53

Kilgore, M. A., Ellefson, P. B., Funk, T. J., & Frey, G. E. (2017). State property tax incentives for promoting ecosystem goods and services from private forest land in the United States: A review and analysis. General Technical Report SRS–228. US Department of Agriculture, Forest Service, Southern Research Station, Asheville, NC. 174 p.

Kilgore, M. A., Greene, J. L., Jacobson, M. G., Straka, T. J., & Daniels, S. E. (2007). The influence of financial incentive programs in promoting sustainable forestry on the nation's family forests. *Journal of Forestry*, 105(4), 184-191.

Kimbell, A., Hickman, C., & Brown, H. (2010). How do taxes affect America's private forest landowners? *Journal of Forestry*, 108(2), 93-102.

King, D. A. (1963). Forest land classification for property tax assessment purposes in Wisconsin. *Land Economics*, 39(1), 96-99. doi.org/10.2307/3144523

Kingsley, E. W. (1995). Enrollment and eligibility in New Hampshire's current use taxation program. Booklet. University of New Hampshire. Durham, NH. 6 p.

LaPierre, S., & Germain, R. H. (2005). Forestland parcelization in the New York City watershed. *Journal of Forestry*, 103(3), 139-145. doi.org/10.1093/jof/103.3.139

Locke, C. M., & Rissman, A. R. (2012). Unexpected co-benefits: forest connectivity and property tax incentives. *Landscape and Urban Planning*, 104(3-4), 418-425. doi.org/10.1016/j.landurbplan.2011.11.022

Ma, Z., Butler, B. J., Catanzaro, P. F., Greene, J. L., Hewes, J. H., Kilgore, M. A., Kittredge, D. B., & Tyrrell, M. (2014). The effectiveness of state preferential property tax programs in conserving forests: Comparisons, measurements, and challenges. *Land Use Policy*, 36, 492-499. doi.org/10.1016/j.landusepol.2013.09.016

Maker, N. F., Germain, R. H., & Anderson, N. M. (2014). Working woods: a case study of sustainable forest management on Vermont family forests. *Journal of Forestry*, 112(4), 371-380. doi.org/10.5849/jof.13-003

Malme, J. (1993). Preferential property tax treatment of land. Lincoln Institute of Land Policy, Cambridge, MA.

Marler, R. L., & Graves, P. F. (1974). A new rationale for small forest landowners. Research Report, AFRI-17. State University of New York, Ithaca, NY.

Meier, J. T., Kilgore, M. A., Frey, G. E., Snyder, S. A., & Blinn, C. R. (2019). A comparison of participants and non-participants of state forest property tax programs in the United States. *Forest Policy and Economics*, 102, 10-16. doi.org/10.1016/j.forpol.2019.02.002

Meng, L., & Zhang, D. (2013). Impacts of property tax on land use change decisions in Georgia. *Urban Ecosystems*, 16(1), 3-12.

Newman, D. H., Brooks, T. A., & Dangerfield Jr, C. W. (2000). Conservation use valuation and land protection in Georgia. *Forest Policy and Economics*, 1(3-4), 257-266. doi.org/10.1016/S1389-9341(00)00024-1

Parks, P. J., & Quimio, W. R. H. (1996). Preserving agricultural land with farmland assessment: New Jersey as a case study. *Agricultural and Resource Economics Review*, 25(1203-2016-94816), 22-27. doi.org/10.1017/S1068280500000034

Polyakov, M., Zhang, D., & Univers, A. (2007). Property taxes: do they affect forestry and agricultural land uses? *Emerging Issues in Forest Economics*, 134. doi.org/10.1016/j.landusepol.2009.01.005

Poudyal, N. C., & Hodges, D. G. (2009). Property taxation and rural land values: Their effect on private forestland ownership structure in Texas. *Land Use Policy*, 26(4), 1100-1105.

Rathke, D. M., & Baughman, M. J. (1996). Influencing nonindustrial private forest management through the property tax system. *Northern Journal of Applied Forestry*, 13(1), 30-36. doi.org/10.1093/njaf/13.1.30

Rickenbach, M., & Saunders, L. (2009). The managed forest law & property tax revenues for townships: a study of enrollment shifts & local impacts. GWQ52. University of Wisconsin. Madison, WI. 24 p.

Rozman, D. (1942). Massachusetts Forest Tax Law. *The Journal of Land & Public Utility Economics*, 18(3), 363-365. doi.org/10.2307/3159067

Sampson, R. N., & DeCoster, L. A. (1997). Public programs for private forestry. *American Forests*. Washington DC. 100 p.

Sendak, P. E., & Huyler, N.K. (1994). Timber management and use-value assessment. Research Paper RP-NE-691. US Department of Agriculture, Forest Service, Northeastern Forest Experiment Station, Broomall, PA. 12 p.

Sendak, P. E., & Dennis, D. F. (1989). Vermont's use value appraisal property tax program: A forest inventory and analysis. Research Paper RP-NE-627. US Department of Agriculture, Forest Service, Northeastern Forest Experiment Station, Broomall, PA. 73 p.

Stone, R. S., & Tyrrell, M. L. (2012). Motivations for family forestland parcelization in the Catskill/Delaware watersheds of New York. *Journal of Forestry*, 110(5), 267-274. doi.org/10.5849/jof.11-015

U.S. Forest Service. (2008). Who owns America's forests? Forest ownership patterns and family forest highlights from the National Woodland Owner Survey. NRS-INF-06-08. US Department of Agriculture, Forest Service, Northern Research Station, Amherst, MA. 7 p.

Udayanganie, D. (2012). Current use property taxation in the conservation of New Hampshire land: an empirical investigation using Multiple Imputations. Working Paper. Lincoln Institute of Land Policy, Cambridge, MA. 21 p.

Wagner, J. E., Davis, C. J., Roczen, D. E., & Herrington, L. P. (2002). Combining zoning regulations and property tax relief to retain forestland and promote forest management. *Northern Journal of Applied Forestry*, 19(2), 59-67. doi.org/10.1093/njaf/19.2.59

Wicker, G. (2002). Motivation for private forest landowners. In: Wear, D.N., John, G. (Eds), Southern forest resource assessment. General Technical Report SRS-53. US Department of Agriculture, Forest Service, Southern Research Station, Asheville, NC. 635 p.

Williams, E. D., Gottfried, R. R., Brockett, C. D., & Evans, J. P. (2004). An integrated analysis of the effectiveness of Tennessee's Forest Greenbelt Program. *Landscape and Urban Planning*, 69(2-3), 287-297. doi.org/10.1016/j.landurbplan.2003.08.008

Williams, E. T. (1961). Trends in forest taxation. *National Tax Journal*, 14(2), 113-144.

Wolde, B., Lal, P., Gan, J., Alavalapati, J., Taylor, E., & Burli, P. (2016). Determinants of enrollment in public incentive programs for forest management and their effect on future programs for woody bioenergy: evidence from Virginia and Texas. *Canadian Journal of Forest Research*, 46(6), 775-782.

Wright, J. B. (1998). The role of conservation easement sites in biogeographic and biological research in the USA. *Environmental Conservation*, 25(2), 95-98. doi:10.1017/S0376892998000149

CHAPTER 3

AN ANALYSIS OF THE FACTORS ASSOCIATED WITH FORESTLAND ENROLLMENT IN PROPERTY TAX INCENTIVE PROGRAMS IN GEORGIA [4]

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Abstract

Georgia has 24.6 million acres of forestland, of which approximately 90% is owned by more than 600,000 private forest landowners. Property tax remains one of the top concerns of private forest landowners in Georgia, since it reduces the profitability of timber investment and may contribute to forest parcelization and fragmentation. The Georgia General Assembly has introduced several property tax incentive programs to provide tax relief for qualifying forest landowners and sustain public benefits from the forests they own. Among them, the Conservation Use Valuation Assessment (CUVA) program and the Forest Land Protection Act (FLPA) program are the most popular. The purpose of this study was to identify and quantify the factors associated with Georgia forest landowners' enrollment in these two programs and assess the effectiveness of the programs in conserving forestland. This study compared a variety of attributes of forest parcels that are enrolled and nonenrolled in the incentive programs. Furthermore, a multilevel logistic regression model was used to quantify the effects of the identified factors on the enrollment decision. The results revealed that the majority of Georgia forests were enrolled under preferential property tax incentive programs. Forest size, distance to city, enrollment status of neighbor parcels, land productivity, and tax-saving amount had significantly positive effects on a parcel's enrollment in the programs, while distance to specified conservation areas, county population density, absentee landowners, and county forest cover ratio had significantly negative effects on enrollment. The effects of land value exhibited a nonlinear pattern. The likelihood of a parcel being enrolled in the incentive programs increased first in line with appreciation in land value. However, when land value attained a certain threshold, the likelihood of it being enrolled began to

decrease with land value increase. The acreage and percentage of enrolled forestland suggested that incentive programs have attracted a significant amount of qualifying land and contributed to conserving forests in Georgia. However, the effectiveness of these programs is limited in attracting parcels near urban areas and lakes.

Keywords

Landowners, enrollment, CUVA, FLPA, multilevel logistic regression model

3.1. Introduction

Of the 24.6 million acres of forestland in Georgia, individual private landowners own 55%, corporations own 29%, and the forest industry owns 6% (GFC, 2015). According to the United States Department of Agriculture (USDA), individual or family ownership includes families, individuals, trusts, estates, family partnerships, and other unincorporated groups. Corporate forest ownerships are businesses that own forestland for timber production and other purposes (e.g., Weyerhaeuser). Forest owned by private wood industry companies comprise forest industry ownership. Landowners may choose to own forestland for economic benefits (timber products and hunting leases), social benefits (hunting, aesthetics, and recreation), and ecological benefits (e.g., wildlife habitat, air purification, climate regulation, and watershed regulation). In addition, many landowners own forestland to cherish a family legacy and pass it along to their heirs.

According to the 2013 USFS National Woodland Owner Survey, local property tax was cited as the top concern of private forest landowners in Georgia (Butler & Butler, 2016). Property tax levied upon the fair market value (FMV) of land fosters the transition of farming and forestland into suburban development (Coughlin et al., 1978). This issue becomes more acute for owners whose forestlands are on the rural-urban fringe due to rising development pressure. In addition, property taxes have been identified as one of the major drivers leading to forest parcelization and fragmentation (Polyakov & Zhang, 2008). Several other studies have also found that the high property tax associated with FMV may force landowners to sell or split their land into smaller parcels (Argow, 1996; Haines et al., 2011; Mehmood & Zhang, 2001; Mundell et al., 2010; Sampson & DeCoster, 1997), which may have significant effects on land use change.

Georgia experienced considerable land use change from 1975 to 2002, seeing a 9.6% decrease in rural lands and a 564.9% increase in developed lands (Meng & Zhang, 2013); this change does not follow a linear pattern over time (Upadhaya & Dwivedi, 2019a). The transformation of forestland into other land cover classes poses profound challenges for environmental conservation (Upadhaya & Dwivedi, 2019b). Although the total acreage of forest in Georgia remained approximately the same between 1982 and 2012, more than 1.7 million acres of forest were converted to residential or commercial uses in this period. An equal amount of cropland or pasture was converted to forests during the same period (U.S. Natural Resources Conservation Service, 2016). According to Georgia's statewide assessment of forest resources (2015), Georgia's canopy cover declined by a total of 398,330 acres from 2001 to 2005, producing significant economic and environmental effects such as an increase in property tax, lower water and air quality, and loss of biodiversity (Meng & Zhang, 2013).

Like many other states, Georgia's legislature has adopted a wide range of policy tools to encourage landowners to own forestland, with particular importance placed on preferential property tax incentives (Kilgore et al., 2007). In Georgia, such programs include the Agricultural Preferential (AP) assessment, Conservation Use Valuation Assessment (CUVA), and Forest Land Protection Act (FLPA) programs. Individuals and corporate forest landowners can participate in these tax incentive programs upon meeting eligibility requirements. The forestland enrolled in preferential tax incentive programs (except for the AP) are valued at their current use instead of FMV for property tax purposes. These programs have been evolving to address landowners' issues and protect Georgia forestland. Before the 1980s, private forestland in Georgia was taxed annually at

its FMV. As a result of urbanization and increased land values, property taxes on forestland in many areas of the state rose dramatically. The Georgia General Assembly introduced the AP program in 1983. Forestland under the AP program is assessed and taxed at 75% of its FMV. This legislation provided property tax relief to qualifying landowners, but the amount of tax savings was not able to keep up with the rapid increase in land values. In 1992, the CUVA program was introduced to keep rural land in traditional uses (agricultural, forestry, and open space) and encourage conservation. CUVA is available to individual landowners and has a maximum acreage limit of 2,000 acres. Once forestland is enrolled, CUVA properties are assessed at the CUVA value developed by the Georgia Department of Revenue. As an exchange, enrolled landowners must sign a 10-year covenant agreeing to maintain the current use throughout the covenant period. Landowners who breach this must pay a penalty that is calculated as twice the amount of savings they received over the covenant period plus interest. However, the CUVA and AP programs are not available to forest industry and corporate owners, nor are forestlands larger than 2,000 acres eligible. These limitations not only created an equity issue in property taxation but also contributed to the increasing divesture of industrial timberland in the state.

To address this issue, the Georgia legislature introduced the Forest Land Protection Act (FLPA) in 2008. The FLPA program extended the property tax relief to industry and corporate forest landowners and lifted the maximum acreage limit for qualifying parcels. Similar to the CUVA program, qualifying landowners are required to place their qualifying property in a 10-year covenant under the FLPA program. The enrolled forestland must be used for conservation and ecological forest management.

Land use may include subsistence or commercial production of trees, timber and other woody products. As with CUVA, landowners who breach a covenant must pay a penalty. CUVA targets small private forest landowners, whereas FLPA extended property tax relief to corporate and large forest landowners, improved uniformity of forestland taxation across the state, and leveled the playing field for different types of forest landowners.

Landowners' decision to enroll in tax incentive programs is influenced by various social, ecological, and economic factors, not merely on landowners' characteristics and program requirements but also on numerous other factors such as urban areas, population growth rate or density, biologically important areas, and other factors. However, only a few past studies have examined the effects of the ecological and social factors (Bagdon & Kilgore, 2013; Frey et al., 2019; Udayanganie, 2012). Most of these empirical studies were based mainly on regional, state, or county-level data. There is a lack of research based on parcel-level data.

Unfortunately, forestland enrollment in such tax incentive programs is low (Hickman, 1982; Jacobson & McDill, 2003; Williams et al., 2004) because of a lack of awareness about these programs (Butler et al., 2010; Meier et al., 2019) and program requirements (Fortney et al., 2011; Ma et al., 2014). To increase participation in these programs, it is essential to explore both the county- and parcel-level factors that might influence enrollment. We address those gaps by designing our research questions using both county- and parcel-level data. This study identified and quantified the effect of factors that influence the enrollment of private forestland into Georgia property tax incentive programs, ultimately allowing for the assessment of the program's effectiveness

in conserving forestland. The results will be of interest to policymakers, forest landowners, and the general public.

3.2. Project Goal, Objectives, and Hypothesis

The overall goal of this study is to understand the effectiveness of state property tax incentive programs in conserving Georgia forestland. The objectives of this study include: 1) comparing the difference in attributes of forest properties enrolled and not enrolled in the CUVA and FLPA programs and 2) identifying and quantifying the factors that influence the enrollment of forest parcels in the CUVA and FLPA programs. The hypothesis is that these two tax incentive programs are effective in conserving Georgia forests.

3.3. Methodology

4.3.1. Study Area

Georgia's 159 counties vary considerably in forest resources, wood industries, economic condition, land market, and socioeconomic status of populations. Georgia is defined by a diversity of landscapes, from the Cumberland Plateau to the Coastal Plain. It is home to approximately 250 tree species and 58 protected plants. Wilkinson is the most heavily forested county, and Cobb County is the least (Brandeis et al., 2016). Moreover, Georgia has one of the fastest population growth rates in the U.S, with growth of approximately 9.6% between 2010 and 2019. Dekalb County has the highest population density (2608 per square mile), whereas Clinch County has the lowest (8 per square mile). In 2019, the median household income in Georgia was $58,700, with the highest being $107,218 in Forsyth County and the lowest being $32,405 in Telfair County (U.S. Census Bureau, 2019). Due to budget and time limitations, a single-stage cluster sampling approach was used to select a sample of counties.

A cluster analysis was used to select counties for the study (Figure 1) by grouping the 159 Georgia counties into five clusters based on median income, population, forestland area, and property tax rate. Table 3 presents the eigenvalues of the covariance matrix. A simple random sampling method was then used to select representative counties within each cluster. All forestland parcels in the selected counties were analyzed. In addition, we analyzed land cover change during 2001-2019 for the study area using the National Land Cover Database (NLCD) to determine the rate of forest cover change during those periods.

Table 3: Eigenvalues of the covariance matrix

	Eigenvalue	**Difference**	**Proportion**	**Cumulative**
1	632.00	632.00	0.32	0.32
2	449.52	182.47	0.22	0.55
3	370.23	79.28	0.18	0.74
4	300.43	69.80	0.15	0.8
5	207.49	92.94	0.10	1.00

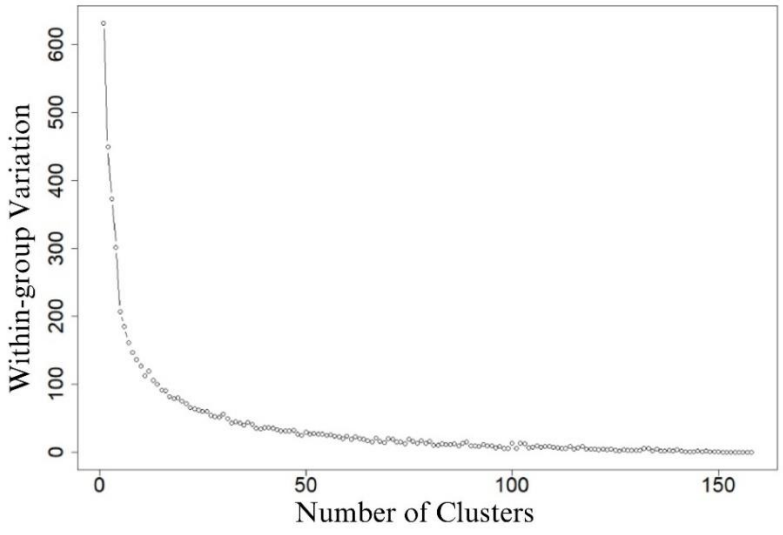


Figure 1: The number of clusters and corresponding eigenvalues

Cluster I (n=4) has the least forestland cover and the highest population. Cluster II (n=24) has the highest average millage rate (31). The tax rate for clusters I and II are the same. Cluster III (n=28) has the highest forest area and lowest median household income. The average tax rate for clusters III and IV is the same (6%). Cluster IV(n=80) has the lowest population. The remaining cluster V (n=23) has the lowest millage rate. Based on the availability of data from each cluster and our study objectives, we selected 32 study counties from the four clusters (Table 4). Due to the lack of data, we were not able to include any cluster-I county in the study. The selected study counties are shown in Figure 2.

Table 4: Distribution of counties based on cluster

Cluster	**Total Counties**	**Sampled Counties**
I	4	0
II	24	2
III	28	8
IV	80	14
V	23	8
Total	**159**	**32**

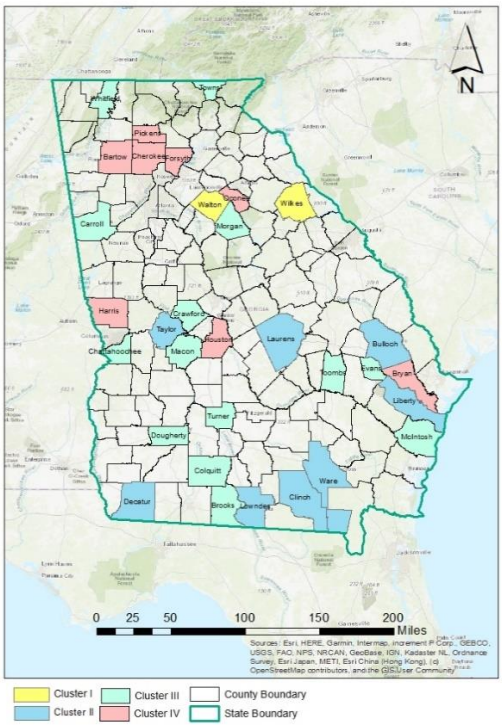


Figure 2: Study area map showing the counties selected and cluster designation

4.3.1. Conceptual Model

A multilevel logistic regression model was used to estimate the effects of the factors associated with forest parcel enrollment in the CUVA or FLPA programs in Georgia. The dependent variable is binary and is coded as 1 if a parcel is enrolled in the CUVA/FLPA programs and 0 otherwise. Whether a forest parcel is enrolled in the CUVA/FLPA programs is assumed to be affected by its physical and economic attributes, the program-related tax savings, and the owner's socioeconomic position. Moreover, the characteristics of the county in which the forest parcel is located may influence individual parcels' enrollment status. Therefore, the explanatory variables include various types of county- and parcel-level variables (binary, categorical, and continuous).

This type of data structure violates one of the assumptions of independence for standard logistic regression analysis (Bressoux, 2010). Therefore, we have chosen

multilevel logistic regression to disentangle the within- and between-county effects (Sommet & Morselli, 2017). Different from a standard logistic regression, the odds that the outcome variable will equal one (rather zero) may vary from one county to another (i.e., the intercept may vary), and the effect of a lower-level variable may also vary from one county to another (i.e., the slope may vary in multilevel logistic regression). The following steps were taken to construct the models.

Step 1. Build an empty logit regression model with no explanatory variables and calculate the intra-class correlation coefficient (ICC) (Eq. 1).

$$Logit(y_{ij}) = \beta_{00} + \beta_{0j} + \varepsilon_{ij} \qquad 1)$$

where y_{ij} denotes the conditional probability that forest parcel *i* in county *j* enrolls in either the CUVA or the FLPA programs in Georgia, β_{00} is the fixed intercept, β_{0j} is the deviation of the county specific intercept from the fixed intercept, and ε_{ij} is the parcel-level error term. $Logit(y_{ij}) = Log\{\frac{P(y_{ij}=1)}{[1-P(y_{ij}=1)]}\}$ is the log-odds.

ICC is an index measuring the heterogeneity of the dependent variables among counties. The value of ICC ranges from 0 (the probability of program enrollment does not vary among counties) to 1 (the probability only differs among counties).

Step 2. Build a logit regression model with parcel-level explanatory variables only. For simplicity, we assume the effects of the parcel-level explanatory variables are fixed across counties (Eq. 2).

$$Logit(y_{ij}) = \beta_0 + \beta_1 x_{1ij} + \cdots + \beta_k x_{kij} \ldots + \beta_K x_{Kij} \qquad 2)$$

where, x_{1ij} through x_{Kij} denote the *K* level-1 (parcel-level) explanatory variables that affect the enrollment of forest parcel *i* in county *j*. β_0 is the intercept. β_k (*k = 1, 2, …, K*) is the regression parameter associated with the explanatory variable x_{kij}.

Step 3. Build a logit regression model with county- and parcel-level explanatory variables (Eq. 3). The variation of the parcel-level regression intercept is modeled as a function of county-level explanatory variables (Eq. 4), while the regression parameters of parcel-level explanatory variables are fixed across counties (Eq. 5).

$$Logit(y_{ij}) = \beta_{0j} + \beta_{1j}x_{1ij} + \cdots + \beta_{kj}x_{kij} \ldots + \beta_{Kj}x_{Kij} \quad 3)$$

$$\beta_{0j} = \gamma_{00} + \gamma_{01}z_{1j} + \cdots + \gamma_{0M}z_{Mj} + \mu_{0j} \quad 4)$$

$$\beta_{kj} = \gamma_{k0} \quad 5)$$

where z_{1j} through z_{Mj} denote the *M* county-level explanatory variables for all parcels in county *j*. β_{0j} is the intercept that varies by county. γ_{0m} (*m=1, 2, …, M*) is the regression parameter associated with the explanatory variable z_{mj}. μ_{0j} is the county-level error. Plugging Eqs. 4) and 5) into Eq. 3) yields the following:

$$Logit(y_{ij}) = \gamma_{00} + \gamma_{01}z_{1j} \ldots + \gamma_{0M}z_{Mj} + \gamma_{10}x_{1ij} + \cdots + \gamma_{K0}x_{Kij} + \mu_{0j} \quad 6)$$

The log odds of participating in a property tax incentive program for a parcel *i* in county *j* (y_{ij}) are determined by the log odds of participating in the programs of a typical forest parcel in a typical county γ_{00}, the effects of the parcel-level and county-level explanatory variables, as well as the county-level error.

The explanatory variables were based on the literature review (Chapter 2). Previous literature on landowners' participation in tax incentive programs was used to identify probable predictor variables to include in the model. Parcel- and county-level explanatory variables were classified into subgroups based on their characteristics. Some

of the parcel-level variables contain the spatial information of a parcel. For example, parcel distance to the nearest road (ROAD), distance to the nearest city (CITY), and distance to the sawmill (SAW) fall under urban characteristics; distance to streams (STRM) and distance to lake (LAKE) are grouped as riparian characteristics; distance to potential conservation areas (CONS) and distance to greenway corridors (GWAY) are classified as ecological characteristics. These distances were measured between the edge of the polygons and/or polylines. Similarly, parcel area (ACRES), land capability class (LCC), and a dummy for forest parcel less than ten acres (CUVA_10) fall under land characteristics. Enrollment of adjacent parcel(s) in programs (NEIGH) and landowners' residence status (ABSENTEE) are categorized under landowners' characteristics. Tax savings per acre (TSAVE),) and per-acre land value (VALUE) are grouped as economic characteristics. County-level variables include median household income (INC), total population (POP), population density (POPD), presence of major sawmill (SMILL), ecoregions as developed by the Georgia Department of Revenue (DOR), forest coverage (FORCOV), and a dummy indicating whether the county is part of a metropolitan statistical area (MSA). The definition and descriptive statistics and expected direction of relationships of all explanatory variables are provided in Table 5.

Table 5: Definition of variables used in the multilevel logistic regression model

Variables	**Type**	**Definition unit**	**Expected sign**
ENROLL	Binary	Forestland enrollment in CUVA/FLPA, 1 if enrolled, 0 otherwise	
		Parcel-level variables	
Urban characteristics			
ROAD	Continuous	Parcel's distance to the nearest state highway in meters, recoded to logRmeter	Negative
CITY	Continuous	Parcel's distance to major cities (area more than 2 square miles) in meters, recoded to logCmeter	Negative

SAW	Continuous	Parcel's distance to nearest sawmill in meters, recoded to logSawmeter	Negative
Riparian Characteristics			
STRM	Continuous	Parcel's distance to the nearest stream in meters, recoded to logSmeter	Negative
LAKE	Continuous	Parcels distance to the nearest lake in meters, recoded to logLmeter	Negative
Ecological characteristics			
CONS	Continuous	Parcel's distance to nearest potential conservations area in meters, recoded to logConsmeter	Negative
GWAY	Continuous	Parcel's distance to nearest greenway corridor in meters, recoded to logGmeter	Negative
Landowners' characteristics			
NEIGH	Binary	Adjacent forestland enrollment status, 1 if at least one adjacent parcel is enrolled, 0 otherwise	Positive
ABSNTEE	Binary	Residence status, 1 if landowners' residence was located in a different county than her/his forestlands, 0 otherwise	Positive
Land characteristics			
CUVA10	Binary	Parcel size, 1 if less than ten acres, 0 otherwise	Negative
LCC	Multiple Binary	Land capability classes recorded in 8 categories ranging from 1 to 8, recoded as three classes: LCC_U for 7–8 (the least productive land), LCC_M for 4–6 and LCC_L for 1–3 (the most productive land)	Negative
ACRE	Continuous	Total agricultural and forest lands in acres, recoded to logACRE	Positive
Economic characteristics			
TSAVE	Continuous	Total tax savings amount from enrolling in tax incentive programs ($/ac)	Positive
Value_Q1	Binary	= 1 if per acre land value is under Quartile 1st, 0 otherwise	Positive
Value_Q3	Binary	= 1 if per acre land value is between the median and the Quartile 3rd , 0 otherwise	Positive
Value_Q4	Binary	= 1 if land value is in the Quartile 4th,, 0 otherwise	Positive
County-level variables			
SMILL	Binary	Presence of a sawmill in the county, 1 if present, 0 otherwise	Positive
DOR	Nominal	Ecoregion ranges developed by Georgia Department of Revenue recorded in 9	

		categories, ranging from 1 to 9, further categories into eight dummy variables	
POP	Continuous	County population based on US 2021 census	Negative
POPD	Continuous	County population density based on US 2021 census	Negative
FORCOV	Continuous	County forest cover (in %) based on FIA database	Positive
MSA	Binary	Metropolitan statistical areas (MSA), 1 if county in a MSA, 0 otherwise	Positive
INC	Continuous	County median household income based on US census 2021	Positive

4.3.1. Data Source

The data for this study was collected from various sources (Table 6). Parcel-level 2018 property tax data of all the selected counties were drawn from Schneider Geospatial, LLC (qPublic.net). Spatial information of 12 counties were acquired from Jimmy Nolan, Carl Vison Institute of Government, University of Georgia. The qPublic.net website allows users to view local government information and also provides web-based GIS data through a quick, user-friendly, and affordable web portal blending searching, reporting, and mapping for every community. GIS data include parcel-level information on parcel number, forest size, ownership status (private individual or corporate landowners), owner name, property classes (land use type, such as agricultural lands, forestland protection, conservation use valuation, environmentally sensitive, commercial, and industrial), and sale date. In addition, the property tax database contains parcel number, owner mailing address, parcel location, property size, property class classification for property tax purposes, land value (or FMV), special land value (preferential assessment value if under programs), and starting year of preferential assessment.

In addition, several other spatial data layers were taken as explanatory variables. Socio-economic data such as population density, total population, median household

income, and shapefiles of road and cities were collected from the US Census Bureau. The US Census Bureau uses the TIGER/Line shapefiles to store geographic and cartographic information for all 50 states. This information includes boundaries (polygons) of states, counties, and lines for roads and cities (polylines). The other spatial data includes wetlands (e.g., stream and lake) and ecologically important areas (e.g., greenway corridor and potential conservation lands). The shapefiles for wetlands were downloaded from the Georgia section of the National Wetlands Inventory. The Georgia Department of Natural Resources provides shapefiles of potential conservation lands and greenway corridors, which are ecologically important (see Figure 3 below). In addition, raster images of land-cover data for two time periods (2001 and 2019) were collected from the United States Geological Survey (USGS). The land-cover data were generated by USGS in cooperation with the Multi-Resolution Land Characteristics Consortium (MRLC), who offer land-cover data for the years 2001, 2003, 2006, 2008, 2011, 2013, 2016, and 2019. We used data for the years 2001 and 2019 to determine the rate of change of forest cover in the study area.

Land Capability Classes (LCC) for each parcel were derived from the Web Soil Survey (WSS) produced by the USDA Natural Resources Conservation Service (NRCS). The NRCS offers soil maps data available online for more than 95% of US counties. To access the soil data of interest, we followed steps in ArcGIS to find the LCC of each parcel as discussed in Section 2.4.

Data such as absentee landowner status and status of the neighboring parcel(s) (enrolled or nonenrolled in tax incentive programs) were further calculated with R software and ArcGIS, respectively. In addition, data about the presence of sawmills in

each county were obtained from a directory managed by the Georgia Forestry Commission (Table 6).

Table 6: Data sources for explanatory variables and their condition

Variables	Data source	Web page	Condition
ROAD	US Census TIGER/ Line	https://www.census.gov/geographies/mapping-files/time-series/geo/tiger-line-file.html	Usable
CITY	US Census TIGER/ Line	https://www.census.gov/geographies/mapping-files/time-series/geo/tiger-line-file.html	Usable
SAW	USDA	https://www.srs.fs.usda.gov/econ/data/mills/	Usable
STRM	National Wetlands Inventory	https://www.fws.gov/wetlands/Data/Data-Download.html	Usable
LAKE	National Wetlands Inventory	https://www.fws.gov/wetlands/Data/Data-Download.html	Usable
CONS	Wildlife Resource Division, DNR	https://data.georgiaspatial.org	Usable
GWAY	Wildlife Resource Division, DNR	https://data.georgiaspatial.org	Usable
NEIGH	Calculated based on parcel-level data in ArcGIS		
ABSENTEE	Derived from R software based on owner physical address and property location		
LCC	USDA, NRCS	https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx	Derived
ACRE	Schneider Geospatial, LLC	https://www.schneidergis.com/beacon-qpublic-net	Derived
TSAVE	Calculated in R using the given land and special value in property tax database		
VALUE	Calculated in R using the given land and special value in property tax database		
SMILL	Georgia Forestry Commission	https://gatrees.org/directories/wood-using-industries-directory/	Derived
DOR	Georgia Department of Revenue	https://dor.georgia.gov/	Usable
POP	US Census Bureau	https://www.census.gov/quickfacts/GA	Usable
POPD	US Census Bureau	https://www.census.gov/quickfacts/GA	Usable
FORCOVMSA	NWOS	https://www.fia.fs.fed.us/nwos/results/	Usable
INC	US Census Bureau	https://www.census.gov/quickfacts/GA	Usable

Fig 3a: Streams

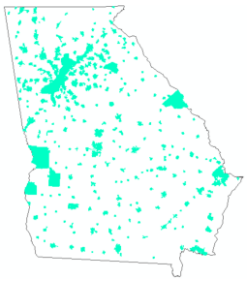


Fig 3b: Cities

Fig 3c: Sawmills

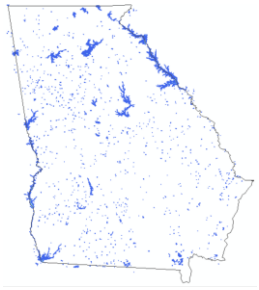


Fig 3d: Lakes

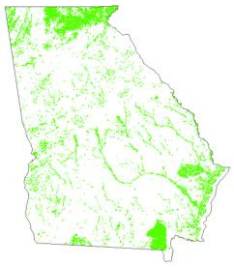


Fig 3e: Potential conservation lands

Fig 3f: Major roads

Fig 3g: Greenway corridors

Fig 3h: Ecoregions classified by DOR

Figure 3: Maps showing the spatial distribution of major variables

4.3.1. Data Extraction and Management

Dependent variable

Each parcel in parcel-level datasets was classified based on land use, such as residential, agricultural, preferential, conservation use, forestland protection, environmentally sensitive, commercial, and rural woodlots. Property classes such as conservation use, and

forestland protection were considered forestlands enrolled in a tax incentive program (denoted by 1 in the regression model and 0 otherwise).

Explanatory variables

The property data includes parcel area in acres. Parcels with zero acres or unavailable data were removed from analysis. The acreage data was highly skewed, so natural log transformation was performed before inclusion in the model. The property data also includes the FMV and special land value for parcels, based on which we calculated the per-acre tax amount. The difference in tax amount between FMV and special land value was referred to as the annual tax saving during participation in tax incentive programs. The data was further used in the natural log transformation before being used in the model. Similarly, the land value was calculated as per-acre land value. Similar to parcel size, parcels with no data or zero value for land value were deleted with the assumption that the data was not available. Since the impacts of land value in tax incentive programs are difficult to understand, we calculated the quartile and further used it as a dummy variable in the models, considering quartile 2 (or median value) as a base.

The original datasets included more than 500 cities, from which we selected the major cities with an area greater than two square miles with the SELECT BY ATTRIBUTES tool in ArcMap. Similarly, we selected only state highways to include in the analysis.

To find the LCC of each parcel, we followed several steps. First, we joined the soil maps and their component tables to obtain information about the LCC, which ranges from I-VIII. The first four (I, II, III, IV) LCCs are suitable for agriculture, and other LCCs (V, VI, VII, VIII) are suitable for permanent vegetation, such as forests (Paudel et

al., 2021; Stubbs, 2014). The join was performed based on the MUKEY and Mapunit Key. Second, we converted the soil map into raster data, which helped us find missing LCCs. Third, we converted the all-zero value into null with the RECLASSIFY tool. After that, we used FOCAL STATISTICS to interpolate new values in null pixels from the mean of the neighboring pixels. Fourth, we employed RASTER CALCULATOR to fill a pixel with a zero value in the original raster from the interpolated raster using the conditional function. Fifth, we converted the raster image into points, which allowed us to join the parcel-level (vector data) using SPATIAL JOIN. This spatial join was performed by using the mean value of points within each parcel. Finally, we obtained the LCC for each of the parcels with an area-weighted average LCC. For simplification and based on the hypothesis, we grouped LCC into three categories: those ranging from I-III were considered as lower-order LCCs (LCC_L); those ranging from IV-VI as a middle class (LCC_M); and LCC VII and VIII were considered as a higher class (LCC_H). Two binary variables (LCC_L and LCC_H) were used for the logistic regression model assuming LCC_M as the base.

We used a raster file of potential conservation opportunity areas and greenway corridor found in Georgia's GIS Data Clearinghouse, which was developed by the Natural Resources Spatial Analysis Laboratory (NARSAL) at the University of Georgia. The Georgia Gap Analysis Program (GAP) 1998 vegetation map was the primary source used to develop that map and employed Fragstats 3.3 for analysis. Kramer & Elliott (2005) analyzed how well the current conservation network protects patches of natural vegetation in Georgia and described a detailed method for developing the raster file. We

used the given raster file and applied the RASTER TO POLYGON tool to convert it into a vector file.

Though there are different types of wetlands, including freshwater lake, freshwater pond, freshwater emergent, and freshwater forested/shrub, we used lakes and streams in our study. For streams, we used the shapefiles created by the Research & Analytics Division of the Atlanta Regional Commission. The layers contain linear hydrographic attributes such as rivers, streams, and artificial flow paths.

We employed two different types of sawmill variables in the study. First, we employed parcel distance to sawmill, for which we used a shapefile of Georgia sawmills created by the Southern Research Station of the USDA Forest Services. The data contain sawmills of different primary and secondary wood products including lumber, posts, poles, plywood, oriented strand board (OSB), fiberboard, particle board, wood pulp, and paperboard products. Second, we extracted the presence of a sawmill for each Georgia county from the Georgia Wood-Using Industries directory managed by the Georgia Forestry Commission to determine the presence or absence of a sawmill. We used a dummy variable indicating whether there is a major softwood sawmill in the county. Enrollment of neighbor landowners in the programs is another important variable. We identified the enrollment status of adjacent landowners with GIS tools including PROXIMITY and POLYGON NEIGHBORS. We also assigned binary variables for neighboring parcel(s).

Other county-level variables, including population, sawmill, population density, median household income, ecoregions, and MSA, were drawn from the US Census Bureau. Information for forest coverage ratio (forest area divided by total land area), was

gathered from the FIA database. We employed binary variables for ecoregions, sawmill, and MSA and continuous variable for forest coverage ratio. In addition, natural log transformation was performed for population density and median household income of county-level variables when including them in the models.

3.4. Results

3.4.1. Parcel Land Characteristics

Figure 4 shows the distribution of parcel lands by size class for our study counties. Approximately 21,000 parcels (~30% of those considered) are less than ten acres. The histogram shows that parcels are highly right skewed with a mean and median of 69.61 and 25.5 acres, respectively. Except for the lowest parcel size class, less than ten acres, there are more parcels enrolled in the tax incentive programs than nonenrolled parcels (Figure 5). More than two-thirds of the parcels in our study area are enrolled in a tax incentive program.

Figure 4: Distribution of forest parcel by size class

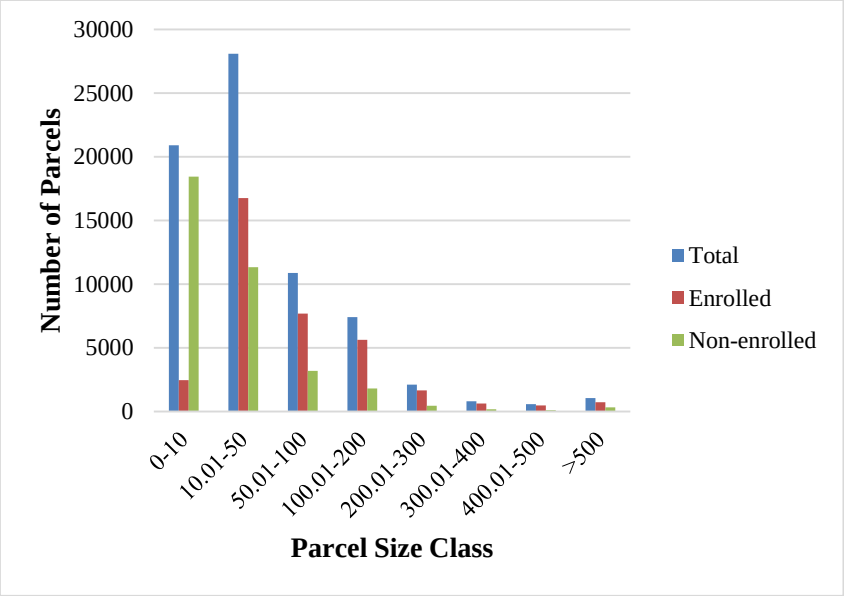


Figure 5: Distribution of enrolled and nonenrolled parcels in tax incentive programs

3.4.2. Comparing the Parcel Lands Between Enrolled and Nonenrolled in the Programs

The study further compared the attributes of properties enrolled and nonenrolled in tax incentive programs. Since the study used three different types of variables, continuous, categorical, and binary, we employed different tools to test the significance of differences. Table 7 provides the descriptive statistics of all variables. A t-test was used to determine whether there is a significant difference in the means of continuous variables of the enrolled and nonenrolled parcels. The enrolled parcels were found to have a greater distance to the nearest road than the nonenrolled parcels. Similarly, enrolled parcels were closer to cities than nonenrolled parcels ($p<0.001$). Enrolled parcels had a lower mean distance to greenways and streams than nonenrolled parcels, indicating an association between distance to greenways/streams and parcel enrollment ($p<0.001$). However, the mean distance from enrolled parcels to lake and potential conservation lands was longer than from nonenrolled parcels ($p<0.001$). The mean parcel size of enrolled parcels was significantly larger than of nonenrolled parcels ($p<0.001$). Per-acre

land value and property tax were lower for enrolled parcels than for nonenrolled parcels ($p<0.001$).

Table 7: Statistical summary and comparison of enrolled and nonenrolled parcels for continuous variables

Variables	Statistics	Enrolled	Nonenrolled	p-value [a]
Distance to road (in meters)	mean	1669.76	1737.98	<0.001
	median	1312.93	1212.19	
	SD	1648.96	1726.94	
Distance to city (in meters)	mean	4581.72	6365.49	<0.001
	median	3626.78	5696.80	
	SD	4127.77	4678.22	
Distance to greenway (in meters)	mean	12212.44	13138.93	<0.001
	median	10174.78	12574.76	
	SD	10052.55	8682.64	
Distance to stream (in meters)	mean	2273.90	2451.02	<0.001
	median	1945.37	2163.78	
	SD	1822.46	1766.34	
Distance to lake (in meters)	mean	5865.92	5306.90	<0.001
	median	5077.89	4553.62	
	SD	4140.44	3802.80	
Distance to conservation land (in meters)	mean	2405.69	2269.71	<0.001
	median	1806.16	1730.72	
	SD	2414.53	2237.28	
Area (acres)	mean	95.41	43.69	<0.001
	median	46.00	9.84	
	SD	265.25	475.85	
Land value ($/ac)	mean	1484.97	5361.34	<0.001
	Median	915.51	2079.59	
	SD	2060.95	8291.10	
Original tax amount ($/ac)	Mean	19.19	35.87	<0.001
	Median	14.89	17.26	
	SD	20.03	41.46	

SD: Standard Deviation
[a] p-value from t-test

With Pearson's chi-square test (Table 8), if the proportions of enrolled and nonenrolled parcel lands vary significantly, the two variables are not independent (i.e., there is contingency). If there is no contingency, the two variables are considered independent. Table 6 shows the descriptive statistics of the categorical variables. Chi-square tests or Fisher's exact tests were used to examine the significance of the

association between program enrollment status and the categorical variables. The fifth column shows the p-values. A previous study showed that MSA, sawmill, neighbor, absentee, and land value were associated with land enrollment in tax incentive programs. More than half of the enrolled parcels (54.67%) were not in an MSA, while approximately 72% of the nonenrolled parcels were in an MSA. The data showed an association between MSA and enrollment, and a chi-square test revealed a contingency between the two variables ($p<0.001$). A majority of the enrolled and nonenrolled parcels were located in counties with sawmills. A chi-square test showed significant associations between sawmill presence and parcel enrollment and between neighbor and enrollment ($p<0.001$). Approximately 30% of landowners were absentee landowners for both enrolled and nonenrolled parcels. More than 90% of enrolled parcels had neighboring parcels that were already enrolled in a tax incentive program.

Table 8: Statistical summary and comparison of enrolled and nonenrolled parcels for binary variables

Variables		**Enrolled** *Count (%)*	**Nonenrolled** *Count (%)*	**p-value** [b]
Metropolitan statistical area				<0.001
	Yes	16324 (45.33)	25681 (71.70)	
	No	19688 (54.67)	10136 (28.30)	
Sawmill				<0.001
	Yes	23546 (65.38)	26569 (74.18)	
	No	12466 (34.62)	9248 (25.82)	
Neighbor				<0.001
	Yes	32333 (89.78)	19533 (54.54)	
	No	3679 (10.22)	16284 (45.46)	
Absentee				<0.001
	Yes	10562 (29.33)	10059 (28.08)	
	No	25450 (70.67)	25758 (71.92)	
CUVA (<10ac)				<0.001
	Yes	2021 (5.61)	NA	
	No	33991 (94.3)	NA	
Value_Q1				<0.001
	Yes	11548 (32.07)	6410 (17.90)	
	No	24464 (67.93)	29407 (82.10)	

Value_Q3				<0.001
	Yes	9298 (25.82)	8659 (24.18)	
	No	26714 (74.18)	27158 (75.82)	
Value_Q4				<0.001
	Yes	3143 (8.73)	14814 (41.36)	
	No	32869 (91.27)	21003 (58.64)	

SD: Standard Deviation
[b] p-value from chi-square test

We used Fisher's exact test to detect associations between categorical variables with less than 5% for any category and the dependent variable. We found that parcel enrollment in tax incentive programs significantly differed across LCCs ($p<0.001$). A Fisher's exact test revealed a contingency between the two variables (Table 9).

Table 9: Statistical summary and comparison of enrolled and nonenrolled parcels for nominal variables

Variables	**Enrolled**		**Nonenrolled**	
	Class	*Count (%)*	*Count (%)*	**p-value [c]**
Land Capability Class	I	200 (0.56)	184 (0.51)	
	II	5812 (16.14)	4157 (11.61)	
	III	13370 (37.13)	9101 (25.41)	
	IV	8828 (24.51)	8434 (23.55)	
	V	4805 (13.34)	6001 (16.75)	
	VI	2466 (6.85)	5123 (14.30)	
	VII	527 (1.46)	2725 (7.61)	
	VIII	4 (0.01)	92 (0.26)	<0.001
Ecoregion Classified by DOR	1	2094 (5.81)	3599 (9.99)	
	2	4862 (13.50)	15511 (43.31)	
	3	1945 (5.40)	499 (1.39)	
	4	6674 (18.53)	3076 (8.59)	
	5	6334 (17.59)	3670 (10.25)	
	6	2800 (7.78)	2245 (6.27)	
	7	833 (2.31)	329 (0.92)	
	8	7650 (21.24)	3516 (9.82)	
	9	2820 (7.83)	3392 (9.47)	<0.001

3.4.3. Results of Land Cover Change from 2001-2019

Analysis of the land-cover change using NLCD data revealed that forest cover of the studied counties decreased by 5.9% from 2001-2019. Figure 6 shows the land cover

map for those two periods. Further, a scatterplot is used to show the relationship between county-wise proportion of forests enrolled in the CUVA/FLPA programs and rate of forest cover change during 2001-2019. The size of the bubbles in the scatterplot shows variability in the relative amount (acres) of forestland converted to urban areas during 2001-2019 for each county (Figure 7). The spread of the dots (counties) is much wider to right side of the graph, indicating that some counties with a higher proportion of lands enrolled in tax incentive programs lost more forest cover, while others lost less or even made gains.

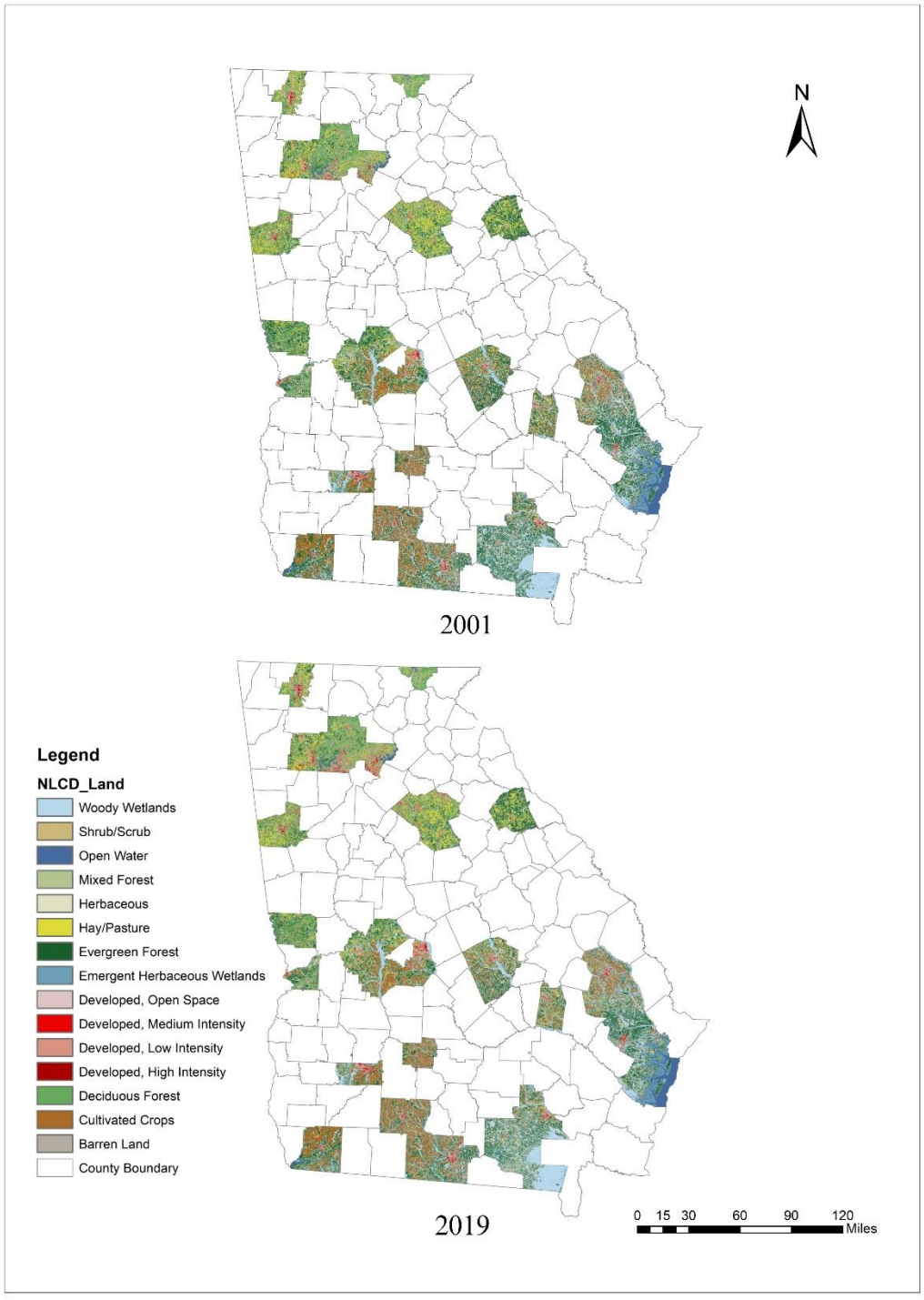


Figure 6: Spatial distribution of land uses in the study area during 2001-2019

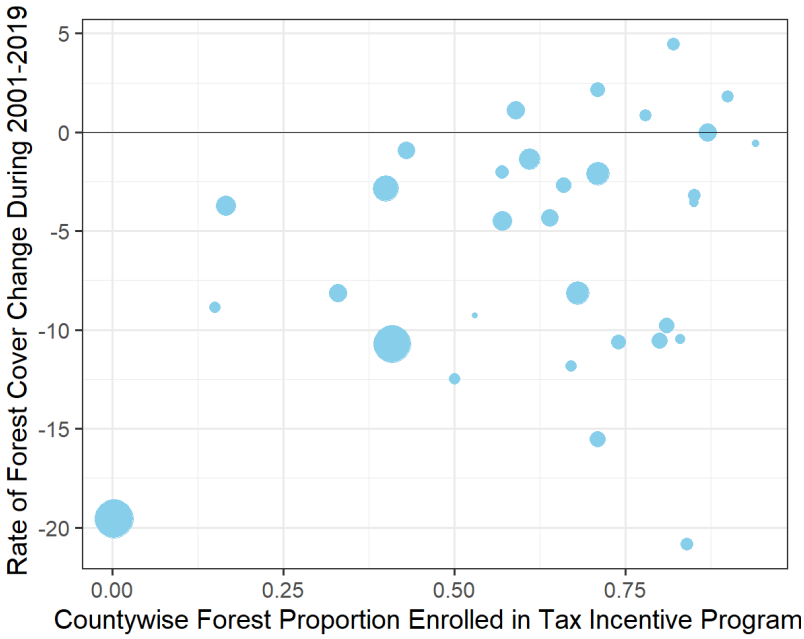


Figure 7: Scatterplot showing the rate of forest cover change and proportion of forestland enrolled in CUVA/FLPA programs in the study counties during 2001-2019 with relative loss of forestland in area indicated in the size of each bubble

3.4.4. Results of the Multilevel Logistic Regression Models

As described above, we performed a stepwise multilevel regression. The first step examined only the null model of the overall probability of a parcel being enrolled in the CUVA/FLPA programs without adjustment for explanatory variables (Model 1). The second step includes parcel-level explanatory variables only (Model 2). The third step included both parcel- and county-level variables that potentially affect a parcel's probability of being enrolled in the CUVA/FLPA programs (Model 3).

Table 10 presents the regression results for the intercept-only model (Model 1). Under the fixed-effects model, the odds of a parcel being enrolled in the CUVA/FLPA programs in a typical county was 1.768. Under the random effects model, the intra-class correlation coefficient (ICC) was 0.18, indicating that 18% of variability in the probability of a parcel being enrolled in a tax incentive program was accounted for by

between-county differences (and, conversely, 82% was explained by within-county differences). This result suggests the need for models with more predictor variables.

Column 2 of Table 11 represents the estimated odds ratios for Model 2 by including all parcel-level explanatory variables (Model 2). Column 3 of Table 11 represents the odds ratios for a refined Model 2 by including only the statistically significant parcel-level explanatory variables (Best Model 2). A parcel's distance to the nearest city, parcel size, being adjacent to an enrolled parcel, having more productive soils\, being close to identified conservation areas, and the amount of tax savings under the CUVA/FLPA programs were found to be positively associated with its probability of being enrolled in a tax incentive program. In contrast, being an absentee property reduces a parcel's probability of being enrolled in the CUVA/FLPA programs. Per-acre land value has a complex effect on the probability of a parcel being enrolled in these two programs. A parcel's distance to roads, streams, lakes, and sawmills were not found to be significantly associated with its enrollment in the CUVA/FLPA programs.

Column 4 of Table 11 represents the estimated odds ratios for the models with both parcel- and county-level explanatory variables (Model 3). Column 5 represents the results with significant explanatory variables only (Best Model 3). Similar to the results from Model 2, a parcel's distance to the nearest city, parcel size, land capability class, neighboring parcel enrollment, being near an identified conservation area, under absentee ownership, per-acre land value, and tax savings amount were found to be significant in Model 3. Additionally, a parcel's distance to the nearest lake was positively associated with the probability of being enrolled in such programs. Population density and forest cover of the county in which the parcel is located had a negative effect on the probability

of a parcel being enrolled in the CUVA/FLPA programs. Specifically, a forest parcel was less likely to be enrolled in tax incentive programs when the population density or forest cover ratio of the county increased. A forest parcel was more likely to be enrolled in these programs as the average household income of the county increased. These two models are consistent in the magnitude and sign of the odds ratio of most variables except for distance to lakes. Distance to the nearest lake was not statistically significant in Model 2 but was significant in Model 3 at the 10% level of significance.

We tested each model for goodness of fit. We found that the Akaike information criterion (AIC) and Bayesian information criterion (BIC) for the "Best Model 3" were relatively lower than for the other models. Additionally, the fixed, adjusted coefficient of determination ($R^2 = 0.79$) was higher than in the other models. Therefore, our best model is "Best Model 3". The following discussion section is based on this best model.

Table 10: Regression results of an intercept-only logit model (Model 1)

Fixed effects		**Estimate**	**Std. error**	***t* value**	**Pr > |*t*|**
Intercept		1.768	1.0394	15.47	<0.01
Random effects		**Covariance parameter estimates**			
Covariance parameter	**Subject**	**Estimate**	**Std. error**	***z* value**	**Pr > |*z*|**
Intercept	County	0.04321	0.2079	0.21	0.83
Residual		0.19071	0.4379	0.43	0.66
ICC	0.18				

Table 11: Regression result showing parcel- and county-level factors associated with tax incentive programs

Variables	**Full Model 2** Odds ratio (95%CI)	**Best Model 2** Odds ratio (95% CI)	**Full Model 3** Odds ratio (95%CI)	**Best Model 3** Odds ratio (95% CI)
ROAD	1.01(0.99-1.02)		1.01(0.99-1.02)	
GWAY	0.99(0.98-1.01)		0.99(0.98-1.01)	

CITY	1.03(1.01-1.05) **	1.03(1.01-1.05) ***	1.03(1.01-1.04) **	1.03(1.01-1.05) **
STRM	1.00(0.98-1.01)		1.00(0.98-1.01)	
LAKE	1.03(1.00-1.06)		1.03(1.00-1.06) †	1.03(1.00-1.06) †
CONS	0.98(0.97-1.00) *	0.98(0.97-1.00) **	0.98(0.97-1.00) *	0.98(0.97-0.99) *
SAW	1.01(0.95-1.07)		1.00(0.95-1.06)	
ACRES	1.53(1.48-1.58) ***	1.53(1.48-1.58) ***	1.53(1.48-1.59) ***	1.53(1.48-1.59) ***
NEIGH	2.32(2.13-2.54) ***	2.33(2.14-2.54) ***	2.31(2.12-2.53) ***	2.32(2.13-2.53) ***
ABSENTE	0.88(0.82-0.94) ***	0.88(0.82-0.94) ***	0.88(0.82-0.94) ***	0.88(0.82-0.94) ***
LCC_L	1.10(1.02-1.18) *	1.10(1.02-1.18) *	1.09(1.01-1.17) *	1.09(1.01-1.17) *
LCC_U	0.91(0.73-1.14)		0.91(0.72-1.14)	
TSAVE	5.22(5.10-5.35) ***	5.22(5.10-5.35) ***	5.21(5.09-5.34) ***	5.21(5.09-5.34) ***
Value_Q1	1.61(1.48-1.76) ***	1.61(1.48-1.76) ***	1.61(1.48-1.76) ***	1.62(1.48-1.77) ***
Value_Q3	0.62(0.56-0.69) ***	0.62(0.56-0.69) ***	0.62(0.56-0.69) ***	0.62(0.56-0.69) ***
Value_Q4	0.26(0.20-0.33) ***	0.26(0.20-0.32) ***	0.27(0.21-0.34) ***	0.27(0.21-0.34) ***
SMILL			0.75(0.50-1.13)	
DOR1			2.86(1.33-6.17) **	3.07(1.39-6.77)**
DOR2			2.09(1.06-4.12) *	2.49(1.35-4.59)**
DOR3			5.45(2.07-14.34) ***	4.63(1.81-11.88)**
DOR4			2.72(1.60-4.62) ***	2.48(1.45-4.25)***
DOR5			3.37(1.90-5.97) ***	3.27(1.84-5.80)***
DOR6			2.85(1.11-7.28) *	2.67(1.06-6.72)*
DOR7			6.88(3.20-14.82) ***	6.15(2.90-13.03) ***
DOR8			1.69(0.94-3.02) †	
POPD			0.99(0.98-0.99) ***	0.99(0.98-0.99) ***
FORCOV			0.98(0.97-1.00) *	0.98(0.97-1.00) *

INC			1.17(0.45-3.03) *	
MSA			0.82(0.50-1.33)	
AIC	30542.06	30535.4	30536.8	30525.7
BIC	30707.21	30645.5	30821.2	30736.7
Log	-15253.0	-15255.7	-15237.4	-15239.8
R^2 fixed	0.75	0.75	0.79	0.79
R^2 total	0.78	0.78	0.80	0.80
ICC	0.13	0.13	0.05	0.05

*** significant at 0.001; ** significant at 0.01; * significant at 0.05; † significant at 0.1

A 1% increase in a parcel's distance to the nearest city or the nearest lake increased the odds of being enrolled in tax incentive programs by 1.28%. A 1% increase in parcel area increased the odds of being enrolled in such programs by 18%. A forest parcel adjacent to an enrolled property was twice as likely to be enrolled in a tax incentive program than one with no currently enrolled adjacent parcels. Holding other variables constant, the odds of being enrolled in the CUVA/FLPA programs for a parcel with land value below the first quartile were 62% higher than for a parcel valued in the second quartile. The odds of being enrolled in the CUVA/FLPA programs for a parcel with above-average soil productivity (land capacity class I-III) were 9% higher for a parcel in the average soil class. A one-dollar increase in tax savings resulted in a five-fold increase in the odds of the parcel being enrolled in these programs. Furthermore, compared to parcels in DOR region 9, parcels in other regions (except for region 8) had higher odds of being enrolled in these programs, especially for parcels in DOR regions 2, 3, 5, and 7.

However, the odds of being enrolled in tax incentive programs decreased by 0.9% for each 1% increase in the parcel's distance to potential conservation lands. Similarly, absentee landowner decreased the odds of a parcel being enrolled in these programs by

12%. The odds of enrollment for a parcel with land value between the 3rd and 4th quartiles were 38% lower than for a parcel valued at approximately the study-area average. The odds of enrollment for a parcel with land value higher than the 4th quartile were 73% lower than for average parcels. The odds of a parcel's enrollment decreased by 1% for each unit increase in county population density (population per square mile). Similarly, the odds of a parcel's enrollment decreased by 2% for each one percent increase in a county's forest cover.

3.5. Discussion

This study compared the attributes of forest parcels enrolled and not enrolled in the most popular property tax incentive programs for private forestland in Georgia. Additionally, the effects of several factors on a parcel's probability of being enrolled in the CUVA/FLPA programs were quantified with a logistic regression model based on county- and parcel-level data. Most past research has been conducted with variables at the county and state levels but not at the parcel level. Moreover, previous research was largely conducted at the state level, employing limited variables and simple logistic regression. This study provides a comprehensive examination of two-level factors associated with parcel enrollment in Georgia tax incentive programs.

A majority of the private Georgia forestland in the study area was enrolled in the CUVA/FLPA programs, suggesting that tax incentive programs are attractive to most larger private forest landowners. This finding is consistent with previous studies on private forest landowners' participation in Georgia tax incentive programs (Gayer, 1987; Newman et al., 2000; Li & Izlar, 2021) but differs from the results of other studies in Minnesota and Tennessee (Hickman, 1982; Jacobson & McDill, 2003). Together, these

studies have shown that landowners' interest in enrollment in tax incentive programs is growing rapidly (Dennis & Sendak, 1992; Kilgore et al., 2007; Straka et al., 2006), possibly due to improved knowledge/awareness of these programs and revision of their requirements. The amendments to program requirements, such as removing the maximum parcel size limits, has triggered the enrollment of a considerable proportion of corporately owned forestland.

Similarly, the results showed that larger forestland parcels were more likely than smaller parcels to be enrolled in the CUVA/FLPA programs. Past studies have reflected similar findings (Kingsley, 1995; Meier et al., 2019). One possible reason is that small forestland parcels (less than 200 acres) are not eligible for the FLPA program and are also considered as producing insignificant tax savings. Furthermore, landowners with larger parcels will see a larger total financial benefit from enrollment (Frey et al., 2019). The study also found that the higher the tax savings amount, the more likely the parcel was to be enrolled in property tax incentive programs. The tax savings amount is directly related to the land value because it is calculated based on the AV and FMV. Parcels under intensive development pressure have higher FMV and, ultimately, increased tax savings. Larger forest parcels are commonly believed to be associated with higher environmental and ecological value (Newman et al. 2000), which suggests that tax incentive programs are effective in conserving forests from an environmental and ecological perspective.

This study found complicated effects of per-acre land value on parcel enrollment in the CUVA/FLPA programs. Generally, as land value increased, the odds of the parcel being enrolled also increased. This likelihood of program enrollment increased until a

certain land value threshold, after which the likelihood of enrollment decreased due to withdrawal penalties. The program withdrawal penalty equals twice the amount of total tax savings plus a 1% interest rate. These phenomena suggest that the effectiveness of these tax incentive programs is limited in attracting certain high-value lands. Therefore, forestland under intensive development pressure and with high speculative values in the near future is less likely to be enrolled in such programs (Frey et al., 2019). These findings suggest that the effectiveness of the CUVA/FLPA programs is limited in conserving forestland near urban areas, which is normally under more intense development pressure.

Similarly, the likelihood of forest parcels being enrolled in CVUA/FLPA programs increased as distance to cities or lakes increases. In other words, forestlands close to cities and lakes are less likely to be enrolled because these parcels are under high development pressure since they can be converted into other land uses, such as commercial lands, in the near future. Owners of these lands are better off not agreeing to the tax incentive programs' 10-year covenant. Moreover, land parcels close to waterbodies such as lakes and rivers have high amenity value (Bagdon & Kilgore, 2013), which increases their value and results in higher property taxes, thereby lowering enrollment likelihood. However, as parcels' distance to conservation lands increased, the likelihood of being enrolled in the CUVA/FLPA programs decreased. This result suggests that forestlands close to conservation lands are more likely to be enrolled in tax incentive programs, suggesting that these programs have a protective effect. Neighboring forestland being enrolled in a tax incentive program increases the enrollment likelihood of adjacent forestland. One possible reason for this effect is landowners' knowledge

about these programs. These programs protect large areas of forestland without fragmentation, which is crucial from a wildlife and ecological point of view.

Absentee landowners were less likely to enroll in tax incentive programs. A previous study also found a negative but no significant correlation (Bagdon & Kilgore, 2013). This result is likely due to landowners' lack of knowledge about these programs, as well as the facts that they spend less time on their forestland and are generally not active forest managers. One study found that most active forest landowners practicing harvesting activities were likely to have enrolled their forestlands in tax incentive programs (Sendak & Huyler, 1994).

The study also found that land in lower land capability classes was more likely to be enrolled in tax incentive programs (Class I are suitable for cultivation, woodlands and pasture, and Class VIII cannot be used for commercial plant production; as a result, we cannot be expected to return significant onsite benefits, although benefits from watershed protection and recreation may be possible). This finding is in line with that of a previous study (Newman et al., 2000). However, LCCs and soil productivity classes are not the same. This result suggests that the Georgia tax incentive programs aim to conserve land that is suitable for agriculture and wildlife but are failing to conserve land of importance for watershed protection and for wildlife and aesthetic reasons.

Among the county-level variables that tested in the study, factors such as various ecoregions (1 to 7) were positively and statistically significant to parcel enrollment, whereas population density and total forested lands were negatively and statistically significant (Ma et al., 2014). This result illustrated that each state has regions with different development pressures and that one overarching tax incentive program will not

work for all regions, which is, for example, why ecoregion 8 was not significant compared to ecoregion 9. The counties in various ecoregions have different population densities and timber-growing capacities. The population density variable was significant and inversely related to enrollment in a tax incentive program, indicating lower enrollment likelihood for parcels located in high-density counties. Theoretically, land parcels in high-density areas might have a greater rate of loss if landowners foresee development in the near future (Frey et al., 2019). This finding indicates that forestland located in high population density areas are highly susceptible to being changed into other developed land uses, thereby sharply reducing program effectiveness in forestland conservation in such areas. Similarly, counties with larger forestland areas were less likely to have lands enrolled in these programs, which was unexpected in our hypothesis. However, an association might be true if the high forest-coverage counties had less private forestland compared to national or state-owned forestland. Higher forest-coverage counties in our study include Taylor (97%), Clinch (98%), Chattahoochee (85%), and Crawford (84%). Since those counties had fewer enrolled forestlands, the model provided an unexpected result. Other variables, such as distance to roads, streams, greenway corridors, distance to sawmill, LCC (higher class), sawmill presence, county's median income, and MSA were expected signs but not statistically significant, suggesting that these variables might be important for future research.

3.6. Conclusions

In summary, a significant portion of the eligible forestlands are enrolled in tax incentive programs among the subset of Georgia counties examined. This result indicates that these programs are effective in slowing land conversion to developed land uses.

These programs are most suitable in areas with low development pressure. Moreover, although these programs attempt to prevent forestland from fragmentation, which is essential for wildlife and biodiversity, they are largely ineffective in conserving forestland close to cities, biologically important areas, and waterbodies.

At the parcel level, factors such as parcel distance to the city, distance to lakes, parcel size, neighboring parcel enrollment, tax savings amount, land value, and land capability class were important predictors of enrollment in tax incentive programs. Similarly, population density, ecoregions, and area of forestland were significant in determining the likelihood of enrollment at the county level. These factors are the most important for policymakers to consider when designing more effective policies that meets these programs' objectives. Therefore, policies should focus on forestlands that are close to lakes and biologically important areas and should be complementary to other programs that have been designed to preserve biodiversity.

Due to its cross-sectional nature, this study of enrolled forestlands cannot provide enrollment trends. Therefore, future studies should be conducted periodically and longitudinally to assess the benefits and effectiveness of such programs. When conducting such studies, landowners' personal characteristics, such as motivation, perception, attitude, and behavior, should be assessed by individual-, county-, and state-level variables. Furthermore, a survey of landowners should be carried out to measure program challenges and shortcomings. Lastly, educational outreach programs should be efficiently communicated and implemented to disseminate knowledge and education about their benefits.

3.7. References

Argow, K. A. (1996). This land is their land: The potential and diversity of nonindustrial private forests. *Journal of Forestry*, 94(2), 30-33.

Bagdon, B. A., & Kilgore, M. A. (2013). Observing forest property tax enrollment preferences in light of a multiyear restriction on development. *Northern Journal of Applied Forestry*, 30(2), 58-66.

Brandeis, T. J., McCollum, J., Hartsell, A., Brandeis, C., Rose, A. K., Oswalt, S. N., Vogt, J. T. J., & Marcano-Vega, H. (2016). Georgia's forests, 2014. Resource Bulletin SRS-209. Asheville, NC: US Department of Agriculture Forest Service, Southern Research Station. 78 p.

Bressoux, P. (2010). Modélisation statistique appliquée aux sciences sociales. De boeck, Bruxelles, Belgium. 464 p.

Butler, B. J., & Butler, S. M. (2016). Family forest ownerships with 10+ acres in Georgia, 2011-2013. Research Note NRS-212. US Department of Agriculture, Forest Service, Northern Research Station, Newtown Square, PA. 2 p.

Butler, B. J., Hewes, J. H., Catanzaro, P., Greene, J. L., & Kilgore, M. A. (2010). Effects of federal, state, and local tax policies on family forest owners: technical report. US Department of Agriculture Forest Service/University of Massachusetts Amherst, Family Forest Research Center, Amherst, MA. 74 p.

Coughlin, R. E., Berry, D., & Plaut, T. (1978). Differential assessment of real property as an incentive to open space preservation and farmland retention. *National Tax Journal*, 31(2), 165-179.

Dennis, D. F., & Sendak, P. E. (1992). An empirical study of enrollment in Vermont's use value appraisal property tax program. *Canadian Journal of Forest Research*, 22(9), 1209-1214. doi.org/10.1139/x92-161

Fortney, J., Arano, K. G., & Jacobson, M. (2011). An evaluation of West Virginia's managed timberland tax incentive program. *Forest Policy and Economics*, 13(1), 69-78.

Frey, G. E., Meier, J. T., Kilgore, M. A., Snyder, S. A., & Blinn, C. R. (2019). Factors associated with family forest landowner enrollment in state preferential forest property tax programs in the United States. *Land Use Policy*, 89, 104240. doi.org/10.1016/j.landusepol.2019.104240

Gayer, P. D. (1987). Financial impact of current-use assessment of forest land in Virginia. Research Paper SO-240. US Department of Agriculture, Forest Service, Southern Forest Experiment Station, New Orleans, LA. 10 p.

Georgia Forestry Commission. (2015). *Georgia statewide assessment of forest resources 2015*. Georgia Forestry Commission, Dry Branch, GA.

Haines, A. L., Kennedy, T. T., & McFarlane, D. L. (2011). Parcelization: forest change agent in northern Wisconsin. *Journal of Forestry*, 109(2), 101-108.

Hickman, C. A. (1982). Property tax impacts of current-use assessment of forest and other rural land in Tennessee. Research Paper SO–180. US Department of Agriculture, Forest Service, Southern Forest Experiment Station, New Orleans, LA. 17 p.

Jacobson, M., & McDill, M. (2003). A historical review of forest property taxes in Pennsylvania: Implications for special forestland tax programs. *Northern Journal of Applied Forestry*, 20(2), 53-60. doi.org/10.1093/njaf/20.2.53

Kilgore, M. A., Greene, J. L., Jacobson, M. G., Straka, T. J., & Daniels, S. E. (2007). The influence of financial incentive programs in promoting sustainable forestry on the nation's family forests. *Journal of Forestry*, 105(4), 184-191.

Kingsley, E. W. (1995). Enrollment and eligibility in New Hampshire's current use taxation program. Booklet. University of New Hampshire. Durham, NH. 6 p.

Kramer, L., & Elliott, M. (2005). Identification of conservation priority areas in Georgia. Research Bulletin-13. US Geological Society Gap Analysis Program, Moscow, ID.

Li, Y., & Izlar, R. L. (2021). The Forest Land Protection Act program (FLPA) and conserving forestland in Georgia. *Forest Policy and Economics*, 124, 102399. doi.org/10.1016/j.forpol.2021.102399

Ma, Z., Butler, B. J., Catanzaro, P. F., Greene, J. L., Hewes, J. H., Kilgore, M. A., Kittredge, D. B., & Tyrrell, M. (2014). The effectiveness of state preferential property tax programs in conserving forests: Comparisons, measurements, and challenges. *Land Use Policy*, 36, 492-499. doi.org/10.1016/j.landusepol.2013.09.016

Mehmood, S. R., & Zhang, D. (2001). Forest parcelization in the United States: a study of contributing factors. *Journal of Forestry*, 99(4), 30-34.

Meier, J. T., Kilgore, M. A., Frey, G. E., Snyder, S. A., & Blinn, C. R. (2019). A comparison of participants and non-participants of state forest property tax programs in the United States. *Forest Policy and Economics*, 102, 10-16.

Meng, L., & Zhang, D. (2013). Impacts of property tax on land use change decisions in Georgia. *Urban Ecosystems*, 16(1), 3-12.

Mundell, J., Taff, S. J., Kilgore, M., & Snyder, S. (2010). Using real estate records to assess forest land parcelization and development: A Minnesota case study. *Landscape and Urban Planning*, 94(2), 71-76.

Newman, D. H., Brooks, T. A., & Dangerfield Jr, C. W. (2000). Conservation use valuation and land protection in Georgia. *Forest Policy and Economics*, 1(3-4), 257-266. doi.org/10.1016/S1389-9341(00)00024-1

Paudel, K., Dwivedi, P., & Dickens, D. (2021). Factors affecting the spatial density of longleaf pine plantations under the Conservation Reserve Program in Georgia, United States. *Trees, Forests and People*, 3. doi.org/10.1016/j.tfp.2020.100045

Polyakov, M., Zhang, D., & Univers, A. (2007). Property taxes: do they affect forestry and agricultural land uses? *Emerging Issues in Forest Economics*, 134. doi.org/10.1016/j.landusepol.2009.01.005

Sampson, R. N., & DeCoster, L. A. (1997). Public programs for private forestry. *American Forests*. Washington DC. 100 p.

Sendak, P. E., & Huyler, N.K. (1994). Timber management and Use-Value assessment. Research Paper RP-NE-691. US Department of Agriculture, Forest Service, Northeastern Forest Experiment Station, Broomall, PA. 12 p.

Sommet, N., & Morselli, D. (2017). Keep calm and learn multilevel logistic modeling: A simplified three-step procedure using stata, R, Mplus, and SPSS. *International Review of Social Psychology*, 30, 203-218.

Straka, T.J., Greene, J.L., Daniels, S.E., Jacobson, M.G., & Kilgore, M.A. (2006). Sources for forestry incentive programs. *Forest Landowner*, 65, 15-16.

Stubbs, M. (2014). *Conservation reserve program (CRP): status and issues*. Congressional Research Service, Washington DC. 20 p. http://www.nationalaglawcenter.org/assets/crs/R42783pdf [accessed on 11/06/2021]

Udayanganie, D. (2012). Current use property taxation in the conservation of New Hampshire land: an empirical investigation using Multiple Imputations. Working Paper. Lincoln Institute of Land Policy, Cambridge, MA. 21 p.

Upadhaya, S., & Dwivedi, P. (2019a). Conversion of forestlands to blueberries: Assessing implications for habitat quality in Alabaha river watershed in Southeastern Georgia, United States. *Land Use Policy*, 89, 104229.

Upadhaya, S., & Dwivedi, P. (2019b). The role and potential of blueberry in increasing deforestation in southern Georgia, United States. *Agricultural systems*, 173, 39-48.

U.S. Census Bureau. (2019). *QuickFacts Georgia*. https://www.census.gov/quickfacts/fact/table/GA/INC110219. [accessed on 11/02/2021]

U.S. Natural Resources Conservation Service. (2016). Georgia's land: its use and condition. Fourth Edition, US Department of Agriculture, Natural Resources Conservation Service, Athens, GA, and Center for Survey Statistics and Methodology, Iowa State University, Ames, IA. 25 p.

Williams, E. D., Gottfried, R. R., Brockett, C. D., & Evans, J. P. (2004). An integrated analysis of the effectiveness of Tennessee's Forest Greenbelt Program. *Landscape and Urban Planning*, 69(2-3), 287-297. doi.org/10.1016/j.landurbplan.2003.08.008

CHAPTER 4

FOREST MANAGEMENT PRACTICES AND COSTS FOR FAMILY FOREST LANDOWNERS IN GEORGIA[5]

[5] Godar Chhetri, S & Li, Y. Submitted to [Forests]

4.1. Introduction

Two-thirds of Georgia, or 24.8 million acres, is forested (Georgia Forestry Commission, 2015), the majority (90%) of which is privately owned (Butler & Butler, 2016). Individual and family owners control 13.4 million acres, or 60%, of the total private forestland in Georgia. The remaining 40%, or 8.8 million acres, is owned by corporate and other private landowners. Private forestland is the cornerstone of the state's forest sector, directly supporting more than 55,000 jobs, $3.94 billion in payroll, and $929 million in state government revenues in 2019 (Georgia Forestry Commission, 2020). This land also provides a wide variety of environmental, ecological, and social benefits (Moore et al., 2011; Stein et al., 2009).

Major forest types in Georgia include southern yellow pine (45%) (mainly loblolly, longleaf, shortleaf, and slash pine), hardwoods (41%), and mixed pine-hardwood (12%) (Brandeis et al., 2016). Loblolly-shortleaf pine is the most prevalent softwood forest-type group, whereas oak-hickory is the most prevalent hardwood group. As in many other U.S. Southern states, the acreage of pine plantations in Georgia grew considerably in the second half of the twentieth century and has gradually leveled out in the past decade (Brandeis et al., 2016). Planted pine accounted for 66% of Georgia's softwood forests in 2019 (USDA Forest Service Forest Inventory and Analysis Program, 2021).

Although most private forests are managed for multiple purposes (Conway et al., 2003; Newman & Wear, 1993; Pattanayak et al., 2002), approximately two-thirds of the private family landowners in Georgia have claimed investment as one reason for holding timberland (Butler et al., 2021). Landowners with large timberland holdings are more inclined to manage the land for timber income or investment. Despite the importance of

family forests to sustainable timber supply (Zhang & Mehmood, 2001; Zhang et al., 1998), many family forest landowners have limited access to information on revenues and costs associated with forest management (Larson & Hardie, 1989; Munn & Rucker, 1998). This lack of information largely inhibits their ability to make sound and timely forest management decisions. Although a few studies have addressed the cost trends for forestry practices in the American South (Callaghan et al., 2019; F&W Forestry Services, 2014; Maggard & Barlow, 2017), the cost data are aggregated and averaged at the regional level. Considering the vast variations in forestry practices and costs among the Southern states, it is highly desirable to obtain finer-grained data.

This study fills this gap by documenting the current common forest management practices for family forest landowners in Georgia and estimating the associated costs through a survey of consulting foresters who practice in the state. It provides more robust information on forest management costs for private forest landowners in Georgia than the studies based on aggregated data. Rural tax assessors and potential investors can benefit from the results, as forest management costs play a critical role in timberland valuation and investment return analysis. Property tax on private forestland also is an important revenue source for many local governments and schools. An assessment of forest management costs provides essential information to county assessors for fair and equitable timberland valuation for property tax purposes. Additionally, comparisons with the study results from other Southern states provide implications on the competitiveness of timber and timberland investment in Georgia.

4.2. Methods

Data was collected through a survey of consulting foresters in 2019. For the survey, forestry activities in two physiographic regions (Coastal Plain and Piedmont) of Georgia were documented separately because the composition of various forest types, prevalent management regimes, rates of timber growth, and timber prices differ by region (Figure 8).

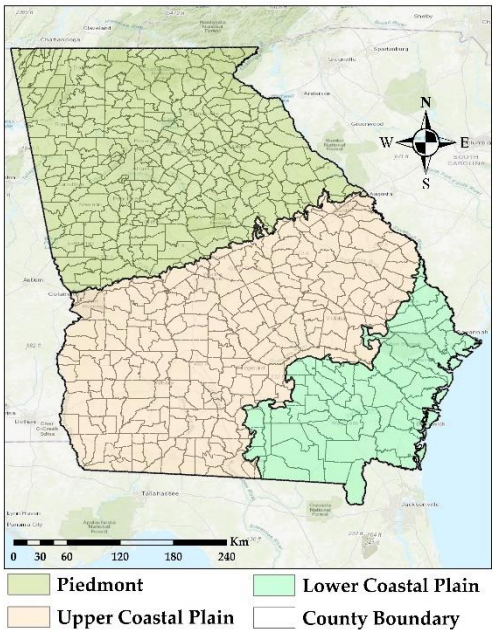


Figure 8: Major physiological regions in Georgia

Foresters offering consulting services in Georgia were identified by using the consulting forester database maintained by the Georgia Forestry Commission, which regularly updates it for the convenience of private forest landowners. One hundred and eighty-three consulting foresters were contacted by mail in 2019. A prepaid return envelope was included in the survey instrument. Personal interviews were conducted with four consultants for clarifications regarding the information on the returned questionnaires.

The eight-page questionnaire included five parts. Part I solicited consultants' region and years in practice. Part II comprised questions on the intensity of silvicultural practices for Georgia's private forest landowners. Specifically, the questions included the preferred species, site preparation activities, midrotation forest management practices, and range of harvesting age by forest type. Part III encompassed information on unit costs for common forestry practices. Questions in Part IV were related to non-timber income from forestland (e.g., hunting lease and sale of pine straw). At the end of the questionnaire, participants were asked to express their opinions on a few statements pertaining to trends in forest management practices in Georgia. Five-point agreement Likert scales were used, with -2 indicating "strongly disagree" and 2 indicating "strongly agree."

A total of 47 questionnaires were returned. Several respondents indicated that they had collectively filled out one questionnaire. After adjusting for this factor, the response rate was 26.2%. The survey data were entered into an electronic database for statistical analysis. T-tests were used to identify significant differences in mean responses across regions. For categorical variables, chi-square tests or Fisher's exact tests were used.

4.3. Results

4.3.1. Characteristics of Surveyed Consulting Foresters

Table 12 presents the characteristics of the surveyed foresters and the respondents, including their credentials, service areas, and provision approaches (personally or subcontract). Many consulting foresters have multiple credentials. In Georgia, foresters must be registered to offer consulting services to the public. A vast

majority of the surveyed consulting foresters (97%) were registered foresters. Forty percent of Georgia consulting foresters were members of the Society of American Foresters (SAF), and 15% were members of the Association of Consulting Foresters (ACF). Approximately 15% of consultants were SAF-certified foresters. Over half (55%) were real estate license holders, and 15% were certified real estate appraisers. Over half (56%) of the consulting foresters were certified prescribed burners. Five percent of the respondents were licensed surveyors. The SAF-certified foresters had a higher response rate than other credential groups.

More than half (55%) of the respondents indicated that they had been practicing consulting forestry for more than 30 years. An additional 28% reported having more than 20 years of experience as a consulting forester, and 25% reported having been in practice longer than ten years. Only 5% had an experience of less than five years. This grouping indicated that the respondents were experienced practitioners in the area and had fair first-hand knowledge of forest management practices in Georgia.

Of the consulting foresters who responded to the survey, 63% were from the Lower and Upper Coastal Plain region and 37% from the Piedmont and Blue Ridge Mountain regions. To protect the confidentiality of the survey respondents, only averages, totals, and ranges were reported.

Table 12: Respondent profiles: credentials, service areas, and ways of providing services

Characteristics	# of Sampled Foresters
Credentials	
Association of Consulting Foresters member	27
Society of American Foresters certified forester	27
Certified real estate appraiser	18
Registered forester	178
Registered land surveyor	9

Society of American Foresters member	73
Certified prescribed burner	102
Real estate license holder	101
Services Provided	
Timber cruising	170
Damage and trespass appraisals	135
Forest litigation	60
Forest management plan	163
Forest stewardship plan	111
Resource investigation and economic studies	46
Investment counselling	62
Land acquisition	109
Wildlife management	100
Recreational land development	69
Real estate brokerage	59
Taxes	38
Timber loans	15
Timber marking	159
Forest product sales	172
Environmental services:	
Impact studies	22
Wetlands & permitting	22
Endangered species	24
Water quality	34
Vendor Services	
Prescribed burning	
Provide personally	117
Sub-contract	66
Mechanical site preparation	
Provide Personally	24
Sub-contract	136
Herbaceous chemical control	
Provide personally	43
Sub-contract	134
Woody chemical control	
Provide personally	38
Sub-contract	135
Tree planting	
Provide personally	36
Sub-contract	128

4.3.2. Common Forest Management Activities

4.3.2.1. Rotation and Thinning Age

The respondents were asked to estimate the typical harvesting and thinning age in timber management for a prudent private forest landowner who manages the property for timber production in their region. The average rotation length of planted pine was 30 years, ranging from 20 to 40 years (Table 13). Despite a wider range of rotation age for pine plantations in the Coastal Plain region, no significant differences were found in the median rotation age between the two regions ($p > 0.15$). Loblolly pine grows faster in the Lower Coastal Plain region and therefore likely has a shorter rotation age (e.g., 20–25 years), resulting in a wider range of rotation age for the Coastal Plain region. On average, the first thinning was carried out at age 15, and the second thinning was made at age 20 for planted pine.

The average rotation age of natural pine stands was reported as longer than pine plantations in both regions: 40 years for the Coastal Plain region and 38 years for the Piedmont region. Natural pines were harvested as early as year 25 and as late as year 60. The first thinning was normally performed around age 20–24 and the second thinning at age 29–33 for natural pine stands.

For hardwood stands, the average final harvest age was 45–50 years, ranging from 40 to 80 years with no significant differences between the two regions ($p > 0.72$). A great majority of the respondents did not report thinning age for hardwood stands, indicating either that it is currently not a common practice in the area or, more likely, is a decision made on a case-by-case basis.

Table 13: Rotation and thinning ages by region and forest type

Physiographic Region /Forest Type	Timber Stand Age (Years)		
	Median	**Minimum**	**Maximum**
Coastal Plain:			
Pine plantation			
First thinning	15	11	18
Second thinning	20	15	25
Final harvest	30	20	38
Natural pine			
First thinning	20	14	60
Second thinning	29	18	60
Final harvest	40	25	60
Hardwood			
Final harvest	50	40	80
Piedmont:			
Pine plantation			
First thinning	15.5	10	18
Second thinning	22	20	25
Final harvest	30	25	40
Natural pine			
First thinning	23.5	16	70
Second thinning	32.5	22	60
Final harvest	37.5	35	60
Hardwood			
Final harvest	45	40	70

4.3.2.2. Plantation Choices

The respondents were asked to estimate the percentage of private landowners with whom they work who are willing to invest in plantation after a harvest. They were also asked to indicate the preferred tree species for commercial timber plantation. Ninety percent of the clients in the Coastal Plain region were likely to be willing to invest in pine plantation after a harvest, while a slightly lower percentage (78%) of the clients in the Piedmont region would like to do so, with significant differences between regions ($p < 0.05$).

Loblolly pine was reported to be the most preferred tree species for a prudent private forest landowner deciding to invest in reforestation after a timber harvest in Georgia. Most respondents (90.2%) believed that prudent private forest landowners would choose loblolly pine for timber production. Only a few respondents (7.84%) reported that private forest landowners would choose slash pine, and the remaining respondents (1.96%) expected that private forest landowners would choose shortleaf pine for timber production. No significant differences in the preferred tree species for commercial timber production were found between regions ($p > 0.64$).

4.3.2.3. Site Preparation Operations

The respondents were asked to estimate the average percentage of pine plantations in their area receiving various types of site preparation operations (i.e., shear and pile, site preparation burning, chemical site preparation, herbaceous weed control, fertilization, and others).

Chemical site preparation with herbaceous weed control (broadcast or banded) was the most frequently reported site preparation treatment in Georgia, followed by prescribed burning (Figure 9). Prescribed fire is often used in conjunction with mechanical or chemical site preparation but can also be used alone.

Thirty percent of the respondents (17 consultants) reported that more than 75% of the pine plantations were treated with chemicals for site preparation, and an additional 21% (10 consultants) reported that more than 50% of the plantations received chemical site preparation. A higher percentage of planted pine in the Coastal Plain region received chemical site preparation than that in the Piedmont region ($p = 0.12$).

Twenty-eight percent of the respondents reported that prescribed fire was applied for site preparation for more than 75% of planted pine, and approximately 30% reported that prescribed burning was applied at establishment for 50–75% of planted pine. A quarter of the respondents estimated that 25–50% of planted pine used prescribed burning. No significant differences were found between regions.

In general, the adoption of mechanical site preparation was very limited. Approximately two-thirds of the respondents reported that less than 5% of the pine plantations in the Coastal Plain region received mechanical site preparation treatment. More than 77% of the respondents in the Piedmont region reported a limited application of mechanical site preparation (less than 5%) for planted pine.

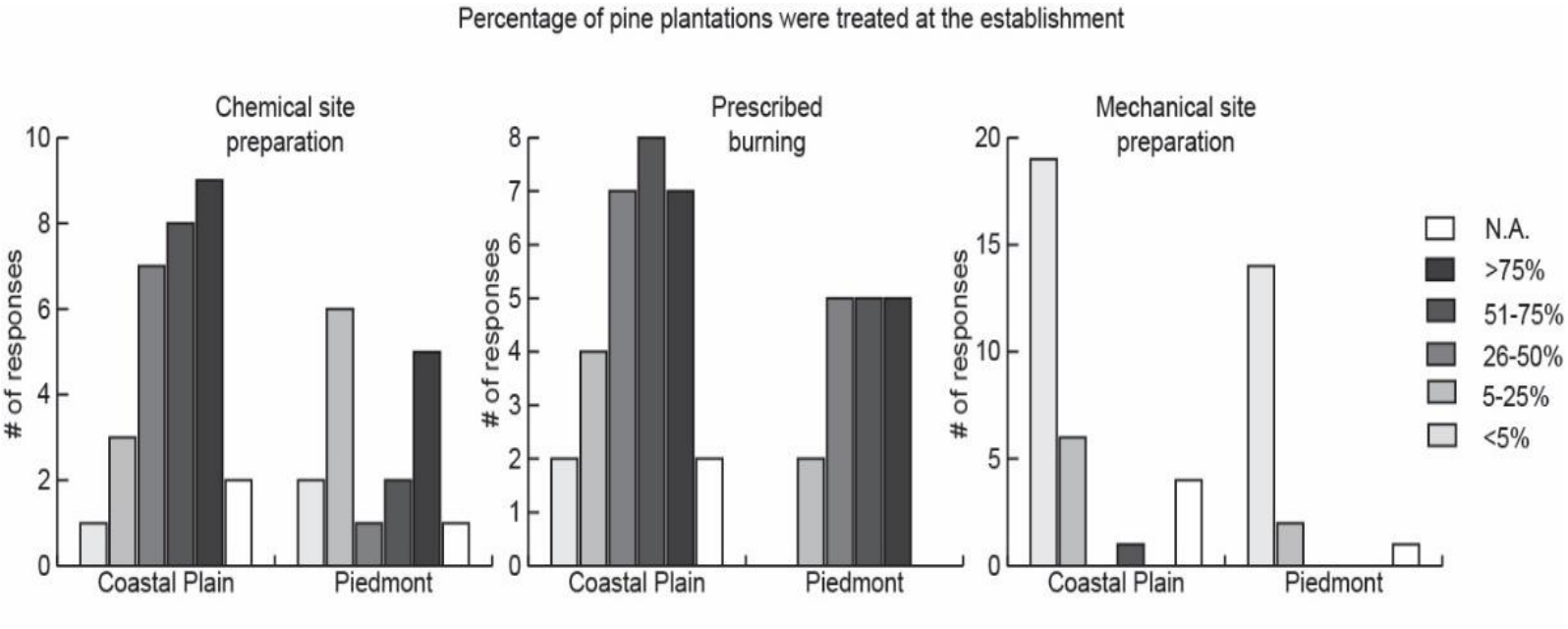


Figure 9: Survey respondents' reported site preparation practices conducted in pine stands in Georgia

More than two-thirds (68%) of the respondents reported that fertilizer was applied for site preparation in less than 5% of plantations. Approximately 20% reported that establishment fertilization was applied to 5–25% of plantations

4.3.2.4. Other Forest Management Activities During a Rotation

The respondents were asked to estimate the average percentage of private forests that receive various midrotation silvicultural treatments (chemical release, prescribed burning, fertilization, and precommercial thinning) in their region. Due to differences in management intensity among forest types, estimations were given separately for pine, mixed forest, and hardwoods.

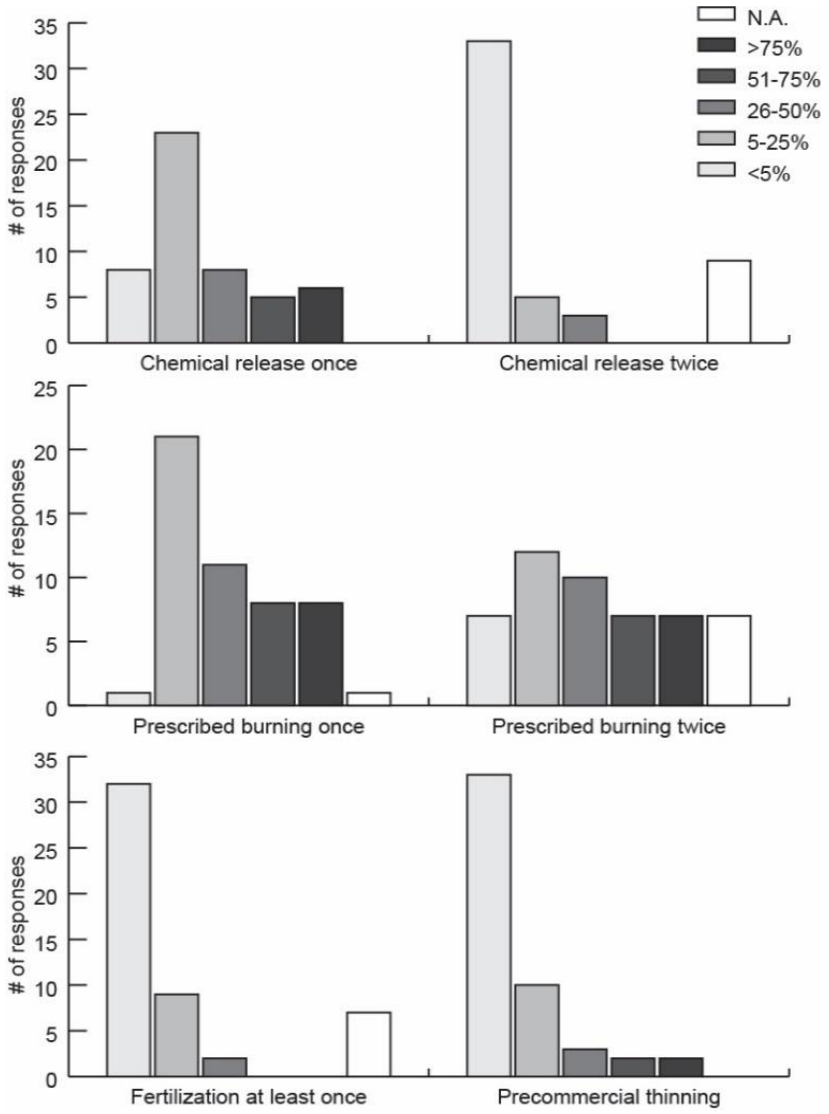


Figure 10: Survey respondents' reported current mid-rotation forest management practices conducted in the pine stands in Georgia

Approximately half of respondents (46%) believed that 5–25% of the pines in their region received one application of chemical release during a rotation (Figure 10). Twelve percent of the respondents reported that more than 75% of pines were treated with chemical release, and 10% reported that 50–75% of planted pines received the treatment. Respondents reporting less than 5% or between 25–50% of pines treated with chemicals for vegetation/woody control each accounted for 16% of the total responding foresters. No significant differences were found between regions ($p = 0.50$).

Respondents' observations about more intensive use of chemical release were less dispersed. Approximately two-thirds of the respondents reported that less than 5% of the pines in their region received two applications of chemical release during a rotation. An additional 10% reported the percentage to be 5–25%.

Forty-two percent of the respondents reported that 5–25% of pines underwent prescribed burning once. Thirty-two percent stated that more than 25% of pines received one treatment of prescribed burning before harvesting. Approximately half of the respondents (44%) reported that less than 25% of the pines underwent prescribed burning more than once during a rotation. No significant differences were found between regions ($p = 0.92$).

Compared to chemical release and prescribed burning, other timber stand improvement practices such as fertilization and precommercial thinning were less commonly used by Georgia's family forest landowners in pine management. Approximately three-quarters (74%) of respondents asserted that less than 5% of the pines managed by family forest landowners received one application of fertilizer. A vast majority (95%) reported that less than 5% of pine stands were fertilized twice. More than two-thirds (68%) of respondents reported that less than 5% of the pines underwent precommercial thinning, with an additional 21% reporting a percentage of 5–25%. The responses did not differ by region ($p = 0.19$).

Table 14: Percentage of the respondents reporting the portion of mixed forests and hardwoods that received various forestry practices in Georgia

	Chemical Release Once	Chemical Release Twice	Prescribed Burning Once	Prescribed Burning Twice
Mixed forests				
<5%	43%	76%	22%	37%
5-25%	31%	6%	29%	18%

26-50%	4%	0%	20%	20%
50-75%	0%	0%	12%	4%
>75%	8%	0%	8%	10%
N.A.	14%	18%	10%	12%
Total	**100%**	**100%**	**100%**	**100%**
Hardwoods				
<5%	86%	78%	75%	76%
5-25%	0%	0%	8%	2%
26-50%	0%	0%	0%	0%
50-75%	0%	0%	0%	0%
>75%	2%	0%	0%	2%
N.A.	12%	22%	18%	20%
Total	**100%**	**100%**	**100%**	**100%**

Compared to pines, mixed forests and hardwoods in Georgia were managed less intensively by family landowners. In many instances, a custodial management approach was used. Approximately two-thirds of respondents (74%) reported that less than 25% of the mixed forests in Georgia received chemical release treatment (Table 14). The proportion that received prescribed burning was slightly higher. Hardwoods were managed largely custodially. Only a very small portion of hardwoods received timber stand improvement practices.

4.3.3. Costs Associated with Forest Management Activities

Using a hypothetical 100-acre loblolly pine stand (site index of 60 at base age 25) as a reference, the surveyed foresters were asked to estimate the unit costs of various services related to owning and managing forests in their region. Table 15 summarizes the respondents' unit cost estimates of various services by region and type. The median and interquartile range (difference between the 25th to 75th percentiles) were reported to reduce the impact of outliers.

Table 15: Estimated unit forest management costs for a 100-acre pine tract by region and type ($/acre unless otherwise specified)

	Coastal Plain			Piedmont			Total		
	N	Median	interquartile range	N	Median	interquartile range	N	Median	interquartile range
Management plan ($/plan)	16	1200	750-2000	8	875	637.5-1750	24	1100	575-2000
Site preparation ($/acre)									
Mechanical (shear-pile-bedding)	18	237.5	195-300	5	125	123-132	23	210	123-270
Chemical site prep	28	85	70-90	14	85	80-90	42	85	75-90
Windrow (shear and pile)	14	175	150-300	*	*	*	16	175	125-300
Burning	26	20	15-25	14	25	20-28	40	21	15.5-25.5
Planting ($/acre)									
Machine planting	28	90	67.5-95	13	90	85-100	41	90	80-95
Hand planting	26	72.5	60-81	13	65	60-70	39	65	60-80
Forest management ($/acre)									
Herbaceous weed control	23	40	35-49	11	40	30-42	34	40	35-45
Mid-rotation woody control	17	65	50-75	10	55	40-75	27	60	50-75
Miscellaneous ($/acre unless otherwise specified)									
Land surveying*	*	*	*	*	*	*	*	*	*
Boundary line establishment ($/mile)	13	250	180-450	*	*	*	17	300	180-450
Boundary line maintenance ($/mile)	15	200	150-300	6	250	160-350	21	200	160-300
Road construction*	*	*	*	*	*	*	*	*	*
Road maintenance*	*	*	*	*	*	*	*	*	*
Prescribed burning ($/acre)	25	20	15-25	12	21	20-25	37	20	16-25
Firebreak establishment ($/hr)	22	85	60-100	8	95	75-100	20	87.5	65-100

Firebreak maintenance ($/hr)	19	80	58.75-96.25	6	95	72.5-97.5	25	85	57.5-97.5
Precommercial thinning ($/acre)	10	112.5	80-200	6	142.5	115-175	16	132.5	100-187.5
Timber stand improvement ($/acre)	6	70	34-110	*	*	*	8	90	47-120
Timber sale administration									
Turnkey operation (mark, cruise, advertise, sell, and supervise timber sale)†	19	10%	8%-10%	7	10%	8%-12%	25	10%	8%-10%
Cruise only ($/acre)	28	10	8-10	11	10	8-10	38	10	8-10
Mark only ($/acre)	22	35	16-45	8	32.5	16.25-42.5	30	35	16-45
Supervise timber sale only†	22	5%	5%-7%	9	9%	7%-10%	31	6%	5%-8.5%

* Estimates were suppressed due to low response rate (<5 responses)

† % of gross sale proceeds

4.3.3.1. Forest Management Plan Preparation Fee

Twenty-four respondents reported their estimates of forest management plan preparation fees. The median management plan preparation fee in Georgia was $1,100 per acre. No significant differences were found among regions ($p = 0.17$).

4.3.3.2. Site Preparation and Planting Costs

Thirty respondents reported information on site preparation costs. Site preparation activities included mechanical site preparation (shear-pile-bedding), chemical site preparation, windrow (shear and pile), and burning. The median site preparation costs for mechanical, chemical, windrow, and burning were $210, $85, $175, and $21 per acre, respectively. The differences in average costs were not statistically significant between regions: mechanical site preparation costs ($p = 0.17$), chemical site preparation costs ($p = 0.11$), windrow ($p = 0.22$), and burning ($p = 0.21$).

Generally, two types of planting methods are used in Georgia: machine planting and hand planting. The median cost was $90 per acre for machine planting and $65 per acre for hand planting. The cost of machine planting was significantly higher than for hand planting ($p < 0.01$). In addition, the average cost for machine planting was higher in Piedmont ($92 per acre) than in the Coastal Plain region ($78 per acre) ($p = 0.02$). In contrast, the average cost for hand planting was not significantly different between the two regions ($p = 0.32$).

4.3.3.3. Midrotation Control

The median cost was $40 per acre for herbaceous weed control and $60 per acre for woody control. No significant differences were found in these costs between regions

4.3.3.4. Timber Sale Administration Costs

Approximately half of respondents reported timber sale administration costs. A turnkey timber sale operation covers all aspects of a timber sale, including timber cruising, marking, advertising, selling, and harvesting monitoring. On average, forestry consultants charged 10% of total gross timber sale revenue for turnkey operation and approximately 6% if only supervising timber sales. Administration costs for thinning were reported as higher than for regular harvests, constituting approximately 12–15% of gross timber revenue. The average costs for timber marking and cruising were $35 and $10 per acre, respectively. No significant differences were found in the reported timber sale administration costs between regions.

4.3.3.5. Other Forest Management Costs

Other major forest management activities included land surveying, boundary establishment and maintenance, road construction and maintenance, prescribed burning, firebreak establishment and maintenance, precommercial thinning, and timber stand improvement.

Responses regarding the costs of land surveying, road construction, and road maintenance were very limited. Some respondents indicated that these services were mainly contracted out to other vendors. Therefore, the cost estimates were not available for these practices. The median costs of boundary line establishment and maintenance were $300 per mile and $200 per mile, respectively. The median prescribed burning cost was $20 per acre. Fees for establishing and maintaining firebreaks were normally charged at $85 per hour. Regional differences in these costs were not significant ($p = 0.19$ for boundary line establishment cost, $p = 0.48$ for boundary line maintenance cost, and $p =$

0.40 for prescribed fire cost). Only a few respondents reported cost estimates for precommercial thinning and timber stand improvement, suggesting that they are not commonly conducted on family-owned forestlands in Georgia.

4.3.4. Non-Timber Income from Forests

Some forest landowners in Georgia may generate income from the sale of non-timber forest products or the provision of recreational opportunities. Pine straw and hunting leases are among the most widely provided products/services in the region (F&W Forestry Services, 2014). The surveyed foresters were asked to estimate the annual income from these two sources for an average private landowner in their service.

4.3.4.1. Hunting Leases

Table 16 presents respondents' estimates of the percentage of forestland leased for hunting purposes in Georgia and the estimated annual hunting lease fee. The respondents estimated that, on average, approximately 75% of Georgia forestland was leased for hunting purposes. A significantly higher portion of pines (74%) were leased for hunting than hardwoods (64%) and mixed forests (68%). There were no significant differences in the percentage of forestland leased for hunting between the two regions.

Since a vast majority of corporate forestland in Georgia is leased for hunting (Morrison et al., 2001), the percentage of family forests available for hunting leases would be lower than 75%. Considering the shares of corporate (8.5 million acres) and family forests (13.4 million acres) among total private forests, an estimated 60–70% of family forests in Georgia are leased for hunting (Table 16).

On average, the annual hunting lease rates were approximately $10 per acre for pine stands and $12 per acre for hardwoods and mixed forests. The differences were

significant between forest types but not significant across regions. Forest landowners were estimated to incur an additional $2 per acre per year to facilitate the provision of hunting services. Costs may include the installation of food plots, legal fees to review lease agreements, insurance premiums, and practices that improve game species habitat. There was a large gap between median and mean annual costs, suggesting a wide range of such costs among landowners.

Table 16: Estimated percentage of forestland leased for hunting purposes by forest type and region in Georgia and average hunting lease rate

	Pine	Hardwood	Mixed Forests
Percentage of forestland leased for hunting purposes			
Coastal Plain			
N	30	29	30
Mean	74%	64%	67%
Median	78%	75%	78%
25^{th}–75^{th} percentile	70%-90%	25%-90%	40%-90%
Piedmont			
N	22	21	18
Mean	75%	68%	66%
Median	78%	75%	75%
25^{th}–75^{th} percentile	60%-95%	50%-95%	30%-95%
Georgia State-wide Average			
N	41	40	40
Mean	73%	64%	68%
Median	75%	75%	75%
25^{th}–75^{th} percentile	60%-85%	28.8%-90%	50%-90%
Annual Hunting Lease Rate (per acre)			
N	41	40	41
Mean (per acre)	$10.36	$11.93	$11.54
Median (per acre)	$10	$12	$12
25^{th}–75^{th} percentile (per acre)	$9.7-$12	$10-$14.5	$10-$12.5
Additional Annual Costs Associated with Providing Hunting Services			
N	30	30	29
Mean (per acre)	$5.69	$9.51	$3.01

Median (per acre)	$2	$2	$2
25^{th}–75^{th} percentile (per acre)	$0-$7	$0-$7	$0-$6

4.3.5. Opinions on Trends in Forest Management Practices

Respondents were asked to express their opinions (ranging from -2 for "strongly disagree" to 2 for "strongly agree") regarding trends in forest management practices in Georgia over the past decade (Table 17). There were several observations:

- The respondents believed that a nonnegligible portion of Georgia's forest landowners generated income from hunting leases.
- Many survey respondents agreed that prescribed burning has been increasingly used in Georgia. This result indicated that landowners were conscious of protecting their forestlands from wildfire and unwanted species.
- The survey respondents agreed that the usage of chemical release has increased. This result suggested that landowners were increasingly concerned about forest health and productivity.
- Reforestation has increasingly gained popularity among forest landowners.
- Forest management on hardwoods was mostly custodial (e.g., paying taxes and maintaining boundaries) in Georgia.

A Mann-Whitney U test was used to determine regional difference in the responses. No significant differences were found between regions in the respondents' opinions about these statements, with one exception. Respondents in the Coastal Plain region were more likely to agree that more landowners chose to plant pines after a harvest than those in the Piedmont region ($p = 0.10$).

Table 17: Respondents' average Likert scale level of agreement with statements pertaining to current trends in forest management in their region of Georgia

Statement	Mean	Median
The usage of artificial regeneration has increased	0.76	1
The usage of chemical release has increased	0.76	1
The usage of prescribed burning has increased	0.30	1
More landowners choose to plant pines after a clearcutting	1.07*	1
A very small percentage of landowners regularly collect income from selling pine straw	0.87	1
A very small percentage of landowners regularly collect income from hunting lease on their forestland	-0.62	-1
Forest management on hardwoods is mostly custodial (e.g., paying taxes and maintaining boundary)	1.11	1

* Statistically different between regions

Additionally, respondents were asked to provide comments on the status of and trends in forest management in Georgia. Surveyed foresters expressed a few common concerns about forest management in Georgia: 1) Forestlands were under intense conversion pressure into pecan and other agricultural croplands in the Upper Coastal Plain region; 2) Continued depressed timber stumpage prices discouraged private landowners from investing in reforestation; 3) Pulp and paper mills and sawmills are likely to exercise their monopsony market power by suppressing timber prices in the local market; 4) *Ad valorem* taxes are confiscatory to private forest landowners in some counties of Georgia.

4.4. Discussion

4.4.1. Forestry Consultant Characteristics

Compared to previous studies (Hodges & Cubbage, 1986, 1990), the number of private forestry consultants in Georgia has increased 24%, from 147 in 1986 to 183 in 2019, suggesting a growing demand for private consulting foresters in the state. This result is consistent with the findings reported by a similar study in Alabama (Zhang &

Sun, 2013). Change in industrial timberland ownership has caused a decrease in industrial foresters and an increase in consulting foresters (Zhang & Sun, 2013).

According to the respondents, consulting foresters in Georgia provided a wide range of services related to forest properties. In addition to the traditional timber sale and silvicultural services, many consulting foresters provided services related to wildlife management, recreational land development, land investment counseling, and real estate. This finding is consistent with the responding foresters' observation that many private forests in Georgia were used for hunting lease purposes. Comparison with an earlier study in Georgia (Hodges & Cubbage, 1986) suggested that timber inventory and preparation of forest management plans were still the most popular services provided by consulting foresters, but more consulting foresters are increasingly offering wildlife management, recreational land development, and real estate-related services. On the one hand, this result suggested that private forests have been increasingly managed and owned for multiple objectives in the state. On the other hand, it also suggested that consulting foresters need to expand their knowledge and expertise beyond traditional silvicultural practices and build their toolbox of skills to meet the growing demand of their clientele.

Most responding foresters had 20 or more years of consulting forestry experience. This was similar to the findings reported in a previous study in Mississippi (Wright & Munn, 2016). Additionally, the SAF-certified foresters had a higher response rate than other groups to our survey. These results may suggest possible biases in our survey. The survey results may be skewed toward the opinions and observations of the more experienced and senior subgroup of consulting foresters in Georgia. Providing electronic

questionnaires may be a way to improve the response rate of the younger forester group and reduce survey biases for future research.

4.4.2. Status and Trends in Georgia Family Forest Landowners' Forest Management

The results of this survey showed that family forest landowners in Georgia generally managed pines more intensively than hardwood and pine-hardwood forests. Pines grow faster and can be harvested sooner than the other two forest types. Intensive management of pines has been asserted to generate attractive financial returns for private landowners (Yin et al., 1998; Yin & Sedjo, 2001).

Forest management regimes may vary greatly depending on site conditions and landowner objectives. The respondents were asked to estimate the management practices that a prudent Georgia private forest landowner would choose to manage his/her property for timber production. Therefore, the results were highly generalized, and it is inappropriate to regard them as suggested management regimes for a particular timber stand. However, the results provided a snapshot of how private forests were managed in Georgia and suggested a general trend over the past few decades. Planted pines were normally harvested around 30 years of age (ranging from 20–40 years), while natural pines were harvested around 40 years of age, but with a wider range (25–60 years). Planted pines were thinned from years 15 to 20. Timing for thinning on natural pines depended on the specific condition of the stand, and thinning was commonly performed from years 20 to 30.

Respondents reported a continued increasing trend in the number of pine plantations in Georgia. Previous empirical studies have suggested that federal cost-share programs have positively affected tree planting in the American South (Alig et al., 1990;

Georgia Forestry Commission, 2015; Li & Zhang, 2007). Major existing programs include the Environmental Quality Incentives Program (EQIP), administered by the Natural Resources Conservation Service (NRCS); the Conservation Reserve Program (CRP), administered by the Farm Service Agency (FSA); and the Southern Pine Beetle (SPB) cost-share program, administered by the Georgia Forestry Commission (GFC). Qualifying landowners are able to obtain financial (e.g., 75% of reforestation costs) and technical assistance in tree planting from these programs. Loblolly pine was reported as the most frequently chosen timber species for planting after a harvest. The increased number of plantations has also advanced the adoption of improved seedlings. Since they have been cultivated to adapt to Georgia's climate and soils, improved seedlings provided by the GFC nursery and private nurseries in the region have a higher survival rate, grow faster, yield larger timber volumes, and have better disease resistance than the seedlings used decades ago.

According to our survey results, site preparation was normally used to facilitate the establishment of a pine plantation, either on cutover sites or agricultural fields. Our study showed that chemical treatment accompanied by burning was commonly used as a cost-effective method of site preparation in Georgia. For competition control, prescribed burning and/or chemical release were conducted on a moderate percentage of pines in Georgia during a rotation. Despite their potential to improve timber productivity (Dickens et al., 2016; Jokela & Stearns-Smith, 1993), some silvicultural practices, such as fertilization and precommercial thinning, were not commonly used by private forest landowners. This observation was similar to the findings from previous studies on Southern forestry practices (Maggard & Barlow, 2017, 2019). Overall, the result was

consistent with the observations of other researchers in that tree improvement, planting, site preparation, and competition control were among the top silvicultural practices contributing to the productivity of pine plantations in the U.S. South in the past several decades (Fox et al., 2007).

Although knowledge about more intensive silvicultural activities pertaining to hardwoods and mixed forests may have improved (Clabo et al., 2019), the survey results indicated that it remained common for a Georgia family forest landowner to manage stands in these two forest types through a hand-off approach. Respondents indicated that paying property taxes and periodically conducting boundary maintenance were the major management activities of private family forest landowners for mixed forests and hardwoods in Georgia. A limited portion of mixed forests received chemical release or prescribed burning over a rotation. The most recent Forest Inventory Analysis (FIA) reported that a vast majority of mixed forests and hardwoods in Georgia originated naturally (USDA Forest Service Forest Inventory and Analysis Program, 2021). The respondents reported that hardwoods were normally harvested around the age of 40–50 years, but with a wide range (40–80 years). Midrotation thinning was not commonly conducted on hardwoods for timber production purposes. Some landowners might carry out wildlife management practices to enhance habitat and improve the quantity and quality of game species on their hardwood and hardwood-pine forest property.

4.4.3. Forest Management Costs

The cost of preparing a forest management plan could be quite significant for a private family forest landowner in Georgia. The average cost of a forest management plan for a 100-acre pine tract in Georgia ranged from $500 to $2000, with $1100 being

the median cost. These costs were similar to those from an earlier study in Mississippi, considering inflation (Wright & Munn, 2016). This result may partially explain the low percentage of Georgia's family forests enrolled under a written management plan, as reported by the National Woodland Owner Survey (NWOS) of the USDA Forest Service (Butler et al., 2021). The survey found that less than 10% of landowners and less than 30% of family forest acreage in Georgia were covered by a written forest management plan in 2018. Consulting foresters prepared 37% of the total forest management plans. Nevertheless, as much as 95% of family forests had landowners who implemented the management plan once a plan was in place. Previous studies have found that having a professionally prepared management plan is often the first step for family forest landowners to obtain help from assistance foresters (consulting, industrial, and public foresters) in their forest management (Zhang et al., 1998). Although not required by law, many county tax assessors in Georgia regard having a forest management plan as an indicator of good-faith timber production in assessing whether a property is eligible for current use property tax relief. This finding suggests that any assistance or effort targeted at reducing a family forest landowner's cost in obtaining a forest management plan would likely prompt family forest landowners to obtain more professional assistance in forest management.

In general, the cost estimates from this study were consistent with those reported by other similar studies conducted at the regional and state levels (Godar Chhetri et al., 2019; Maggard & Barlow, 2017, 2019; Watkins & Munn, 1999; Wright & Munn, 2016), with a few exceptions. For example, the mechanical site preparation costs reported by our study ($210/acre) were higher than the 2018 regional average ($182/acre) reported by

Maggard and Barlow (Maggard & Barlow, 2019). Nonetheless, we were unable to make statistical inferences regarding the significance of this difference. Several possible causes may have contributed to this difference. Mechanical site preparation comprises various techniques, and specific site conditions (e.g., topography, vegetation condition, soil condition, and tree species) largely determine the type of technique needed. The combination of various techniques has different cost implications. Shear-pile-bedding, specified in our study, was close to the mechanical site preparation in double passes reported in Maggard and Barlow (Maggard & Barlow, 2019), while windrow (shear and pile) was similar to their specification for a single pass. Thus, considering these factors would reduce the difference in mechanical site preparation costs. The statistical method of reporting could also play a role. Our study used the median with the 25^{th}–75^{th} percentile, whereas the regional study reported averages weighted by acreage treated by different techniques. Costs could also vary by forest tract size. Due to economies of scale, the average costs per acre for some forestry practices decrease with an increase in tract size. In our survey, we asked foresters to estimate costs for a hypothetical 100-acre pine stand. The regional cost trend study focused on the actual acreage assisted and the costs associated with the practices in the study period.

Additionally, the cost estimates for prescribed burning (for site preparation or understory control) from our study ($20/acre) were similar to the findings ($21.05/acre in 2015) in Mississippi (Godar Chhetri et al., 2019) but lower than those ($31.92/acre in 2018) reported by regional studies. Maggard and Barlow (Maggard & Barlow, 2019) suggested that prescribed burning cost more in the Piedmont than in other regions,

whereas our study showed no statistical difference in the prescribed burning costs between the Piedmont and the Coastal Plain regions

4.4.4. Opportunities and Issues

Besides receiving revenue from timber sales, many landowners in Georgia receive income from hunting leases and selling pine straw. Based on the respondents' estimates regarding private forests leased for hunting, approximately 60–70% of family forests in Georgia were leased for this purpose. However, this rate was significantly higher than the percentage (32%) reported by the NWOS (Butler et al., 2021) and the acreage (in 2019, 5.6 million acres for hunting lease – deer, and 2.2 million acres for hunting lease – turkey) estimated by the University of Georgia Cooperative Extension (Stubbs, 2020).

Previous studies have shown that hunting lease fees vary by game species on the property, property amenities, and region (Munn & Hussain, 2010; Rhyne et al., 2009; Zhang et al., 2006). The median annual hunting lease rate ($12 per acre) reported by the respondents in this study was largely consistent with those reported in previous studies (F&W Forestry Services, 2014; Stubbs, 2020). Stubbs (2020) reported that the weighted average annual hunting lease (deer) rate was $15.69 per acre, ranging from $10 to $30 per acre in the top 10 counties in Georgia in 2019 (Stubbs, 2020). A report by F&W Forestry Services suggested that the annual hunting lease rates per acre ranged from $10 to $15 in southwestern Georgia in 2014 (F&W Forestry Services, 2014). This study differed from some previous studies regarding the effects of physiographic region on hunting leases (Munn & Hussain, 2010; Rhyne et al., 2009) and agreed with the results of Mingie et al. (2017) that hunting leases/club dues were not significantly different across physiographic regions. Nevertheless, this study also supported previous results that the

hunting lease rate for hardwoods was higher than for pines (Munn & Hussain, 2010; Rhyne et al., 2009). Hardwoods and mixed forests are generally believed to provide better habitat for major game species and thus are associated with better game quality, abundance, and diversity (Harris, 1984).

4.5. Conclusions

Family forest landowners in Georgia may manage their forests for multiple purposes, but they are interested in generating financial returns from the land. Generally, intensive forest management can increase timber yield and bring in more revenue for private forest landowners. At the same time, such practices incur costs for landowners, and it is thus important for private landowners to have appropriate expectations regarding the revenues and costs associated with forest management for better-informed decision-making. In addition to receiving revenue from timber sales, many landowners in Georgia receive income from hunting leases and selling pine straw.

The information compiled in this study is helpful for landowners, policymakers, and interested stakeholders. In particular, policymakers need information concerning the types of practices being implemented in various ecoregions to develop appropriate legislation or conservation programs that ensure investment in reforestation and site preparation, low-interest loans, tax incentives, and forest insurance programs that can mitigate risk, encourage investment, and promote active management. Finally, the findings from this study improve our understanding of the contribution of forest management to local economies by providing information on annual investments in forestry activities.

4.6. References

Alig, R.J., Lee, K.J., & Moulton, R.J. (1990). Likelihood of timber management on nonindustrail private forests: evidence from research studies. General Technical Report SE-60. US Department of Agriculture, Forest Service, Southeastern Forest Experiment Station, Asheville, NC. 17 p.

Brandeis, T. J., McCollum, J., Hartsell, A., Brandeis, C., Rose, A. K., Oswalt, S. N., Vogt, J. T. J., & Marcano-Vega, H. (2016). Georgia's forests, 2014. Resource Bulletin SRS-209. US Department of Agriculture Forest Service, Southern Research Station, Asheville, NC. 78 p.

Butler, B. J., & Butler, S. M. (2016). Family forest ownerships with 10+ acres in Georgia, 2011-2013. Research Note NRS-212, US Department of Agriculture, Forest Service, Northern Research Station. Newtown Square, PA. 2 p.

Butler, B.J., Butler, S.M., Caputo, J., Dias, J., Robillard, A., & Sass, E.M. (2021). Family forest ownerships of the United States, 2018: results from the USDA Forest Service, National Woodland Owner Survey. General Technical Report NRS-199, US Department of Agriculture, Forest Service, Northern Research Station, Madison, WI. 52 p.

Callaghan, D.W., Khanal, P.N., & Straka, T.J. (2019). An analysis of costs and cost trends for southern forestry practices. *Journal of Forestry*, 117(1), 21-29, doi.org/10.1093/jofore/fvy060

Clabo, D., Peairs, S., & Dickens, E. D. (2019). Managing upland loblolly pine-hardwood forest types for Georgia landowners. WSFNR-19-50. Warnell School of Forestry and Natural Resources, University of Georgia, Athens, GA. 12 p.

Conway, M.C., Amacher, G.S., Sullivan, J., & Wear, D. (2003). Decisions nonindustrial forest landowners make: an empirical examination. *Journal of Forest Economics*, 9(3), 181-203. doi.org/10.1078/1104-6899-00034

Dickens, E.D., Moorhead, D.J., Kissel, D.E., & Morris, L.A. (2016). Mid-rotation rate of return (ROR) estimates with a single nitrogen+phosphorus or nitrogen+phosphorus+potassium fertilizer application in loblolly, longleaf, and slash pine stands. Warnell School of Forestry and Natural Resources, University of Georgia, Athens, GA.

F&W Forestry Services. (2014). Hunting leases. F&W Forestry Report Winter.

Fox, T. R., Jokela, E. J., & Allen, H. L. (2004). The evolution of pine plantation silviculture in the southern United States. In: General Technical Report SRS–75 Chapter 8, US Department of Agriculture, Forest Service, Southern Research Station. Asheville, NC. 63-82.

Georgia Forestry Commission. (2020). *Economic benefits of the forest industry in Georgia statewide assessment of forest resources: 2018*. Dry Branch, GA.

Georgia Forestry Commission. (2015). *Georgia statewide assessment of forest resources 2015.* Dry Branch, GA.

Godar Chhetri, S., Gordon, J., Munn, I., & Henderson, J. (2019). Comparison of the timber management expenses of non-industrial private forest landowners in Mississippi, United States: results from 1995–1997 and 2015. *Environments,* 6(9), 107-125. doi.org/10.3390/environments6090107

Harris, L. D. (1984). Bottomland hardwoods: valuable, vanishing, vulnerable. Florida Cooperative Extension Service, Institute of Food and Agricultural Services, University of Florida, Gainesville, FL. 18 p.

Hodges, D.G., & Cubbage, F.W. (1986). Private forestry consultants: 1983 status and accomplishments in Georgia. *Southern Journal of Applied Forestry,* 1986, 10(4), 225-230. doi.org/10.1093/sjaf/10.4.225

Hodges, D.G., & Cubbage, F.W. (1990). Nonindustrial private forest management in the South: assistance foresters' activities and perceptions. *Southern Journal of Applied Forestry*, 14(1), 44-48. doi.org/10.1093/sjaf/14.1.44

Jokela, E.J., & Stearns-Smith, S.C. (1993). Fertilization of established southern pine stands: effects of single and split nitrogen treatments. *Southern Journal of Applied Forestry*, 17(3), 135-138. doi.org/10.1093/sjaf/17.3.135

Larson, D., & Hardie, I. (1989). Seller behavior in stumpage markets with imperfect information. *Land Ecocnomics,* 65(3), 239-253. doi.org.10.2307/3146669

Li, Y., & Zhang, D. (2007). A spatial panel data analysis of tree planting in the US South. *Southern Journal of Applied Forestry*, 31(4), 192-198. doi.org.10.1093/sjaf/31.4.192

Maggard, A. & Barlow, R. (2017). *Special report: 2016 costs and trends for southern forestry practices.* Forest Landowner September/October 2017, 31-39 pp.

Maggard, A. & Barlow, R. (2019). C*osts & trends of southern forestry practices 2018.* Forestry & Widllife. Alabama Cooperative Extension System, Montgomery, AL. 5 p.

Mingie, J. C., Poudyal, N. C., Bowker, J. M., Mengak, M. T., & Siry, J. P. (2017). A hedonic analysis of big game hunting club dues in Georgia, USA. *Human Dimensions of Wildlife,* 22(2), 110-125. doi.org/10.1080/10871209.2017.1263767

Moore, R., Williams, T., Rodriguez, E., & Hepinstall-Cymmerman, J. (2011). Quantifying the value of non-timber ecosystem services from Georgia's private forests. University of Georgia, Athens, GA.

Morrison, H.S. IV., Marsinko, A.P., & Guynn, D.C. (2001). Forest industry hunt-lease programs in the southern United States: 1999. *In Proceedings: The fifty-fifth annual conference of southeastern association of fish and wildlife agencies,* Louisville, KY. 567-574.

Munn, I. A., & Hussain, A. (2010). Factors determining differences in local hunting lease rates: insights from Blinder-Oaxaca decomposition. *Land Economics,* 86(1), 66-78. doi.org/10.3368/le.86.1.66

Munn, I.A., & Rucker, R.R. (2008). Predicting forestry consultant participation based on physical characteristics of timber sales. *Journal of Forest Economics,* 4(2), 105-126.

Newman, D., & Wear, D. (1993). Production economics of private forestry: a comparison of industrial and nonindustrial forest Owners. *American Journal of Agricultural Economics,* 75(4). doi.org.10.2307/1243574

Pattanayak, S., Murray, B., & Abt, R.(2002). How joint is joint forest production? An econometric analysis of timber supply conditional on endogenous amenity values. *Forest Science,* 48(3), 479-491. doi.org/10.1093/forestscience/48.3.479

Rhyne, J. D., Munn, I. A., & Hussain, A. (2009). Hedonic analysis of auctioned hunting leases: a case study of Mississippi Sixteenth Section Lands. *Human Dimensions of Wildlife*, 14(4), 227-239. doi.org/10.1080/10871200902736678

Stein, S.M., McRoberts, R.E., Mahal, L.G., Carr, M.A., Alig, R.J., Comas, S.J., Theobald, D.M., & Cundiff, A. (2009). Private forests, public benefits: increased housing density and other pressures on private forest contributions. General Technical Report PNW-GTR-795. US Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR. 74 p.

Stubbs, K. (2020). *2019 Georgia farm gate value report.* University of Georgia Center for Agribusiness and Economic Development: Athens, GA.

USDA Forest Service Forest Inventory and Analysis Program. (2021). Forest Inventory EVALIDator web-application Version 1.8.0.01. US Department of Agriculture, Forest Service, Northern Research Station, St. Paul, MN.

Wright, W.C., & Munn, I.A. (2016). 2013 fees and services of Mississippi's consulting foresters; Forest and Wildlife Research Center, Mississippi State University, Mississippi State, MS.

Yin, R., Pienaar, L., & Aronow, M. (1998). The productivity and profitability of fiber farming. *Journal of Forestry,* 96(11), 13-18. doi.org.10.1093/jof/96.11.13

Yin, R., & Sedjo, R.A. (2001). Is this the age of intensive management? A study of loblolly pine on Georgia's Piedmont. *Journal of Forestry,* 99(12), 10-17 doi.org.10.1093/jof/99.12.10

Zhang, D., & Mehmood, S. (2001). Predicting nonindustrial private forest landowners' choices of a forester for harvesting and tree planting assistance in Alabama. *Southern Journal of Applied Forestry*, 2001, 25(3), 101-107. doi.org10.1093/sjaf/25.3.101

Zhang, D., & Sun, X. (2013). Assistance foresters and nonindustrial private forest management in Alabama. *Southern Journal of Applied Forestry*, 37(4), 189-195. doi.org10.5849/sjaf.12-013

Zhang, D., Warren, S., & Bailey, C. (1998). The role of assitance foresters in nonindustrial private forest management: Alabama landowners' perspectives. *Southern Journal of Applied Forestry*, 22(2), 101-105. doi.org10.1093/sjaf/22.2.101

CHAPTER 5

CONCLUSIONS

Private forests in Georgia provide vital economic, social, and ecological benefits. Maintaining and enhancing the profitability of private forests is crucial to ensuring sustainable provision of the multiple benefits provided by these forests. The costs incurred in forest management activities can vary greatly by forest management intensity. Landowners make forest management decisions to maximize profit from timber without compromising other benefits from the property. However, every landowner incurs property tax on forestland, regardless of their objective and timber market condition. Entering into the state property tax incentive programs could help qualifying private forest landowners save property tax. They need to sign a covenant with the county where the property locates and agree to keep the land in current use. Despite the popularity among forest landowners, the major two property tax incentives in Georgia (CUVA and FLPA programs) have been frequently questioned by concerned stakeholder regarding its effectiveness in conserving forests and open space.

This dissertation advances understanding of the effectiveness of the CUVA/FLPA programs in forest conservation by examining the attributes of enrolled and nonenrolled forest parcels and quantifying the effects of the factors affecting parcels' enrollment in these programs. Different from most existing studies on the topic, this dissertation conducts the analysis based on parcel-level and county-level data. Spatial information is incorporated for many variables. Understanding the underlying determinants of

enrollment in tax incentive programs could form the basis for developing policy tools and extension materials to encourage private landowners to enroll in property tax incentive programs to ensure forestland conservation. Additionally, we conduct a survey on consulting foresters in Georgia regarding current forest management activities of Georgia family forest landowners and the associated unit costs. This prepares us to assess the forest management costs and land expectation value for an average family forest landowner in Georgia.

Chapter 2 identified the major findings, challenges, and gaps of tax incentive programs through a literature review. Our study showed that sociodemographic and forestland characteristics are the most important factors influencing parcel enrollment in tax incentive programs. Moreover, the programs are still not working effectively in conserving the forestlands. The gap we identified from the previous research was that not a single study used parcel-level data and geospatial information to determine the effectiveness of tax incentive programs. This chapter undergirded the research presented in Chapter 3.

In Chapter 3, we compared the attributes of forest parcels enrolled and nonenrolled in the CUVA/FLPA programs. Furthermore, a multilevel logistic regression model was constructed to quantify the factors associated with parcel enrollment. We hypothesized that several social, economic, ecological, and geospatial characteristics influence parcel enrollment in these programs, based on the literature review. Factors such as distance to the nearest city, distance to the nearest lake, parcel acreage, neighbor, land capability class, tax savings amount, lower land value, and ecoregions had positive significance, whereas the distance to potential conservation lands, absentee landowners,

higher land value, county forest coverage, and population density had significant negative effects on a parcel's enrollment in tax incentive programs. In contrast, distance to the road, distance to the nearest greenway, distance to the nearest stream, distance to the nearest sawmill, presence of a sawmill in the county, parcels belongings to metropolitan statistical areas, and median household income were not statistically significant. In short, the findings suggested the need for both periodical and longitudinal assessments of program effectiveness.

Chapter 4 explored major forestry-related activities performed and associated costs incurred by Georgia's private landowners. The study employed a questionnaire survey of consulting foresters working in Georgia. The results showed that forest landowners in Georgia managed pine more intensively than hardwood forest for timber production. More specifically, loblolly pine was reported to be the most preferred tree species for reforestation among landowners. Chemical site preparation was the most common site preparation operation. Other forestry-related activities, such as weed control, prescribed burning, and thinning, were common. A higher proportion of the costs were associated with the preparation of a written forest management plan, site preparation, and precommercial thinning, which are directly related to timber production. This study provides valuable information to landowners and managers considering long-term goals and management activities. In addition, it can help policymakers in developing appropriate legislation or conservation programs to ensure sustainable forest management.

REFERENCES

Alig, R.J., Lee, K.J., & Moulton, R.J. (1990). Likelihood of timber management on nonindustrail private forests: evidence from research studies. General Technical Report SE-60. US Department of Agriculture, Forest Service, Southeastern Forest Experiment Station, Asheville, NC 17 p.

Anderson, J. E. (1993a). Use-value property tax assessment: effects on land development. *Land Economics*, 69(3), 263-269. doi.org/10.2307/3146592

Arano, K. G., & Munn, I. A. (2004). Non-industrial private forest landowners' forest management activities and expenditures in Mississippi, 1998-2000 data. Forest and Wildlife Research Center, Bulletin FO249， Mississippi State University，Mississippi State, MS. 13 p.

Argow, K. A. (1996). This land is their land: The potential and diversity of nonindustrial private forests. *Journal of Forestry*, 94(2), 30-33.

Bagdon, B. A., & Kilgore, M. A. (2013). Observing forest property tax enrollment preferences in light of a multiyear restriction on development. *Northern Journal of Applied Forestry*, 30(2), 58-66.

Bengston, D. N., Asah, S. T., & Butler, B. J. (2011). The diverse values and motivations of family forest owners in the United States: an analysis of an open-ended question in the National Woodland Owner Survey. *Small-Scale Forestry*, 10(3), 339-355. doi.org/10.1007/s11842-019-09423-7

Bengston, D. N., Fletcher, J. O., & Nelson, K. C. (2004). Public policies for managing urban growth and protecting open space: Policy instruments and lessons learned in the United States. *Landscape and Urban Planning*, 69, 271–286.

Brandeis, T. J., McCollum, J., Hartsell, A., Brandeis, C., Rose, A. K., Oswalt, S. N., Vogt, J. T. J., & Marcano-Vega, H. (2016). Georgia's forests, 2014. Resource Bulletin SRS-209. US Department of Agriculture, Forest Service, Southern Research Station, Asheville, NC. 78 p.

Bressoux, P. (2010). Modélisation statistique appliquée aux sciences sociales. De boeck, Bruxelles, Belgium. 464 p.

Brockett, C. D., Gottfried, R. R., & Evans, J. P. (2003). The use of state tax incentives to promote forest preservation on private lands in Tennessee: An evaluation of their equity and effectiveness impacts. *Politics & Policy*, 31(2), 252-281. doi.org/10.1111/j.1747-1346.2003.tb00148.x

Butler, B. J., & Butler, S. M. (2016). Family forest ownerships with 10+ acres in Georgia, 2011-2013. Res. Note NRS-212. Newtown Square, PA: US Department of Agriculture, Forest Service, Northern Research Station. 2 p.

Butler, B.J., Butler, S.M., Caputo, J., Dias, J., Robillard, A., & Sass, E.M. (2021). Family forest ownerships of the United States, 2018: results from the USDA Forest Service, National Woodland Owner Survey, General Technical Report NRS-199, US Department of Agriculture, Forest Service, Northern Research Station, Madison, WI. 52 p.

Butler, B. J., Hewes, J. H., Catanzaro, P., Greene, J. L., & Kilgore, M. A. (2010). Effects of federal, state, and local tax policies on family forest owners: technical report. US Department of Agriculture Forest Service/Univesity of Massachusetts Amherst, Family Forest Research Center, Amherst, MA. 74 p.

Callaghan, D.W., Khanal, P.N., & Straka, T.J. (2019). An analysis of costs and cost trends for southern forestry practices. *Journal of Forestry*, 117(1), 21-29. doi:10.1093/jofore/fvy060.

Chang, S. J. (1982). An economic analysis of forest taxation's impact on optimal rotation age. *Land Economics*, 58(3), 310-323. httpdoi.org/https://doi.org/10.2307/3145939

Chhetri, S. G., Gordon, J. S., Munn, I. A., & Henderson, J. E. (2018). Factors influencing the use of consulting foresters by non-industrial private forest landowners in Mississippi. *The Forestry Chronicle*, 94(3), 254-259. doi.org/10.5558/tfc2018-038

Clendenning, J. G., & Stier, J. C. (2002). Ecosystem management and preferential property taxes for forestland in the United States. *Forstwissenschaftliche Beiträge* 27, Zurich, Switzerland 47 p

Clabo, D., Peairs, S., & Dickens, E. D. (2019). Managing upland loblolly pine-hardwood forest types for Georgia landowners. WSFNR-19-50. Warnell School of Forestry and Natural Resources, University of Georgia, Athens, GA. 12 p.

Conway, M.C., Amacher, G.S., Sullivan, J., & Wear, D. (2003). Decisions nonindustrial forest landowners make: an empirical examination. *Journal of Forest Economics*, 9(3), 181-203, doi:10.1078/1104-6899-00034.

Costello, S. T. (1997). Analysis of the efficiency, equity, and adequacy of a forest site value tax. Dissertation Virginia Polytechnic Institute and State University, Blacksburg, VA. 97 p.

Coughlin, R. E., Berry, D., & Plaut, T. (1978). Differential assessment of real property as an incentive to open space preservation and farmland retention. *National Tax Journal*, 31(2), 165-179.

Cubbage, F., & Wear, D. (1994). Can nonindustrial private forest landowners make up the shortfall in timber production from national forests? *In Proceedings: Foresters together: meeting tomorrow's challenges Society of American Foresters National Convention*. Private nonindustrial private forests working group session. November 6-10. Indianapolis, IN. 421-426.

Cushing, T. L. (2006). A comparison of the relative reduction in land expectation value due to taxation of private forest land in the United States. (Doctoral dissertation) University of Georgia, Athens, GA. 148 p.

Dennis, D. F., & Sendak, P. E. (1992). An empirical study of enrollment in Vermont's use value appraisal property tax program. *Canadian Journal of Forest Research*, 22(9), 1209-1214. doi.org/10.1139/x92-161

Dickens, E.D., Moorhead, D.J., Kissel, D.E., & Morris, L.A. (2016). Mid-rotation rate of return (ROR) estimates with a single nitrogen+phosphorus or nitrogen+phosphorus+potassium fertilizer application in loblolly, longleaf, and slash pine stands. Warnell School of Forestry and Natural Resources, University of Georgia, Athens, GA.

Eckhoff, M., Mackes, K., & Reader, T. (2007). Assessing state-sponsored tax incentive programs for nonindustrial private forest landowners in the western United States. *Western Journal of Applied Forestry,* 22(4), 253-260. doi.org/10.1093/wjaf/22.4.253

Egan, A. F. (1997). From timber to forests and people: a view of nonindustrial private forest research. *Northern Journal of Applied Forestry*, 14(4), 189-193.

F&W Forestry Services. (2014). Hunting leases. F&W Forestry Report Winter.

Flick, W. A., Krietemeyer, S. W., & Hickman, C. A. (1989). Current-use assessment in Alabama. Bulletin 600, August 2009. Alabama Agriculture Experiment Station. Auburn, AL.

Fortney, J., & Arano, K. G. (2010). Property taxes and forests in West Virginia: a historical review. *Small-Scale Forestry*, 9(1), 67-80. doi.org/10.1007/s11842-009-9102-6

Fortney, J., Arano, K. G., & Jacobson, M. (2011). An evaluation of West Virginia's managed timberland tax incentive program. *Forest Policy and Economics*, 13(1), 69-78.

Fox, T. R., Jokela, E. J., & Allen, H. L. (2004). The evolution of pine plantation silviculture in the southern United States. In: General Technical Report SRS–75 Chapter 8, US Department of Agriculture, Forest Service, Southern Research Station. Asheville, NC. 63-82.

Frey, G. E., Meier, J. T., Kilgore, M. A., Snyder, S. A., & Blinn, C. R. (2019). Factors associated with family forest landowner enrollment in state preferential forest property tax programs in the United States. *Land Use Policy*, 89, 104240. doi.org/10.1016/j.landusepol.2019.104240

Gayer, P. D. (1987). Financial impact of current-use assessment of forest land in Virginia. Research Paper SO-240. US Department of Agriculture, Forest Service, Southern Forest Experiment Station, New Orleans, LA. 10 p.

Georgia Department of Revenue. (2021). *Table of conservation use land values*. https://dor.georgia.gov/table-conservation-use-land-values [accessed on 11/10/2021].

Georgia Forestry Commission. (2015). *Georgia statewide assessment of forest resources 2015*. Georgia Forestry Commission, Dry Branch, GA.

Georgia Forestry Commission. (2019). *Georgia Forest Facts*. https://gfagrow.org/advocate/numberone/ [accessed on 11/24/2021].

Georgia Forestry Commission. (2020). *Economic benefits of the forest industry in Georgia statewide assessment of forest resources: 2018*. Dry Branch, GA.

Georgia Forestry Commission. (2021). *The #1 forestry state in the nation*. https://gfagrow.org/advocate/numberone/ [accessed on 11/24/2021].

Godar Chhetri, S., Gordon, J., Munn, I., & Henderson, J. (2019). Comparison of the timber management expenses of non-industrial private forest landowners in Mississippi, United States: Results from 1995–1997 and 2015. *Environments*, 6(9), 107.

Guz, A. N., & Rushchitsky, J. J. (2009). Scopus: a system for the evaluation of scientific journals. *International Applied Mechanics*, 45(4), 351-362.

Haas, J. L. (2011). The impact of taxation on Land Expectation Value and sustainable forest management in the Northern Forest states. (Thesis). State University of New York College of Environmental Science and Forestry, Syracuse, NY. 160 p.

Haines, A. L., Kennedy, T. T., & McFarlane, D. L. (2011). Parcelization: forest change agent in northern Wisconsin. *Journal of Forestry*, 109(2), 101-108.

Harris, L. D. (1984). Bottomland hardwoods: valuable, vanishing, vulnerable. Florida Cooperative Extension Service, Institute of Food and Agricultural Services, University of Florida, Gainesville, FL. 18 p.

Hibbard, C. M., Kilgore, M. A., & Ellefson, P. V. (2003). Property taxation of private forests in the United States: A national review. *Journal of Forestry*, 101(3), 44-49. doi.org/10.1093/jof/101.3.44

Hickman, C. A., & Crowther, K. D. (1991). Economic impacts of current-use assessment of rural land in the east Texas pineywoods region. Research Paper SO-261. US Department of Agriculture, Forest Service, Southern Forest Experiment Station, New Orleans, LA. 10 p.

Hickman, C. (n.d.). Property taxes and the loss of private forests. Issue Paper. US Department of Agriculture, Forest Service, 18 p.

Hickman, C. A. (1982). Property tax impacts of current-use assessment of forest and other rural land in Tennessee. Research Paper SO–180. US Department of Agriculture, Forest Service, Southern Forest Experiment Station, New Orleans, LA. 17 p.

Hickman, C. A., & Greene, J. L. (2015). Property tax. In: Forests and Forestry in the Americas: An Encyclopedia. In: Cubbage, F.W. (Eds), Society of American Foresters and International Society of Tropical Foresters. http://64.78.1.15/index.php/Main_Page [accessed on 04/21/2021]

Hodges, D.G., & Cubbage, F.W. (1986). Private forestry consultants: 1983 status and accomplishments in Georgia. *Southern Journal of Applied Forestry*, 1986, 10(4), 225-230. doi.org/10.1093/sjaf/10.4.225

Hodges, D.G., & Cubbage, F.W. (1990). Nonindustrial Private Forest Management in the South: Assistance Foresters' Activities and Perceptions. *Southern Journal of Applied Forestry,* 14(1), 44-48. doi.org/10.1093/sjaf/14.1.44.

Jacobson, M., & McDill, M. (2003). A historical review of forest property taxes in Pennsylvania: Implications for special forestland tax programs. *Northern Journal of Applied Forestry*, 20(2), 53-60. doi.org/10.1093/njaf/20.2.53

Jokela, E.J., & Stearns-Smith, S.C. (1993). Fertilization of established southern pine stands: effects of single and split nitrogen treatments. *Southern Journal of Applied Forestry*, 17(3), 135-138. doi.org/10.1093/sjaf/17.3.135.

Kilgore, M. A., Ellefson, P. B., Funk, T. J., & Frey, G. E. (2017). State property tax incentives for promoting ecosystem goods and services from private forest land in the United States: A review and analysis. General Technical Report. SRS–228. US Department of Agriculture, Forest Service, Southern Research Station, Asheville, NC. 174 p.

Kilgore, M. A., Greene, J. L., Jacobson, M. G., Straka, T. J., & Daniels, S. E. (2007). The influence of financial incentive programs in promoting sustainable forestry on the nation's family forests. *Journal of Forestry*, 105(4), 184-191.

Kimbell, A., Hickman, C., & Brown, H. (2010). How do taxes affect America’s private forest landowners. *Journal of Forestry*, 108(2), 93-102.

King, D. A. (1963). Forest land classification for property tax assessment purposes in Wisconsin. *Land Economics*, 39(1), 96-99. doi.org/10.2307/3144523

Kingsley, E. W. (1995). Enrollment and eligibility in New Hampshire's current use taxation program. Booklet. University of New Hampshire. Durham, NH. 6 p.

Kramer, L., & Elliott, M. (2005). Identification of conservation priority areas in Georgia. Reseach Bulletin-13. US Geological Society Gap Analysis Program, Moscow, ID.

LaPierre, S., & Germain, R. H. (2005). Forestland parcelization in the New York City watershed. *Journal of Forestry*, 103(3). 139-145. doi.org/10.1093/jof/103.3.139

Larson, D., & Hardie, I. (1989). Seller behavior in stumpage markets with imperfect information. *Land Economics*, 65(3). 239-253. doi:10.2307/3146669.

Li, Y., & Izlar, R. L. (2021). The Forest Land Protection Act program (FLPA) and conserving forestland in Georgia. *Forest Policy and Economics*, 124, 102399. doi.org/10.1016/j.forpol.2021.102399

Li, Y., & Zhang, D. (2007). A spatial panel data analysis of tree planting in the US South. *Southern Journal of Applied Forestry*, 31(4), 192-198. doi.org/10.1093/sjaf/31.4.192.

Locke, C. M., & Rissman, A. R. (2012). Unexpected co-benefits: forest connectivity and property tax incentives. *Landscape and Urban Planning*, 104(3-4), 418-425. doi.org/10.1016/j.landurbplan.2011.11.022

Ma, Z., Butler, B. J., Catanzaro, P. F., Greene, J. L., Hewes, J. H., Kilgore, M. A., Kittredge, D. B., & Tyrrell, M. (2014). The effectiveness of state preferential property tax programs in conserving forests: Comparisons, measurements, and challenges. *Land Use Policy*, 36, 492-499. doi.org/10.1016/j.landusepol.2013.09.016

Maggard, A. & Barlow, R. (2017). Special report: 2016 costs and trends for southern forestry practices. Forest Landowner September/October 2017, 31-39 pp.

Maggard, A. & Barlow, R. (2019). C*osts & trends of southern forestry practices 2018.* Forestry & Widllife. Alabama Cooperative Extension System, Montgomery, AL. 5 p.

Maker, N. F., Germain, R. H., & Anderson, N. M. (2014). Working woods: a case study of sustainable forest management on Vermont family forests. *Journal of Forestry*, 112(4), 371-380. doi.org/10.5849/jof.13-003

Malme, J. (1993). Preferential property tax treatment of land. Lincoln Institute of Land Policy. Cambridge, MA.

Marler, R. L., & Graves, P. F. (1974). A new rationale for small forest landowners. Research Report, AFRI-17. State University of New York, Ithaca, NY.

Mehmood, S. R., & Zhang, D. (2001). Forest parcelization in the United States: a study of contributing factors. *Journal of Forestry*, 99(4), 30-34.

Meier, J. T., Kilgore, M. A., Frey, G. E., Snyder, S. A., & Blinn, C. R. (2019). A comparison of participants and non-participants of state forest property tax programs in the United States. *Forest Policy and Economics*, 102, 10-16. doi.org/10.1016/j.forpol.2019.02.002

Meng, L., & Zhang, D. (2013). Impacts of property tax on land use change decisions in Georgia. *Urban Ecosystems*, 16(1), 3-12.

Mingie, J. C., Poudyal, N. C., Bowker, J. M., Mengak, M. T., & Siry, J. P. (2017). A hedonic analysis of big game hunting club dues in Georgia, USA. *Human Dimensions of Wildlife*, 22(2), 110-125. doi.org/10.1080/10871209.2017.1263767

Moore, R., Williams, T., Rodriguez, E., & Hepinstall-Cymmerman, J. (2011). Quantifying the value of non-timber ecosystem services from Georgia's private forests. University of Georgia, Athens, GA.

Morrison, H.S. IV., Marsinko, A.P., & Guynn, D.C. (2001). Forest industry hunt-lease programs in the southern United States: 1999. *In Proceedings: The fifty-fifth annual conference of southeastern association of fish and wildlife agencies*, Society of American Foresters. Louisville, KY. 567-574.

Mundell, J., Taff, S. J., Kilgore, M., & Snyder, S. (2010). Using real estate records to assess forest land parcelization and development: A Minnesota case study. *Landscape and Urban Planning*, 94(2), 71-76.

Munn, I. A., & Hussain, A. (2010). Factors determining differences in local hunting lease rates: insights from Blinder-Oaxaca decomposition. *Land Economics*, 86(1), 66-78. doi.org/10.3368/le.86.1.66

Munn, I.A., & Rucker, R.R. (2008). Predicting forestry consultant participation based on physical characteristics of timber sales. *Journal of Forest Economics*, 4(2), 105-126.

Newman, D., & Wear, D. (1993). Production economics of private forestry: a comparison of industrial and nonindustrial forest Owners. *American Journal of Agricultural Economics*, 75(4). doi.org/10.2307/1243574

Newman, D. H., Brooks, T. A., & Dangerfield Jr, C. W. (2000). Conservation use valuation and land protection in Georgia. *Forest Policy and Economics*, 1(3-4), 257-266. doi.org/10.1016/S1389-9341(00)00024-1

Oswalt, S.N., & Smith, W.B. (2014). US forest resource facts and historical trends. General Technical Report FS-1035. US Department of Agriculture, Forest Service, Southern Research Station. Knoxville, TN. 63 p.

Parks, P. J., & Quimio, W. R. H. (1996). Preserving agricultural land with farmland assessment: New Jersey as a case study. *Agricultural and Resource Economics Review*, 25(1203-2016-94816), 22-27. doi.org/10.1017/S1068280500000034

Pattanayak, S., Murray, B., & Abt, R. (2002). How joint is joint forest production? An econometric analysis of timber supply conditional on endogenous amenity values. *Forest Science*, 48(3), 479-491. doi.org/10.1093/forestscience/48.3.479

Paudel, K., Dwivedi, P., & Dickens, D. (2021). Factors affecting the spatial density of longleaf pine plantations under the Conservation Reserve Program in Georgia, United States. *Trees, Forests and People*, 3. doi.org/10.1016/j.tfp.2020.100045

Polyakov, M., Zhang, D., & Univers, A. (2007). Property taxes: do they affect forestry and agricultural land uses? *Emerging Issues in Forest Economics*, 134. doi.org/10.1016/j.landusepol.2009.01.005

Poudyal, N. C., & Hodges, D. G. (2009). Property taxation and rural land values: Their effect on private forestland ownership structure in Texas. *Land Use Policy*, 26(4), 1100-1105.

Rathke, D. M., & Baughman, M. J. (1996). Influencing nonindustrial private forest management through the property tax system. *Northern Journal of Applied Forestry*, 13(1), 30-36. doi.org/10.1093/njaf/13.1.30

Rhyne, J. D., Munn, I. A., & Hussain, A. (2009). Hedonic analysis of auctioned hunting leases: a case study of Mississippi Sixteenth Section Lands. *Human Dimensions of Wildlife*, 14(4), 227-239. doi.org/10.1080/10871200902736678

Rickenbach, M., & Saunders, L. (2009). The managed forest law & property tax revenues for townships: a study of enrollment shifts & local impacts. GWQ52. University of Wisconsin. Madison, WI. 24 p.

Rozman, D. (1942). Massachusetts Forest Tax Law. *The Journal of Land & Public Utility Economics*, 18(3), 363-365. doi.org/10.2307/3159067

Sampson, R. N., & DeCoster, L. A. (1997). Public programs for private forestry. *American Forests*. Washington DC. 100p.

Sendak, P. E., & Huyler, N.K. (1994). Timber management and Use-Value assessment. Research Paper. RP-NE-691. US Department of Agriculture, Forest Service, Northeastern Forest Experiment Station, Broomall, PA. 12 p.

Sendak, P. E., & Dennis, D. F. (1989). Vermont's use value appraisal property tax program: A forest inventory and analysis. Research Paper. RP-NE-627. US

Department of Agriculture, Forest Service, Northeastern Forest Experiment Station, Broomall, PA. 73 p.

Sommet, N., & Morselli, D. (2017). Keep calm and learn multilevel logistic modeling: A simplified three-step procedure using stata, R, Mplus, and SPSS. *International Review of Social Psychology*, 30, 203-218.

Stein, S.M., McRoberts, R.E., Mahal, L.G., Carr, M.A., Alig, R.J., Comas, S.J., Theobald, D.M., & Cundiff, A. (2009). Private forests, public benefits: increased housing density and other pressures on private forest contributions. General Technical Report PNW-GTR-795. US Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR. 74 p.

Stone, R. S., & Tyrrell, M. L. (2012). Motivations for family forestland parcelization in the Catskill/Delaware watersheds of New York. *Journal of Forestry*, 110(5), 267-274. doi.org/10.5849/jof.11-015

Straka, T.J., Greene, J.L., Daniels, S.E., Jacobson, M.G., & Kilgore, M.A. (2006). Sources for forestry incentive programs. *Forest Landowner*, 65, 15–16.

Stubbs, K. (2020). *2019 Georgia farm gate value report*. University of Georgia Center for Agribusiness and Economic Development: Athens, GA.

Stubbs, M. (2014). *Conservation reserve program (CRP): status and issues*. Congressional Research Service, Washington DC. 20 p. http://www.nationalaglawcenter.org/assets/crs/R42783pdf [accessed on 11/06/2021]

Udayanganie, D. (2012). Current use property taxation in the conservation of New Hampshire land: an empirical investigation using Multiple Imputations. Working Paper. Lincoln Institute of Land Policy, Cambridge, MA. 21 p.

Upadhaya, S., & Dwivedi, P. (2019a). Conversion of forestlands to blueberries: Assessing implications for habitat quality in Alabaha river watershed in Southeastern Georgia, United States. *Land Use Policy*, 89, 104229.

Upadhaya, S., & Dwivedi, P. (2019b). The role and potential of blueberry in increasing deforestation in southern Georgia, United States. *Agricultural systems*, 173, 39-48.

U.S. Census Bureau. (2019). *QuickFacts Georgia*. https://www.census.gov/quickfacts/fact/table/GA/INC110219. [accessed on 11/02/2021]

USDA Forest Service Forest Inventory and Analysis Program. (2021). Forest Inventory EVALIDator web-application Version 1.8.0.01. US Department of Agriculture, Forest Service, Northern Research Station. St. Paul, MN.

U.S. Natural Resources Conservation Service. (2016). Georgia's land: its use and condition. Fourth Edition, US Department of Agriculture, Natural Resources Conservation Service, Athens, GA, and Center for Survey Statistics and Methodology, Iowa State University, Ames, IA. 25 p.

U.S. Forest Service. (2008). Who owns America's forests? Forest ownership patterns and family forest highlights from the National Woodland Owner Survey. NRS-INF-06-08. US Department of Agriculture, Forest Service, Northern Research Station, Amherst, MA. 7 p.

US Forest Service. (2015). Who owns America's trees, woods, and forests? Results from the U.S. Forest Service 2011-2013 National Woodland Owner Survey. NRS-INF-31-15. US Department of Agriculture, Forest Service, Northern Research Station, Newtown Square, PA. 12 p.

Wagner, J. E., Davis, C. J., Roczen, D. E., & Herrington, L. P. (2002). Combining zoning regulations and property tax relief to retain forestland and promote forest management. *Northern Journal of Applied Forestry*, 19(2), 59-67. doi.org/10.1093/njaf/19.2.59

Wicker, G. (2002). Motivation for private forest landowners. In: Wear, D.N., John, G. (Eds), Southern forest resource assessment. General technical Report SRS-53. US Department of Agriculture, Forest Service, Southern Research Station, Asheville, NC. 635 p.

Williams, E. D., Gottfried, R. R., Brockett, C. D., & Evans, J. P. (2004). An integrated analysis of the effectiveness of Tennessee's Forest Greenbelt Program. *Landscape and Urban Planning*, 69(2-3), 287-297. doi.org/10.1016/j.landurbplan.2003.08.008

Williams, E. T. (1961). Trends in forest taxation. *National Tax Journal*, 14(2), 113-144.

Wright, W.C., & Munn, I.A. (2016). 2013 fees and services of Mississippi's consulting foresters; Forest and Wildlife Research Center, Mississippi State University: Mississippi State, MS.

Wolde, B., Lal, P., Gan, J., Alavalapati, J., Taylor, E., & Burli, P. (2016). Determinants of enrollment in public incentive programs for forest management and their effect on future programs for woody bioenergy: evidence from Virginia and Texas. *Canadian Journal of Forest Research*, 46(6), 775-782.

Wright, J. B. (1998). The role of conservation easement sites in biogeographic and biological research in the USA. *Environmental Conservation*, 25(2), 95-98. doi.org/10.1017/S0376892998000149

Yin, R., Pienaar, L., & Aronow, M. (1998). The productivity and profitability of fiber farming. *Journal of Forestry*, 96(11), 13-18. doi.org/10.1093/jof/96.11.13

Yin, R., & Sedjo, R.A. (2001). Is this the age of intensive management? A study of loblolly pine on Georgia's Piedmont. *Journal of Forestry*, 99(12), 10-17. doi.org/10.1093/jof/99.12.10

Zhang, D., & Mehmood, S. (2001). Predicting nonindustrial private forest landowners' choices of a forester for harvesting and tree planting assistance in Alabama. *Southern Journal of Applied Forestry*, 2001, 25(3), 101-107. doi.org/10.1093/sjaf/25.3.101.

Zhang, D., & Sun, X. (2013). Assistance foresters and nonindustrial private forest management in Alabama. *Southern Journal of Applied Forestry*, 37(4), 189-195. doi.org/10.5849/sjaf.12-013

Zhang, D., Warren, S., & Bailey, C. (1998). The role of assistance foresters in nonindustrial private forest management: Alabama landowners' perspectives. *Southern Journal of Applied Forestry*, 22(2), 101-105 doi.org/10.1093/sjaf/22.2.101

APPENDIX

Georgia Consulting Forester Survey

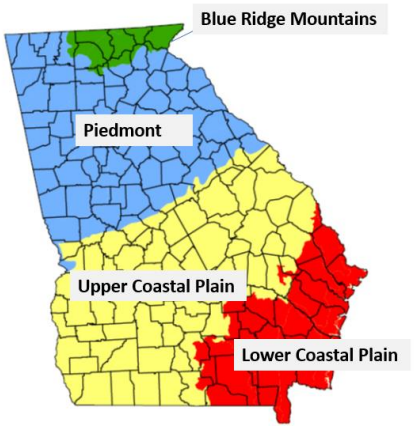
Part I. General background

1. **How long have you been a practicing consulting forester?**

   ☐ < 5 years ☐ 5-10 years ☐ 11-20 years ☐ 21- 30 years ☐ >30 years

2. **Referring to the map below, which ecological region have you worked in most frequently during the past 5 years (please choose one)?**

   ☐ Lower Coastal Plain ☐ Upper Coastal Plain ☐ Piedmont ☐ Blue Ridge Mountains



Part II. Silvicultural practices of forest landowners in the region you chose in Question 2. What is the most prevalent tree species that a prudent private forest landowner will choose for timber production in the region?

☐ Loblolly pine ☐ Longleaf pine ☐ Shortleaf pine ☐ Slash pine

☐ Oaks ☐ Other (please specify: _____)

3. **What are the typical harvesting & thinning practices for a prudent private forest landowner to manage his/her forests for timber production in the region?**

	Pine		
	Plantation	**Natural Regeneration**	**Hardwoods**
Average rotation length (in years)			
First thinning (in Year #, if any)			
Second thinning (in Year #, if any)			

4. **What percent of private landowners that you work with are willing to invest in artificial regeneration after a harvest?**

Pine	**Hardwoods**	**Mixed forest**
____ %	____ %	____ %

5. **Based on your observation, please check your estimated average percentage of the region's artificially regenerated forestland that receives the following site prep/planting treatment?**

Treatment	Pine				
	<5%	**5-25%**	**26-50%**	**51%-75%**	**>75%**
Shear, pile and bedding	☐	☐	☐	☐	☐
Shear and pile	☐	☐	☐	☐	☐
Site prep burn	☐	☐	☐	☐	☐
Chemical site prep	☐	☐	☐	☐	☐
Herbaceous weed control (broadcast or banded)	☐	☐	☐	☐	☐
Fertilization	☐	☐	☐	☐	☐
Other (Please specify:____)	☐	☐	☐	☐	☐

6. **Over the course of a rotation, please check your estimated average percentage of private forests (by forest type) that receive the following treatment?**

Treatment	**Pine**

	<5%	5-25%	26-50%	51%-75%	>75%
One application of chemical release	☐	☐	☐	☐	☐
Two applications of chemical release	☐	☐	☐	☐	☐
One prescribed burning	☐	☐	☐	☐	☐
Two prescribed burnings	☐	☐	☐	☐	☐
One application of fertilization	☐	☐	☐	☐	☐
Two applications of fertilization	☐	☐	☐	☐	☐
Precommercial thinning	☐	☐	☐	☐	☐
Other (Please specify:_____)	☐	☐	☐	☐	☐

Treatment	Mixed Forests				
	<5%	5-25%	26-50%	51%-75%	>75%
One application of chemical release	☐	☐	☐	☐	☐
Two applications of chemical release	☐	☐	☐	☐	☐
One prescribed burning	☐	☐	☐	☐	☐
Two prescribed burnings	☐	☐	☐	☐	☐
One application of fertilization	☐	☐	☐	☐	☐
Two applications of fertilization	☐	☐	☐	☐	☐
Precommercial thinning	☐	☐	☐	☐	☐
Other (Please specify:_____)	☐	☐	☐	☐	☐

Treatment	Hardwoods				
	<5%	5-25%	26-50%	51%-75%	>75%
One application of chemical release	☐	☐	☐	☐	☐
Two applications of chemical release	☐	☐	☐	☐	☐
One prescribed burning	☐	☐	☐	☐	☐
Two prescribed burnings	☐	☐	☐	☐	☐

One application of fertilization	☐	☐	☐	☐	☐
Two applications of fertilization	☐	☐	☐	☐	☐
Precommercial thinning	☐	☐	☐	☐	☐
Other (Please specify:_____)	☐	☐	☐	☐	☐

Part III. Forest management costs

For a 100-acre loblolly pine timberland with site index of 60 (base age=25), please enter your standard rate by service type. If you contract out the service or your firm does not offer the service, please provide an estimate in the region:

Service	Standard Fee	
Management plan preparation	**$**	**/Plan**
Timber sale administration		
Turnkey operation (mark, cruise, advertise, sell and supervise timber sale)	**$**	**/Acre**
Cruise only	**$**	**/Acre**
Mark only	**$**	**/Acre**
Supervise timber sale only	**$**	**% of Gross Timber Sales**
Site preparation		
Mechanical (shear-pile-bedding)	**$**	**/Acre**
Chemical site prep	**$**	**/Acre**
Windrow (shear and pile)	**$**	**/Acre**
Burning	**$**	**/Acre**
Planting		
Machine planting	**$**	**/Acre**
Hand planting	**$**	**/Acre**
Forest management		
Herbaceous weed control	**$**	**/Acre**
Mid-rotation woody control	**$**	**/Acre**
Miscellaneous		
Land surveying	**$**	**Per Acre** or **per Day***
Boundary line establishment	**$**	**/Mile**
Boundary line maintenance	**$**	**/Mile**
Road construction	**$**	**/Mile**

Road maintenance	**$**	**/Mile**
Prescribed burning	**$**	**/Acre**
Firebreak establishment	**$**	**Per Acre** or **per Hour***
Firebreak maintenance	**$**	**Per Acre** or **per Hour***
Precommercial thinning	**$**	**/acre**
Timber stand improvement	**$**	**/acre**

**Please circle one that applies.*

Part IV. Additional income from forestland

7. **Please estimate the percentage of forestland leased for hunting purposes by forest type and ecoregion in Georgia:**

	Pine	**Hardwoods**	**Mixed forest**
Blue Ridge Mountains	**%**	**%**	**%**
Piedmont	**%**	**%**	**%**
Upper Coastal Plain	**%**	**%**	**%**
Lower Coastal Plain	**%**	**%**	**%**
Georgia average	**%**	**%**	**%**

8. **Please indicate the typical annual hunting lease rate per acre by forest type in Georgia:**

Pine	**Hardwoods**	**Mixed forest**
$ **/ac**	**$** **/ac**	**$** **/ac**

9. **For the forest owner who provides hunting lease at rates indicated above, please estimate average annual costs per acre paid by the landowner:**

Pine	**Hardwoods**	**Mixed forest**
$ **/ac**	**$** **/ac**	**$** **/ac**

10. **Please estimate the percentage of longleaf pine used for collecting and selling pine straw in Georgia and average per ac annual income from the sale:**

Percentage of longleaf pine used for collecting and selling pine straw		**%**
Average annual income from pine straw	**$**	**/ac**

Part V. Trends in forest management practices in Georgia

11. Please comment on the following statements based on your observation of forest management practices in Georgia over the past 10 years.

Statement	Strongly disagree	Somewhat disagree	Have no opinion	Some what agree	Strongly agree
The usage of artificial regeneration has increased	☐	☐	☐	☐	☐
The usage of chemical release has increased	☐	☐	☐	☐	☐
The usage of prescribed burning has increased	☐	☐	☐	☐	☐
More landowners choose to plant pines after a clearcutting	☐	☐	☐	☐	☐
A very small percentage of landowners regularly collect income from selling pine straw	☐	☐	☐	☐	☐
A very small percentage of landowners regularly collect income from hunting lease on their forestland	☐	☐	☐	☐	☐
Forest management on hardwoods is mostly custodial (e.g., paying taxes and maintaining boundary)	☐	☐	☐	☐	☐
Other (Please specify:_____)	☐	☐	☐	☐	☐

12. Please use the space below for any additional comments you may wish to make.

Thank you for your time and effort!