REVENUE IMPLICATIONS OF GENETICALLY IMPROVED LOBLOLLY PINE SEEDLINGS AND BARRIERS TO ADOPTION AMONG FAMILY FOREST OWNERS IN GEORGIA

by

Matthew K. Pruitt

(Under the Direction of Puneet Dwivedi)

ABSTRACT

Genetic improvement programs have increased the productivity of loblolly pine (*Pinus taeda*) stands in the U.S. South over the past five decades, and adopting genetically advanced seedlings can translate into increased timber revenue for landowners. However, expert opinion suggests adoption of the more advanced genetics among family forest owners remains low. This study estimates potential gains in revenue from both timber and carbon resulting from adopting advanced genetics. It also explores potential barriers to adoption among landowners and foresters in the U.S. state of Georgia. Results suggest that adopting more genetically advanced seedlings could increase profitability via timber and carbon revenue. Still, the cost and uncertainty about the benefits of advanced genetics may be barriers to adoption. Additional evidence of the benefits of higher genetics, communicated to stakeholders through trusted sources, may be necessary to overcome those concerns and spur higher rates of adoption.

INDEX WORDS: open pollinated, controlled mass pollinated, timber revenue, afforestation, carbon storage

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MATTHEW K. PRUITT

BA, University of South Carolina, 1998

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MATTHEW K. PRUITT

Major Professor:	Puneet Dwivedi
Committee:	Daniel Markewitz
	Greg Colson

Electronic Version Approved:

Ron Walcott
Vice Provost for Graduate Education and Dean of the Graduate School
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CHAPTER 1

INTRODUCTION

The U.S. South is a highly productive region for timber. Though it contains 32.1% of the country's total forestland, it currently supplies 63.4% of total softwood (8.9 billion ft^3) and 52.4% of total hardwood (4.1 billion ft^3) nationwide (Oswalt et al. 2019). Loblolly pine (*Pinus taeda*) is integral to this productivity, accounting for 59.8 million acres of timberland and 20% of the above-ground biomass in the region (Oswalt et al. 2019). More specifically, planted loblolly pine is the centerpiece of Southern silviculture: the region contains 71% of the nation's planted timberland, with loblolly-shortleaf pine accounting for 71% of those planted forests.

Of the roughly 1.1 billion pine seedlings planted in the South annually (Tyson, 2018), nearly all of them are genetically improved (Rauscher and Johnsen, 2004). Genetic improvement in loblolly pine seedlings over the past several decades has been an important driver of increased productivity. Trees grown from genetically improved seedlings have been shown to produce more volume per acre and experience reduced rates of mortality (Li et al. 1999; Rousseau et al. 2015; Cumbie and De La Torre 2018). This increased productivity can translate into increased revenue potential and profitability for landowners, with estimated gains ranging from \$50/acre to \$300/acre (Rousseau, 2014; Bridgwater et al. 1998; McKeand et al. 2006). By one estimate, the present value to landowners in the U.S. South of continued improvement is greater than \$1.7 billion in aggregate (McKeand et al. 2021).

Along with the dominance of loblolly pine, another salient feature of forestry in the U.S. South is the prevalence of private ownership of forestlands. Most timberland in the South is under private ownership: family forest landowners and corporate landowners own about 58.3% and 28.2% of total forestlands in the southern states, respectively (Oswalt et al. 2019). Just as importantly, they supply between 50% and 60% of the total wood for industrial production in the region. With so much timberland under private ownership, the decisions of private forest owners, and family forest owners in particular, have the potential to shape the timber management practices of the region and exert significant influence on the direction of the industry.

The prevalence of loblolly pine, the longstanding efforts at genetic improvement of that species, and the importance of family forest owners in the U.S. South all provide essential context for the following research. This study was motivated by two important questions:

(1) Given the increased productivity of loblolly stands resulting from genetic gains, what are the implications for potential revenues from carbon payment schemes?

Previous studies have attempted to quantify the additional carbon sequestration that results from planting genetically advanced seedlings (e.g., Aspinwall et al. 2012), with no consideration of revenue from carbon payments schemes or conversely, examined the revenue potential of carbon payment schemes, with no consideration of the impact of planting genetically advanced seedlings. Only one study (Ahtikoski et al. 2020) was found that considered how genetically advanced seedlings might increase carbon revenues in conjunction with timber revenues; however, its geographic focus was not the U.S. South, and loblolly pine was not one of the species of interest. Thus, the first question addresses a critical gap in understanding the relationship between genetically advanced pine seedlings and carbon revenue potential. This study investigates the revenue implications of planting different genetic varieties of loblolly pine seedlings for both timber operations *and* carbon revenues.

(2) Why have the more genetically advanced seedlings not been adopted by family forest owners at a higher rate?

Expert opinion suggests that family forest landowners in the U.S. South are not adopting the more genetically advanced pine seedlings (i.e., controlled mass pollinated or clonal/varietals) at a high rate: their informal estimate is that these are planted on no more than 15%-20% of annually reforested family forest lands. As a result, these landowners are foregoing potential revenue and leaving their stands more susceptible to disease. Anecdotal evidence drawn from industry and landowner stakeholders suggests several explanations, but no published literature was found on the factors and motivations that influence the decisions of family forest owners related to planting the more genetically advanced seedlings. This study seeks to improve our understanding of family forest landowner knowledge and attitudes about genetically advanced seedlings and to probe some of the underlying factors in their decisions about what seedlings to plant. Because forestry consultants influence landowner decisions about which seedlings to plant, it is important to likewise understand their knowledge and attitudes in this area; as such, a parallel investigation of these forestry consultants is undertaken in this research. To make the scope of such a study practical and timely, this portion of the study focuses on the U.S. South state of Georgia.

The state of Georgia is representative of the prominent role of timber production in the South and reflects the importance of loblolly pine in the region. Georgia has 24 million acres of timberland, more than any other state, and one of the highest rates of planted timberland (32%). Of the 20.9 billion ft^3 of softwood growing stock on timberland in Georgia, 13.8 billion ft^3, or 66.3%, is in loblolly or shortleaf pine (Oswalt et al. 2019). As is the case elsewhere in the South, the overwhelming majority of timberlands in Georgia (89%) are privately held, with 55% of total forestlands under family forest ownership (Oswalt et al. 2019). Furthermore, as in neighboring states, the forestry industry is important to Georgia's economy, providing $4.4 billion in wages and salaries and $774 million in tax revenues (Georgia Forestry Commission, 2021). As such, Georgia can serve as a microcosm and rough proxy for the timber culture in the region. Combined, the two components of this study can help provide a complete picture of the revenue implications of planting more genetically advanced loblolly pine seedlings and improve our understanding of how family forest owners select seedlings for their land. As such, this research can inform future education and outreach efforts directed at landowners and future research about landowner behavior.

CHAPTER 2

POTENTIAL FOR ADVANCED PINE GENETICS TO INCREASE THE INCOME OF LANDOWNERS IN THE U.S. SOUTH WITH AND WITHOUT CARBON PAYMENTS

1. Introduction

1.1 Background

The total forestland in the 13 southern states is 245.5 million acres, i.e., 32.1% of the total forestland (765.5 million acres) in the United States (Oswalt et al. 2019). The southern states currently supply 63.4% of total softwood (8.9 billion ft^3) and 52.4% of total hardwood (4.1 billion ft^3) nationwide (Oswalt et al. 2019). Family forest landowners and corporate landowners own about 58.3% and 28.2% of total forestlands in the southern states, respectively (Oswalt et al. 2019). Out of 4.9 million family forest landowners in the southern United States, about 99% own less than 500 acres of forestland, amounting to 55.0% of the total forestland under family forestland ownership in the region (Oswalt et al. 2019). The family forest landowners supply between 50% and 60% (Zhang et al. 2005) of the total wood consumed for industrial production in the region, thereby supporting rural jobs, strengthening the regional economy, and promoting the bioeconomy.

The large supply of softwood from southern states can be attributed to two factors. First, the total area under loblolly (P. *taeda*) and slash (P. *Elliottii*) pine plantations has increased over the years and currently covers 41.2 million acres (Oswalt et al. 2019). Second, the productivity of loblolly and slash pine plantations, on average, increased from one ton/acre/year (natural regeneration) to eight tons/acre/year (Varietal seedlings) between 1920 and 2003 (Stanturf et al. 2003). This remarkable rise in productivity can be attributed to the development and the availability of genetically improved pine seedlings to all the forest landowners, including family forest landowners in the region, coupled with the development of related silvicultural treatments (Borders and Bailey, 2001; South and Rakestraw, 2002; Stanturf et al. 2003).

In the Southern United States, about 1.1 billion pine seedlings are planted each year (Tyson, 2018), and nearly every seedling is genetically improved (Rauscher and Johnsen, 2004). However, anecdotal evidence suggests that only 15% - 20% of the annual reforested land (between about 2 million and 2.67 million acres) is planted using genetically advanced pine seedlings (e.g., Controlled Mass Pollination [CMP] or Varietals),[1] whereas the remaining 85% is planted using seedlings from seeds which are mixtures of improved Open Pollinated (OP) families.[2] Conversations with organizations affiliated with industry and landowners indicate that most corporate forest landowners who own and manage large forestlands are planting CMP/Varietal seedlings, whereas family forest landowners mostly plant mixed OP seedlings or, even in a lot of cases, using natural regeneration for reforestation. The exact adoption rate of genetically advanced pine seedlings by family forest landowners is unknown as per personal communications with Dr. Scott Enebak (Director of Southern Forest Nursery Management Cooperative at the School of Forestry and Wildlife Sciences, Auburn University), Ms. Diane Haase (United States Department of Agriculture Forest Service & Editor of The Planter's Note, https://rngr.net/), Dr. Rafael De la Torre (Manager, ArborGen, Inc.) and Mr. Jeff Fields (Chief of Restoration, Georgia Forestry Commission). Nevertheless, experts agree that the adoption rate of genetically advanced pine seedlings among family forest landowners cannot be more than 15%-20% based on their current and past experiences. If this adoption rate could be increased, then significant gains in productivity and disease resistance could be achieved at the regional level.

The existing literature indicates that reforestation using genetically advanced pine seedlings significantly increases the overall profitability of a forest landowner due to the higher growth rate of

[1]Seeds for Controlled Mass Pollination (CMP) are prepared by placing pollen isolation bags over female flowers of an improved parent before they become receptive to pollen, then injecting the isolation bags with pollen from another improved parent or mix of parents when the female flowers in the isolation are receptive (White et al. 2017).
[2] Seeds for Open Pollinated (OP) seedlings are obtained from tested (for desired characteristics) female flowers who were fertilized by the pollen of unknown male trees through open wind pollination without any control. OP seedlings come from open-pollinated seed orchards and are known as half-sibs since only the mother is known (Rousseau, 2014).

CMP/Varietal seedlings. Rousseau (2014) showed that the net present value increases by $239/acre between OP (3rd generation seedlings) versus CMP (2nd generation seedlings) in Mississippi. Bridgwater et al. (1998) showed that the net present value could range between $108 and $154/acre with CMP loblolly pine seedlings obtained from seed orchards in the Western Gulf Forest Improvement Program. McKeand et al. (2006) reported that forest landowners could realize the net present value of $50 to over $300/acre across a range of productivity and silvicultural management regimes by planting the best genotypes currently available from commercial and state forest nurseries. Studies have also found that diseases affect the profitability of southern pines. Bridgwater and Smith (1997) found that stumpage values for a pulpwood management scheme (final harvest at age 25) declined approximately linearly at about 2%-2.5% per 10% increase in stem rust infection (at age 5) to 80%-84% of the value of a stand with 10% or less rust, thereby suggesting that the use of genetically advanced seedlings could help in increasing the profitability of a loblolly pine stand due to reduction in disease-related catastrophic risk. Cubbage et al. (2000) showed that compounded fusiform rust research cost $49 million in 1992 and returned discounted benefits to plantation owners between $108 and $999 million in 1992, thereby generating benefit-cost ratios of about 4:1 to 6:1 at a regional level.

1.2 Climate Change and Forestlands

The most recent report from the Intergovernmental Panel on Climate Change (IPCC) concludes that climate change driven by anthropogenic activity is already having adverse impacts on both people and nature. A primary concern is the increased frequency and intensity of extreme weather, which has repercussions for both natural ecosystems and human infrastructure, including adverse impacts on terrestrial, freshwater, and marine ecosystems; food and water security; human health; and economic stability (IPCC 2022). Furthermore, the IPCC report predicts that without intensive intervention, adverse impacts will only become more severe, noting the potential for compounding impacts and cascading effects as these climate risks overlap and interact. Other consequences include reductions in Arctic Sea ice and permafrost and subsequent sea level rise. These impacts are predicted to become more severe in proportion to the incremental increase in global temperature; avoiding the worst of these consequences will require large-scale reductions in atmospheric CO_2 and other greenhouse gases (IPCC 2022).

Mechanisms for effecting such reductions will have greater impacts if they are cost-effective, employ technology that is existing or ready to implement, and have relatively few barriers to adoption. Forestry practices, part of a larger suite of strategies the IPCC categorizes as Agriculture, Forestry, and Land Use (AFOLU), can be employed to reduce atmospheric CO_2 utilizing 'technology' that is already in use. The IPCC's report from Working Group III notes that AFOLU mitigation strategies are effective and widely deployable and that the AFOLU sector holds the greatest potential for short-term, large-scale removal of atmospheric CO_2 (Nabuurs et al. 2022). Likewise, in its annual inventory of GHG, the United States Environmental Protection Agency continues to identify forest carbon sequestration as an important sink for carbon as the Land Use, Land-Use Change, and Forestry sector produced carbon offsets equivalent to 13.6% of gross greenhouse gas emissions in 2020, 91% of which is attributable to sustaining and expanding forested lands nationwide (USEPA 2022).

1.3 Rise of Carbon Markets

The total value of global carbon markets continues to grow steadily (Environmental Finance 2020; Chestney 2022), and while compliance markets still dominate the landscape, financial analysts predict strong growth in voluntary carbon markets in the coming decade, with demand for carbon credits potentially increasing up to 15 times relative to 2020 levels (GIC et al. 2021). Forest carbon projects are popular in the compliance market—for instance, they comprise 80% of the offsets issued by California's Air Resource Board (2022; Haya 2019)—as well as in the voluntary market, where they are helping to drive current growth (Forest Trends' Ecosystem Marketplace 2021). Opportunities for forest projects in both of these markets are predicted to increase: although offsets based on avoided carbon emissions are gaining in popularity, buyers and brokers continue to place value on projects based on carbon capture (O'Kelly 2022; Research and Markets 2021). The growth in voluntary markets could present opportunities for increased participation by private forest landowners, especially as new verification methodologies are developed with greater accessibility for family forest landowners in mind—e.g., the Dynamic Matched Baselines methodology developed through the Family Forest Carbon Program and recently approved by Verra under its VCS standard (Verra, 2022b).

1.4 Carbon Markets and Advanced Genetics

Participation in voluntary carbon markets can provide revenue for landowners while advancing carbon sequestration and, in some cases, yielding co-benefits for local ecosystems. Increased productivity due to advanced genetics leads to more carbon sequestration on stands. This additional carbon can potentially be monetized in emerging carbon markets. However, existing studies have not incorporated considerations of advanced genetics into their analysis of potential carbon revenues (e.g., Nepal et al. 2012; Huang et al. 2004; Shrestha et al. 2015). It is critical to investigate the role that using genetically advanced seedlings can have on carbon payments and, in turn, on the overall forest stand profitability of family forest landowners. Increased revenue potential from carbon payments could possibly facilitate large-scale adoption of advanced genetics since payments from carbon markets could offset the higher cost of advanced genetics seedlings.

1.5. Goal and Objectives

While revenue is not the lone driver of decisions to participate in carbon payment programs, demonstrating revenue potential is an essential step in the process. The type of seedling that landowners plant during afforestation or reforestation has revenue implications not only related to timber but also for carbon payments since generating a higher volume of wood over a given period means storing more carbon. Reluctance to adopt genetically advanced seedlings may unnecessarily limit the profitability of forest carbon projects and, consequently, the overall revenue potential of the land. At the same time, increased adoption could provide a higher revenue ceiling resulting from the combination of timber and carbon revenues.

The goal of this study is to investigate the revenue implications of planting different genetic varieties of loblolly pine seedling, both for timber operations and carbon payments. Our objectives include (1) to estimate the differences in potential timber revenue among stands planted with different seedling types; (2) estimate the differences in potential carbon revenue among stands planted with different seedling types; and (3) estimate the potential gains resulting from adding carbon revenue to timber revenue for each seedling type.

We compare estimated revenues resulting from different types of advanced genetic seedlings, considering income from both traditional sources (timber and hunting licenses) as well as carbon payments. We estimate predicted timber revenues for three seedling types: an open-pollinated variety serving as the control ("OPC"); an improved open-pollinated variety ("OPE"); and a controlled mass-pollinated seedling ("CMP"). Each seedling type is assigned a corresponding Site Index that serves as a proxy for genetic gain: SI65 for the OPC; SI73 for the OPE; and SI81 for the CMP. We also estimate potential carbon revenues associated with each seedling type. We report the expected difference in revenues from timber alone, carbon alone, and the combination of timber and carbon revenue.

2. Methods

Estimations for the growth and yield of timber products, along with the carbon content of the timber stand, were generated using a model for loblolly pine from the University of Florida's Carbon Resource Science Center (University of Florida 2016). We used site index (SI) at a base age of 25 years as a proxy for seed genetics, following McKean (2006), Li (1999), Talbert (1985). Specific site index values associated with each seedling type came from ArborGen, based on measurements of trees grown from each seedling variety taken at six years, then matched to a corresponding site index using data from SiMS: SI65 for the open-pollinated seedling that represented the control ("OPC"); SI73 for an advanced variety of open-pollinated seedling, referred to as "open-pollinated elite" ("OPE"); and SI81 for an advance variety of controlled mass-pollinated seedling referred to as “controlled mass-pollinated elite” (“CMPE”).[3] For each site index, we assumed planting on bare ground at a density of 605 seedlings per acre, with herbaceous weed control applied in Year 1 and fertilizer (N at 250 lbs/acre, P at 25 lbs/acre) applied in Year 2.

In calculating overall revenues from timber and carbon, we assumed a 200-acre stand. This acreage was meant to reflect a holding more typical of a family forest landowner than large-scale industrial forest landowners. Recent developments in carbon accounting standards designed to offer fewer barriers to entry for forest projects—e.g., SilviaTerra and Family Forest Carbon project –could make parcels such as these more viable for participation in the carbon market. We provide revenues on a per acre basis to facilitate comparison among different stand sizes. In estimating carbon revenues, we assumed a 25-year carbon project with a full harvest at the end of the project period.

2.1 Costs of silvicultural practices

Cost estimates for timber operations were based on a survey of costs of forestry practices in the Southeast (Maggard 2021), specifically those associated with planting loblolly pine in the southern coastal plain. All silvicultural costs are reported in Table 2.1. The costs of seedlings were derived from a 2019/2020 ArborGen price catalog and were based on cost per 1,000 bareroot seedlings. At 605 seedlings/acre, the costs are as follows: OPC = $37.51/acre; OPE = $52.03/acre; and CMPE = $141.57/acre.

Item	**Cost per acre**	**Timing**
Site prep - chemical	$73.16	Year 0
Site prep - mechanical	$131.44	Year 0
Hand Planting	$72.60	Year 0
Herbaceous weed control	$53.80	Year 1
Fertilizer	$83.79	Year 2
Tax	$5	Annual
Administration/Management	$5	Annual

Table 2.1. Per acre costs of establishing a loblolly pine stand, plus associated annual costs.

[3] We do not report the estimates for varietals/clonals because they were assigned the same Site Index (81) in the ArborGen modeling but cost significantly more than the OPE or CMP seedlings. As a result, they were less profitable in each scenario, and reporting the details seemed unlikely to add value to the analysis.

2.2. Costs of forest carbon projects

Estimates for costs associated with securing carbon payments were largely based on the fee schedule for participation in the Verified Carbon Standard (VCS) program administered by Verra (Verra 2022a). VCS is a widely used standard for forest carbon projects and the framework under which the Family Forest Carbon project developed its carbon accounting methods. Fees for VCS included: a) an account opening fee of $500, b) a registration fee of 10% of the estimated annual volume of emission reductions (in tonnes CO_2e), and c) an issuance levy, assessed annually, calculated at 5% of the volume of VCUs (1 VCU = 1 tonne of CO_2e). Additionally, we include in the analysis costs associated with developing a forest carbon project. We calculate project development costs as a percentage of the revenue from carbon payment, assuming that project development will cost 30% of project revenues. Finally, the costs of the carbon project include the costs of replanting in Year 26 (following the timber harvest) so that the project satisfies the permanence requirement for carbon sequestration projects.

2.3 Revenue from timber operation

Timber prices ($11/ton PW; $19/ton CNS; $28/ton ST) were estimated using publicly available resources that provide price data and trends for timber sales in the Southeast (TimberMart-South, TimberUdpate). While timber prices fluctuate and can vary widely with location, these prices approximate recent price trends for the regions. Timber prices were held constant under each scenario. We also assumed an income of $10/acre per year for hunting leases.

2.4 Revenue from carbon payments

To estimate carbon payments, we largely followed calculation methods employed by Verra under its VCS standard (VCS Association 2011). Our hypothetical scenario would fall under requirements for Afforestation, Reforestation, and Revegetation activities, one of Verra's AFOLU project categories (Verra 2023). Our scenario assumes afforestation on pastureland, with a project period of 25 years and a baseline level of CO_2 of 3.67 tons/acre.

We first estimated the Expected Total Benefit (ETB), i.e., the total CO_2 sequestered as a result of the project activities. This was done by subtracting the baseline level of CO_2 from the annual level of estimated CO_2 in the stand (provided by the growth and yield model), and then summing these annual differences to get the ETB over the 25-year period. Since the G&Y model's output is in C, this required converting to CO_2 using a multiplier of 44/12.

We then used the ETB to calculate the Long-term Average Benefit (LAB), which provides an average amount of carbon stored over the life of the product. The LAB is simply the ETB divided by the number of years in the project. We assumed a harvest of all standing stock at the end of the project period, so following guidance provided by Verra (VCS 2011), a "zero year" in Year 26 was included in the long-term average. The ETB and LAB play a central role in determining the payment schedule, as the project is only eligible to receive payments in those years where the Expected Total Benefit to date is less than or equal to the Long-term Average. The implication of this provision is that all revenue from a carbon project may be received well before the end of the project period—for example, by Year 12 of a 25-year project.

Using the estimates for year-by-year CO_2 storage provided by the growth and yield model, we calculated the annual change in CO_2 stored on the stand. This provides the basis for determining the monetizable CO_2, as landholders are only compensated for the additional CO_2 sequestered year-over-year. We assumed that landowners would be compensated for only 90% of this monetizable amount; the other 10% serves as part of a required buffer pool designed to mitigate the risk of loss or reversal (i.e., damage to or destruction of trees that results in carbon being released, as in the case of trees lost to fire, disease, pests, or storms).

We assumed that payments would start in Year 2 of the project and then be issued every four years until the terminal year, identified as the last year in which the estimated total benefit to date exceeded the long-term average for the contract period. In addition, we assumed a final "resolution" payment in that terminal year, which could come sooner than the standard four-year interval.

For our simulation, income from CO_2 was calculated by first converting tons of monetizable CO_2 into metric tons to conform with standard practice for carbon payment projects, where metric tons of CO_2e

(t CO_2e) is the relevant unit of compensation. The initial price of carbon was assumed to be $6/tonne, with a price increase of 3% per year. Prices for carbon projects can vary widely by year and based on whether they are part of compliance or voluntary markets; likewise, estimates of average prices vary depending on the specific data used by the source reporting them. The value used here is an approximation selected following a survey of publicly available sources (Colorado School of Mines 2022; Opanda 2022; The World Bank 2022).

2.5 Mechanisms for Analyzing and Comparing Profitability

For both the timber operation and carbon payment scenarios, costs and income were converted to present value:

$$PV = FV / (1+r)^t$$

where PV is present value, FV is future value, r is the discount rate, and t is the period (number of years from the present). The discount rate was held constant at 6% for all scenarios. Net Present Value (NPV) was calculated for each year in the study period by subtracting the present value of costs from the present value of revenue.

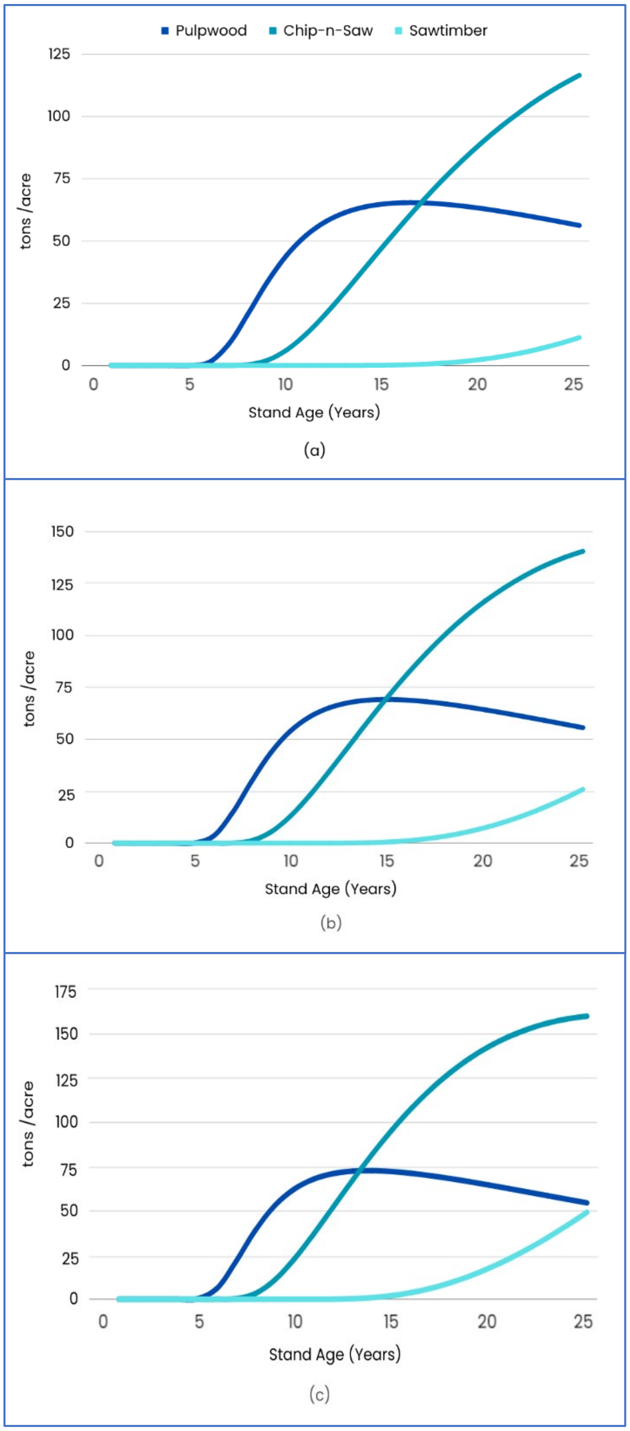
Note that for timber operations, NPV in Year 25 is the relevant statistic, but for carbon payments, we look at Year 26, due to the carbon accounting techniques referenced above.

3. Results

3.1 Growth and Yield by Seedling Variety

Over the simulated 25-year period, the stands planted with the more genetically advanced seedlings are predicted to produce higher volumes of timber in both the chip-n-saw and the Sawtimber category when

Figure 2.1. Growth and yield estimates for three types of loblolly pine seedlings over a 25-year growth period. Each seedling is assigned a different Site Index as a proxy for genetic gains: (a) OPC (SI65); (b) OPE (SI73); and (c) CMP (SI81)



compared to the open-pollinated control. The advanced seedlings also produce more pulpwood mid-rotation relative to the control, though the pulpwood quantities converge at the end of the period. See Fig. 2.1

3.2. Financial Returns from Timber Operations

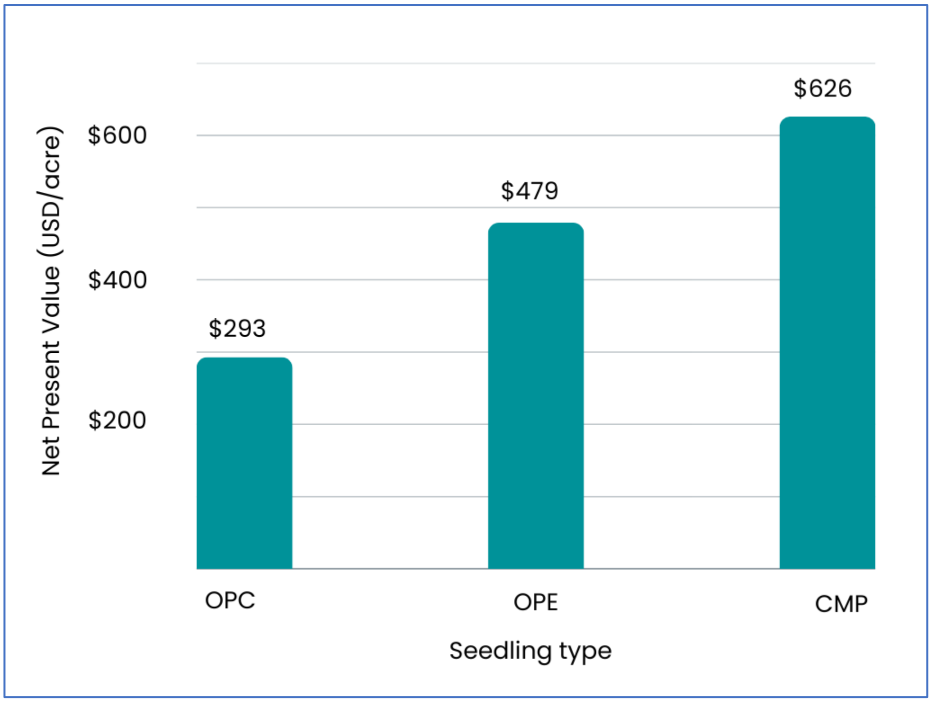
The increased volume of timber predicted from the use of advanced genetic seedlings corresponds to higher financial returns for each variety relative to the control. The comparison of financial returns from timber for the three seedling varieties is summarized in Fig. 2.2.

Predicted NPV per acre for the improved open-pollinated seedling is 64% higher than the control and 114% higher for the controlled mass-pollinated seedling.

3.3 Financial Returns for Carbon Payments

Over the 25-year simulation period, a stand planted with the more genetically advanced seedlings is expected to store more carbon than one planted with the open-pollinated control.

Figure 2.2. Estimated net present value from timber operations, based on stands planted with three different genetic varieties of loblolly pine seedling over a 25-year rotation period.



Specifically, the improved open-pollinated (OPE) stand is predicted to sequester 18% more carbon than the control and the controlled mass-pollinated stand 37% more than the control. See Fig. 2.3.

In our calculations, the Expected Total Benefit exceeds the Long-Term Average Benefit in Year 12, so no carbon credits are available beyond that year. A final resolution payment would be made in Year 12. See Fig. 2.4.

As with timber revenues, the increased volume of wood predicted for stands planted with advanced genetic seedlings corresponds to higher financial returns for each variety relative to the control.

The predicted NPV of carbon payments resulting from planting the improved open-pollinated seedling is 21% percent higher than the control and 38% higher for controlled mass-pollinated seedlings. See Fig. 2.5

Figure 2.3. Estimated carbon storage per acre on stands planted with three different genetic varieties of loblolly pine seedlings. OPE and CMP seedlings are expected to store 18% and 37% more carbon compared to the control, respectively.

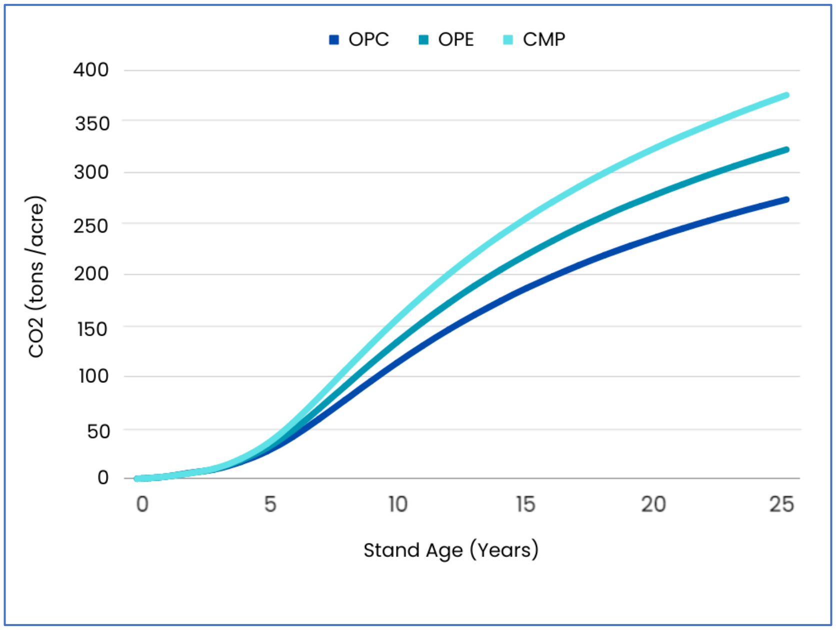


Figure 2.4. Intersection of estimated Expected Total Benefit (total C stored over project period) and Long-term Average (ETB divided by number of years in the project). Carbon payments are issued only for years in which LTA > ETB.

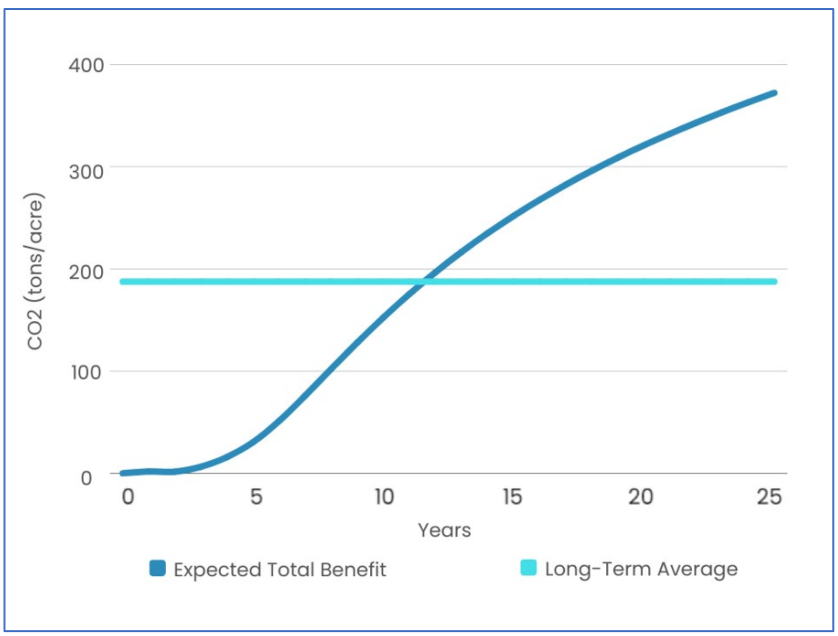
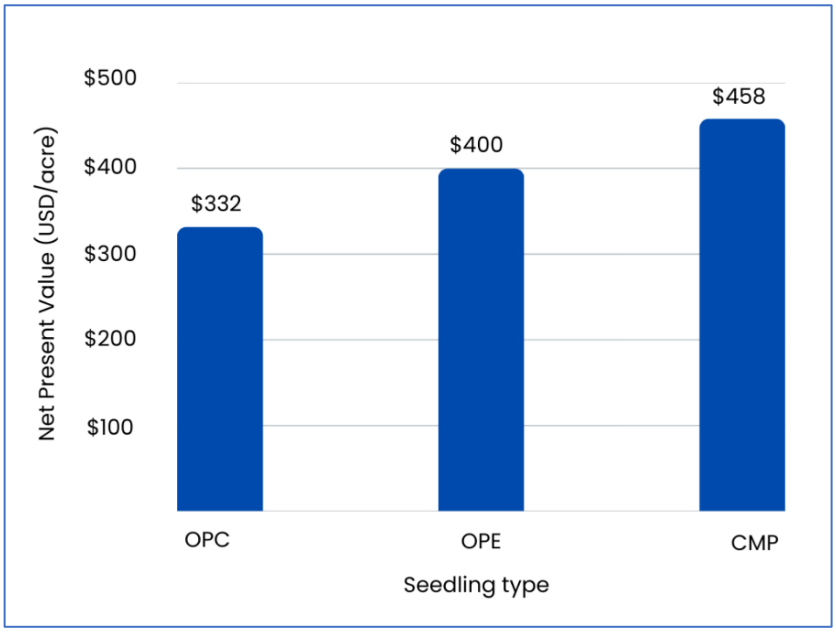


Figure 2.5. Estimated net present value from carbon payments over a 26-year period, based on stands planted with three different genetic varieties of loblolly pine seedling.



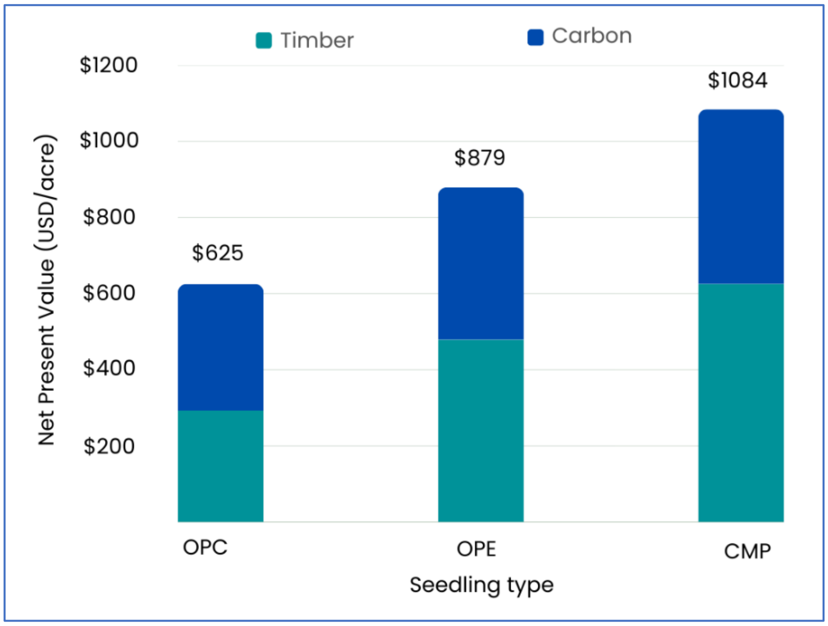
3.4 Financial Returns from Combined Timber and Carbon Revenues

The estimates for combined timber and carbon revenue follow the same pattern for the individual revenue sources: each advanced genetics seedling results in higher NPV. However, we report them here to demonstrate the income potential for combined revenues and further highlight the expected differences resulting from seedling choice. Fig. 2.6 summarizes the estimates for combined revenues.

Predicted NPV per acre for the combined timber and carbon revenues is 41% higher for the stand planted with improved open-pollinated seedling compared to the control and 73% higher for the controlled mass-pollinated seedling.

We note that, regardless of seedling type, the addition of carbon payments increases the overall revenue significantly in each case. Predicted NPV per acre for the control is 113% higher with carbon payments than with timber revenues alone; 84% higher for the advanced open-pollinated seedling; and 73% higher for the controlled mass-pollinated seedling.

Figure 2.6. Estimated net present value from combined timber and carbon income over a 25-year period, based on stands planted with three different genetic varieties of loblolly pine seedling.



3.5 Sensitivity Analysis

Table 2.2 summarizes the sensitivity of the revenue estimates to changes in key inputs. In each case, one variable of interest was altered while all other inputs were held constant. In analyzing the impact of changes in timber revenue, the prices for all product classes were increased or decreased simultaneously.

Estimated NPV for stands planted with OPC seedlings showed the greatest sensitivity to changes in timber prices and discount rate, while NPV for those planted with CMP showed the least responsiveness to changes in either variable. Across all estimates for timber revenues, changes in the discount rate had the most significant impact.

Estimates of carbon revenues were less responsive to changes in price or discount rate relative to estimates of timber revenues. Size of holding did not impact estimates of timber revenues but did affect carbon revenue estimates. When compared to a baseline stand of 200 acres, smaller stands were estimated to yield lower carbon revenues. Again, the CMP stands showed less deviation from the baseline but notably did show the greatest potential gains as stand size increased.

	OPC	+/-	OPE	+/-	CMP	+/-
TIMBER REVENUE						
Baseline NPV/acre	$293	-	$479	-	$626	-
Timber price +10%	$366	*24.9%*	$573	*19.6%*	$743	*18.7%*
Timber price -10%	$220	*-24.9%*	$386	*-19.4%*	$509	*-18.7%*
Discount rate 4%	$736	*151.2%*	$1,045	*118.2%*	$1,336	*113.4%*
Discount rate 7%	$142	*-51.5%*	$286	*-40.3%*	$383	*-38.8%*
CARBON REVENUE						
Baseline NPV/acre (200 ac)	$333		$400		$458	
Carbon Price +10%	$374	*12.3%*	$448	*12%*	$514	*12.2%*
Carbon Price -10%	$293	*-12%*	$352	*-12%*	$402	*-12.2%*
Discount rate 4%	$354	*6.3%*	$430	*7.5%*	$489	*7%*
Discount rate 7%	$320	*-3.9%*	$382	*-4.5%*	$439	*-4%*
25 acres	$314	*-5.7%*	$382	*-4.5%*	$441	*-3.7%*
50 acres	$324	*-2.7%*	$392	*-2.0%*	$451	*-1.5%*
100 acres	$329	*-1.2%*	$397	*-0.8%*	$456	*-0.4%*
500 acres	$333	-	$401	*0.3%*	$460	*0.4%*
1500+ acres	$334	*0.3%*	$402	*0.5%*	$461	*0.7%*

Table 2.2. Summary of sensitivity analysis testing how NPV/acre responds to changes in timber price, carbon price, discount rate, and size of holding (carbon revenues only). Variables of interest were changed one at a time while all other inputs were held constant at the baseline level.

4. Discussion

The results of our analysis support previous findings that landowners could see significant increases in profitability from timber production by adopting advanced genetic seedlings. Our estimates suggest that the more advanced seedlings would result in more profitable stands relative to the control in each case. This will be particularly true as the price differential between open pollinated and controlled mass-pollinated seedlings continues to fall.

The primary limitations of this study stem from the variability of the inputs and parameters. Different growth and yield simulators might produce different quantities of timber and carbon under a given set of inputs. Timber prices vary not only temporally but by region and even by areas within a state. Carbon prices vary widely not only temporally but also by project type and market type. Likewise, carbon accounting procedures vary by the specific standard employed; in particular, the different methods for determining baseline carbon storage can have a significant impact on the amount of monetizable carbon that a project yields. The variability in these key factors may limit how broadly these findings can be generalized. Furthermore, we note that the growth and yield models represent averages, not guarantees of performance, and that our calculations are based on a full harvest with no significant loss event (e.g., fire, weather, etc.). Finally, these results apply only to afforestation scenarios; a separate analysis would be required for reforestation scenarios, as the baseline for carbon storage would be different.

Our study raises new considerations regarding adoption of genetically advanced pine seedlings in the South, namely the impact on potential carbon revenues. Previous studies have examined either the carbon sequestration potential of genetically advanced seedlings or the added revenue potential from carbon payments in general, but not the potential impact of advanced genetics on carbon revenue. Aspinwall et al. (2012) attempted to quantify the overall carbon sequestration resulting from decades of planting advanced genetics loblolly pine seedlings in the Southeast but did not analyze the revenue implications. Conversely, McKeand et al. (2021) estimated the economic value of tree improvement efforts for loblolly pine and their deployment to landowners in the U.S. South but did not factor in potential carbon revenues.

Multiple studies have analyzed how carbon revenues might impact bottom-line profitability for loblolly pine stands, either in isolation or in conjunction with timber revenues, but with no reference to genetically advanced varieties (e.g., Nepal et al. 2012; Huang et al. 2004; Shrestha et al. 2015). Other studies have examined how the presence of carbon payments might impact forest management practices, e.g., how landowners might manage to optimize both timber and carbon revenues, but these did not account for the role of advanced genetics (see, for instance, Huang et al. 2006; Clay et al. 2019; Kolo et al. 2020). Ahtikoski et al. (2020) examined how planting genetically advanced seedlings might impact carbon revenue in combination with timber revenues, but the geographic focus was Finland, and the tree species of interest were Scots pine, Norway spruce, and others suited for the region (e.g., birch). We found no published studies applying this lens to loblolly pine in the Southeast.

We demonstrate that adopting advanced genetic seedlings could also have implications for revenue from carbon payments in afforestation scenarios. The more genetically advanced seedlings are expected to generate a higher volume of wood over a given period than the control and in turn, are assumed to capture a higher volume of sequestered carbon. Ahtikoski et al. (2020) note that the gains in growth from genetic selection may be accompanied by decreased density. However, they add that lignin concentrations are a key factor in carbon capture and that these concentrations are likely to be as high or higher in genetically advanced seedlings that in non-improved stock. (The rationale is that lignin concentrations are higher in earlywood, and gains in growth from genetic improvement are attributed largely to a higher proportion of earlywood production.) Thus, they reason that any decreases in density may be offset by increased lignin concentrations and, as such, find it reasonable to assume that increased growth from genetic gains results in increased carbon storage.

As with timber, our analysis indicates that each variety of advanced genetic seedlings would result in greater potential for carbon payment revenue relative to the control. Given that the literature shows concerns about income to be an important factor for landholders considering entry into carbon markets, the relative profitability of each seedling type may inform their decision-making. As voluntary carbon markets grow and carbon standard developers seek to develop standards that allow greater access to family forest owners, the amount of carbon sequestered on a stand could become increasingly relevant to a broader spectrum of landholders.

Finally, the type of seedling planted could have implications for combined revenue from timber production and carbon payments. As landowners seek to maximize the profitability of their land, understanding the potential for carbon payments to augment their timber income and the ways in which seedling choice can impact overall profitability will be of increasing utility.

5. Conclusion

Our analysis suggests that landowners planting pine, especially family forest owners, might be foregoing revenue by not adopting the best available seedling genetics, whether they engage in timber production, carbon markets, or a combination of the two. If voluntary carbon markets grow as predicted, the potential for lost opportunity related to carbon revenue is likely to increase.

Efforts to increase the adoption rate of genetically advanced seedlings could yield financial benefits not just for individual landowners but also for the forest industry in the Southern region. Such efforts would require a better understanding of how those who purchase seedlings—whether landowners or foresters—make their decisions and why they have not adopted genetically advanced seedlings at a higher rate. Given the revenue implications of seedling adoption, it will be important to understand why adoption rates remain low and what structural barriers or specific concerns among landowners are preventing more widespread adoption.

CHAPTER 3

KNOWLEDGE AND ATTITUDES ABOUT GENETICALLY ADVANCED LOBLOLLY PINE SEEDLINGS AMONG FORESTERS AND FAMILY FOREST OWNERS IN GEORGIA

1. Introduction

1.1 The importance of family forest owners in Southern forestry

There are an estimated 272 million acres of family forest land in the United States, accounting for 39 percent of all forest land, the largest ownership category. The U.S. South contains a disproportionate amount of that total, with nearly 148 million acres (54%) of the nation's family forest land. Family forest lands make up 56% of total forestlands in the southern states (Butler et al. 2021).

Family forest owners not only own most of the forestland in the south; they also play a critical role in the region's timber productivity. The southern states currently supply 63.4% of total softwood (8.9 billion ft^3) and 52.4% of total hardwood (4.1 billion ft^3) nationwide (Oswalt et al. 2019). Family forest landowners supply between 50% and 60% (Zhang et al. 2005) of the total wood consumed for industrial production in the region.

Georgia is one of the most productive states for timber in the nation, harvesting 1.2 billion ft^3 for softwood products annually (Lambert et al. 2023). The forestry industry is integral to Georgia's economy, providing 55,418 jobs, $4.4 billion in wages and salaries, and $774 million in tax revenues (Georgia Forestry Commission, 2021). In a state where forestry is a key economic driver, an estimated 13.3 million acres are under family forest ownership, comprising 54% of total forestlands in the state (Butler et al. 2021).

1.1.2 The relationship between forest professionals and family forest owners

When family forest owners seek professional help in managing their lands, private forestry professionals are an important source of information and guidance on a wide array of topics. Results from a survey of family forest owners in the Southeast indicate that an estimated 45% of family forest owners, accounting for 59% of the acreage held by respondents, received advice on the management of their lands. Of those who did, 68% of them indicated “Private consultant” as a source of advice. By comparison, “State” and “Extension” were cited as a source by 42% and 34% of those who had received advice, respectively. (Butler et al. 2021). When asked about their preferred method for getting assistance with managing their land, 44% of family respondents chose “Talk to Expert,” higher than any other choice besides “Written material” (53%). Of family forest owners who said they had a forest management plan, 46% said the plan was written by a private forestry consultant; the second highest response was from a state forester, with 27% (Butler et al. 2021). In a survey of attitudes about climate change among family forest owners in the Southeast, respondents chose “Consultants” as a source of forestry information at a rate as high or higher than all other sources, including “Friends and Relatives” and “State Agencies” (Khanal et al. 2016).

Survey data specific to family forest owners in Georgia show similar patterns: 43% of respondents said they had received advice on managing their lands in the past five years; of those, 68% indicated “Private Consultant” was a source, whereas 50% selected “State” and 25% “Extension” (Butler et al. 2021). While only a quarter of respondents said they had a management plan, a plurality of those who did (43%) indicated it was written by a private forestry consultant.

1.2 Adoption of Genetically Advanced Pine Seedlings

In the Southern United States, about 1.1 billion pine seedlings are planted each year (Tyson, 2018), and nearly every seedling is genetically improved (Rauscher and Johnsen, 2004). However, expert opinion suggests that only 15%-20% of the annual reforested land (about 2 million – 2.7 million acres) is planted using genetically advanced pine seedlings (e.g., CMP or Varietals), whereas the rest is planted using seedlings from seeds that are mixtures of improved OP families. Conversations with organizations affiliated with industry and landowners indicate that most corporate forest landowners who own and manage large forestlands are planting CMP/Varietal seedlings, whereas family forest landowners are mostly planting mixed OP seedlings or, in many cases, using natural regeneration for reforestation. The exact adoption rate of genetically advanced pine seedlings by family forest landowners is unknown, as per personal communications with Dr. Scott Enebak (Director of Southern Forest Nursery Management Cooperative at the School of Forestry and Wildlife Sciences, Auburn University), Ms. Diane Haase (United States Department of Agriculture Forest Service & Editor of The Planter's Note, https://rngr.net/), Dr. Rafael De la Torre (Manager, ArborGen, Inc.) and Mr. Jeff Fields (Chief of Restoration, Georgia Forestry Commission). Nevertheless, experts agree that the adoption rate of genetically advanced pine seedlings among family forest landowners cannot be more than 20% based on their current and past experiences. Given the potential to increase profitability and reduce the risk of disease-related mortality, it is unclear why the adoption rate is not higher.

1.3 Benefits of Genetically Advanced Pine Seedlings

The existing literature indicates the use of genetically improved pine seedlings significantly increases the productivity of a timber stand. Li et al. (1999) reported that trees grown from seeds obtained from first-generation seed orchards have produced between 7% and 12% more volume per acre at harvest than trees grown from wild seeds, whereas a gain of between 13% and 21% is expected in volume per acre from the seeds obtained from the second-generation seed orchards relative to unimproved seed lots.

More genetically advanced seedlings, such as controlled mass pollinated or clonal/varietals, can offer even greater gains in volume as well as other benefits. The evidence suggests that controlled mass pollinated (CMP) seedlings have higher growth rates relative to most open pollinated (OP) seedlings available to family forest landowners. Rousseau et al. (2015) reported that the CMP families at Age 6 significantly outperformed the second-generation OP family for both diameter and volume in Mississippi. Cumbie and De La Torre (2018) reported that Family CP-1 (a CMP) exhibits a growth rate of 8.3 tons/acre/year compared to the relevant OP1 famil which showed a growth rate of 6.7 tons/acre/year at the age of 20 years in Berkeley County, South Carolina.

The use of genetically improved pine seedlings also helps in reducing mortality caused by diseases that attack pine plantations. One such disease is fusiform rust, which is caused by the fungus *Cronartium quercuum* f. sp. *fusiforme (Cqf)*, as it leads to rust galls or cankers on the main stem and/or branches of trees. It is the most damaging disease of pine forests, occurring in a band across the Southern United States as shown in Figure 3.1 (Cowling and Randolph, 2013). Li et al. (1999) stated that genetically improved seedlings had lower incidences of fusiform rust than the seeds obtained from unimproved seed lots, ranging between 20% and 25%.

Importantly, these gains in productivity and disease resistance translate into significant increases in the overall profitability for a forest landowner. A recent study estimated that the

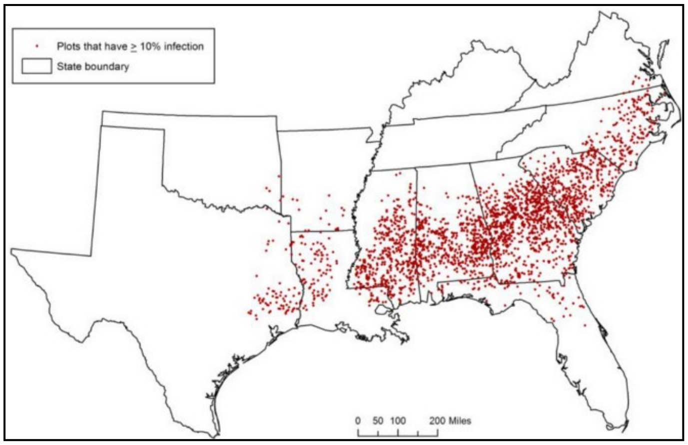


Figure 3.1: Location of Forest Inventory and Analysis (FIA) plots with the loblolly pine forest type and >10% fusiform rust infection on trees at least 5.0 inches diameter at breast height. Reproduced from Cowling and Randolph, 2013.

present value of improved loblolly pine genetics realized by landowners is over $1.7 billion in the U.S. South (McKeand et al. 2021). Rousseau (2014) showed that the net present value increases by $239/acre between OP (3rd generation seedlings) versus CMP (2nd generation seedlings) in Mississippi. Bridgwater et al. (1998) showed that the net present value could range between $108 and $154/acre with CMP loblolly pine seedlings obtained from seed orchards in the Western Gulf Forest Improvement Program. McKeand et al. (2006) reported that forest landowners could realize the net present value of $50 to over $300/acre across a range of productivity and silvicultural management regimes by planting the best genotypes currently available from commercial and state forest nurseries. Studies have also found that diseases affect the profitability of southern pines. Bridgwater and Smith (1997) found that stumpage values for a pulpwood management scheme (final harvest at age 25) declined approximately linearly at about 2%-2.5% for every 10% increase in stem rust infection (at age 5). These losses translate into stumpage values of 80%-84% of a stand with 10% or less rust. This suggests that the use of genetically advanced seedlings could help in increasing the profitability of a loblolly pine stand by reducing disease-related catastrophic risk. Cubbage et al. (2000) showed that cumulative fusiform rust research cost $49 million in 1992 and returned discounted benefits to plantation owners between $108 and $999 million in 1992, thereby generating benefit-cost ratios of about 4:1 to 6:1 at a regional level.

These revenue estimates are based only on timber revenues and do not account for any potential revenue from carbon payments. Intuitively, stands that have higher growth rates would store more carbon over a given period, and there may be potential for genetically advanced seedlings to increase the potential revenue from carbon payments, though the issue has not been studied extensively.

Consultations with organizations representing industry and landowner stakeholder groups suggest several factors that might contribute to the low adoption rate of genetically advanced pine seedlings. These include higher relative costs of genetically advanced pine seedlings, lack of knowledge about the availability of genetically advanced pine seedlings or uncertainty about their benefits, apprehensions related to learning new technologies, lack of understanding about the match between seedling and site characteristics, concerns about the potential ecological risks related to the deployment of uniform genetic stock, and absence of an easy-to-use decision-making tool. However, there were no results from a detailed search for published literature on the intrinsic motivations of family forest landowners and factors affecting their decisions about adopting genetically advanced pine seedlings. This suggests a critical gap exists in our understanding of the decision-making framework of the southern family forest owners related to the adoption of genetically advanced pine seedlings.

If the adoption rate of the more genetically advanced seedlings could be increased, significant gains in productivity and disease resistance could be achieved at the regional level. However, this first requires further understanding of the motivations and criteria involved in seedling selection in general, as well as specific factors that might influence the selection (or rejection) of the more genetically advanced pine seedlings. Surveying the population of interest could help facilitate such understanding.

Although family forest owners across the Southeast are not a completely homogeneous population, they share certain commonalities, including broad cultural similarities and a preference for planting loblolly pine. As such, results from a survey of landowners in one state could provide indications about the motivations and attitudes of smaller-scale forest owners in the region, even if caution is required in extrapolating the results too broadly.

1.3 Goal and Objectives

The goal of this study is to inform the estimates of the adoption rate of genetically advanced pine seedlings and better understand the factors that influence seedling choice among family forest landowners and consulting foresters in Georgia.

Our specific objectives were as follows: 1) solicit information that can inform estimates of the adoption rate of genetically advanced pine seedlings among family forest owners in Georgia; (2) gauge the level of knowledge and familiarity regarding advanced genetics seedlings among both family forest owners and registered foresters in the state; (3) gain insights into attitudes and opinions about advanced genetic seedlings among these populations; (4) identify factors that influence decisions about which seedlings to purchase/plant among both of the populations of interest; (5) identify specific barriers to adoption of genetically advanced pine seedlings; and (6) determine whether the presence of potential additional revenues from carbon payments might influence the type of seedlings that landowners or foresters choose to plant.

2. Methods

We conducted two surveys, one for landowners in Georgia and one for registered foresters in the state. Areas of focus as well as some specific questions, were informed by a survey previously developed but not distributed or published by ArborGen and shared with the authors. The survey was revised to better suit the research purpose, though some questions remained largely in their original form. Both were delivered online via Qualtrics.

While the surveys were tailored to the specific audiences, we maintained as much similarity as possible to facilitate direct comparisons between the two populations. Both surveys implemented screening questions to verify that respondents were in the intended population (described further below). Respondents were asked to indicate their level of knowledge and familiarity with advanced pine genetics and their experience with selecting these types of seedlings. Subsequent questions were designed to elicit attitudes about genetically advanced seedlings, e.g., benefits and disadvantages in comparison to standard open-pollinated seedlings and how favorably or unfavorably they view the advanced varieties. In the latter part of the survey, we broadened the focus to gather information on how these surveyed populations go about selecting seedlings, including both financial and social factors that influence their decision-making. Finally, respondents were asked to indicate their knowledge and attitudes toward carbon payment schemes and indicate whether the potential for greater carbon revenues would influence what type of seedling they choose. Question types were a mix of 5-point Likert scales and multiple choice (see appendices).

Demographic and profile information (e.g., size of holdings or acres managed, ownership tenure) was gathered to examine possible links between these characteristics and attitudes toward advanced pine genetics. These questions were most commonly presented in the "slider" format offered by Qualtrics, which allows for a continuous whole number response by sliding a bar to the appropriate age, number of acres, or years of tenure.

Both surveys remained open for three weeks—consecutively rather than concurrently, to avoid confusion, given the overlapping networks of these populations. We anticipated a response rate of 15%-20%, informed by Khanal et al. (2017), Thompson and Hansen (2012), and Joshi and Arano (2009), all of which surveyed attitudes of non-industrial private forest owners at differing scales (regional, national, and state level, respectively) and reported response rates in this range.

The forester survey was distributed via the Southeastern Society of American Foresters (SESAF). It was sent to 347 potential addresses on a distribution list for the state of Georgia. The list included recipients in the target group (registered foresters in Georgia) as well as landowners or other stakeholders in the state. The number of foresters reached via this distribution is unknown since members of the distribution list are not classified by type of stakeholder. Upon realizing within moments of the survey's release that the list was not limited to foresters, the authors added a screening question to ensure that only foresters registered in Georgia could respond to the survey. The survey was open from 23 Mar 2023 to 6 Apr 2023.

The landowner survey was distributed via two channels. With the assistance of the Georgia Tree Farmers Association, it was sent to email addresses in a database of certified tree farm landowners managed by the American Tree Farm Association. This distribution went to 618 addresses, with 36 of those "bouncing back" as undeliverable or incorrect addresses and one opting to unsubscribe from the list. Post-distribution activity was tracked using Constant Contact, which showed that the email was opened by 335 recipients. The survey link was also distributed to 378 email addresses compiled from attendees of two forest carbon workshops in Georgia, with 29 bounce-backs. There was no post-distribution tracking for these emails. The survey was open from 28 Apr 2023 to 19 May 2023.

Because the respondents were anonymous, it is not possible to know whether they were reached via the American Tree Farm distribution or the one sent by the authors. Furthermore, because the American Tree Farm distribution was carried out by that organization and not the authors, we did not have access to that list and, as such, do not know the potential overlap or redundancy between the two distributions.

3. Results

3.1.1 Responses to the Forester Survey

We received a total of 104 responses; of these, 33 started the survey but answered “No” to the screening question asking if they were a registered forester in Georgia, thereby ending the survey. Two additional respondents answered “No” to a screening question asking if they were ever involved in the selection of pine seedlings to plant on private lands. Out of the remaining eligible respondents, 34 reached the end of the survey, with some omissions in the demographic/profile section; 1 completed 97% and was included. In addition, there were 12 responses received before the “registered forester” screening question was added upon the realization that the distribution list was not limited to registered foresters. Of these 12 responses, seven were deemed suitable for inclusion in the analysis based primarily on their responses to questions later in the survey about their tenure as a registered forester and the number of acres under management, leading to 42 responses included in the analysis for a usable response rate of 12%.

3.1.2 Profile of Responding Foresters

Table 3.1 summarizes the numeric-response profile data from the forester survey. Respondents had a median age of 64, with a median of nearly forty years of experience in forestry.

Table 3.1. Summary of demographic and profile data for eligible forester respondents. For "Acres owned personally": Respondents were asked if they owned their own land. Those who responded "Yes" (n=24) were asked to provide the number of acres owned.

	n	Median	Range
Age (yrs)	42	64.00	32 - 78
Experience as forester (yrs)	42	39.50	2 - 55
Registered forester in Georgia (yrs)	42	33.50	1 - 50
Acres under management (ac)	33	3134.00	0 - 25,000
Acres in loblolly (ac)	35	1444.00	0 - 25,000
Acres in genetically advanced loblolly (ac)	41	423.00	0 - 20,415
Acres owned personally	24	148.00	37 - 612

Table 3.2 summarizes the non-numeric profile data. All but one of the included respondents was male. All 35 respondents who provided their race were White; the other seven opted for the "Prefer Not to Say" response. Thirty-four of the respondents identified as non-Hispanic, with all of the others choosing "Prefer Not to Say."

3.1.3 Knowledge, Experience, and Opinions of Foresters Regarding Genetically Advanced Seedlings

Respondents were asked to rate their knowledge of the varieties of genetically advanced pine seedlings, identified as open-pollinated, controlled mass-pollinated, and varietals/clonals. Four (10%) rated themselves as "Extremely knowledgeable"; 12 (29%) selected "Very

Table 3.2 Summary of non-numeric response data to forester demographic and profile questions. In some categories, respondents were provided with additional choices not represented here; only responses that were selected are included.

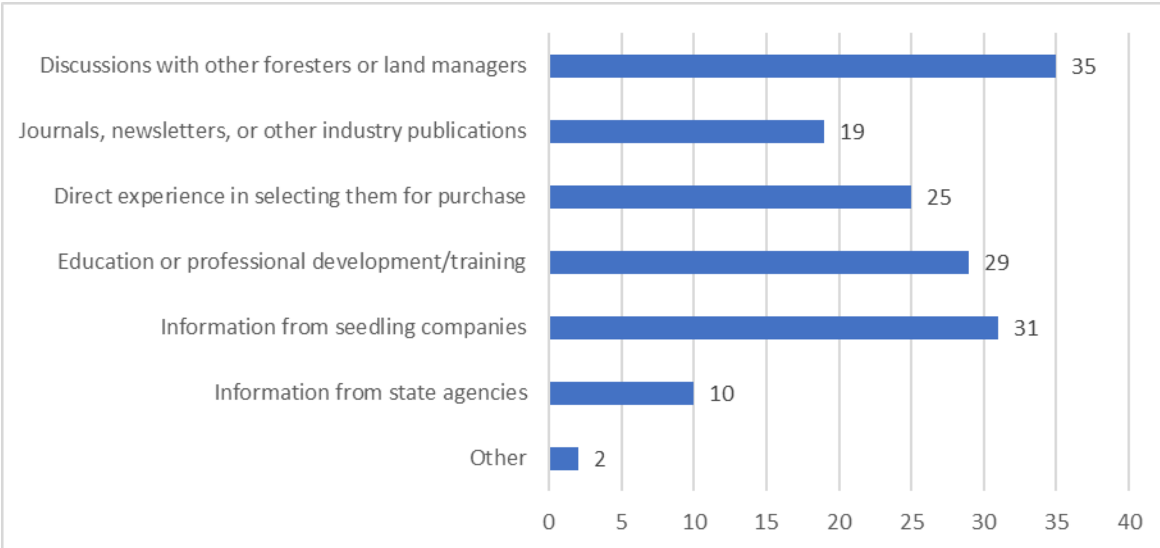
	n	Responses	#	%
Gender	42	Male	41	98%
		Female	1	2%
Race	42	White	35	83%
		Prefer Not to Say	7	17%
	42	Non-Hispanic	34	81%
		Prefer Not to Say	8	19%
Education	42	Associates	3	7%
		Bachelors	25	60%
		Graduate	14	33%
Income	42	less than $25,000	2	5%
		$25,000-$49,000	4	10%
		$50,000-$99,999	13	31%
		$100,000-$199,999	10	24%
		$200,000+	4	10%
		Prefer Not to Say	9	21%
Work status	42	Full-Time	27	64%
		Part-Time	11	26%
		Retired	4	10%

knowledgeable"; and 23 (55%) chose "Moderately Knowledgeable." Only 3 (7 %) identified as "Not very knowledgeable," and no respondents chose "Not all knowledgeable."

When asked to identify the sources of that knowledge, respondents most frequently pointed to information-sharing with other foresters and land managers, followed closely by information from seedling companies. Education and professional development was the third most common response. See Fig. 3.2.

Asked to describe their overall opinion of genetically advanced loblolly pine seedlings—specified in this case as controlled mass pollinated or varietals/clonals—81% expressed a favorable opinion: 13 respondents (31%) chose "Extremely Favorable," while 21 (50%) selected

Fig. 3.2. Summary of forester responses to the question "Where does your knowledge about the different genetic varieties of loblolly pine seedlings come from? Please select all that apply?" (n=42)

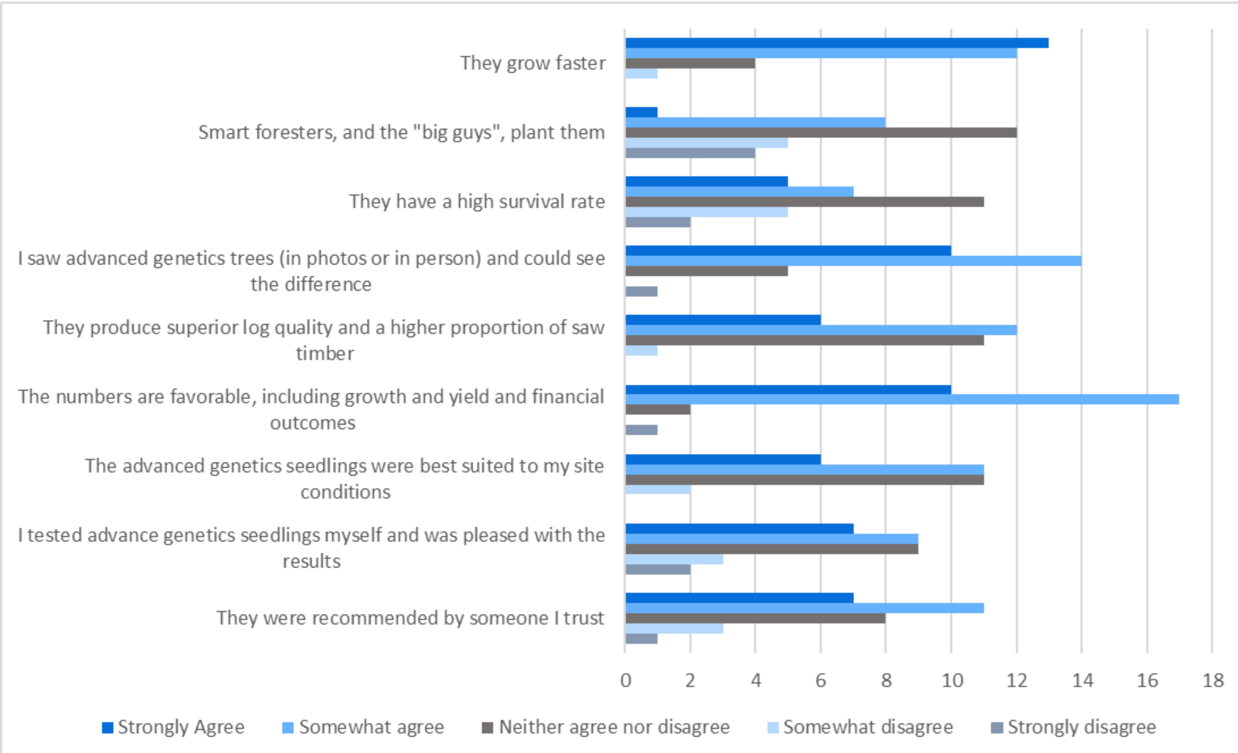


"Somewhat Favorable." Four respondents (10%) chose "Somewhat unfavorable," with another four indicating they did not know enough to form an opinion.

Of the 42 included respondents, 30 (71%) answered "Yes" to the question, "Have you chosen controlled mass-pollinated loblolly pine seedlings or varietals/clonal for lands you have managed or consulted on?" These respondents were directed to a follow-up question that asked them how strongly they agreed or disagreed with various explanatory statements. Statements about growth rate and financial incomes resonated most with respondents: 25 (83%) either strongly agreed or somewhat agreed with the statement "They grow faster," and 27 (90%) offered those responses for the statement "The numbers are favorable, including growth and yield and financial outcomes." Twenty-four respondents (80%) either strongly agreed or somewhat agreed with the statement, "I saw advanced genetics trees (in photos or in person) and could see the difference." See Fig. 3.3.

Twelve respondents indicated they had not chosen controlled mass pollinated or clonal/varietals. When asked how strongly they agreed or disagreed with various statements

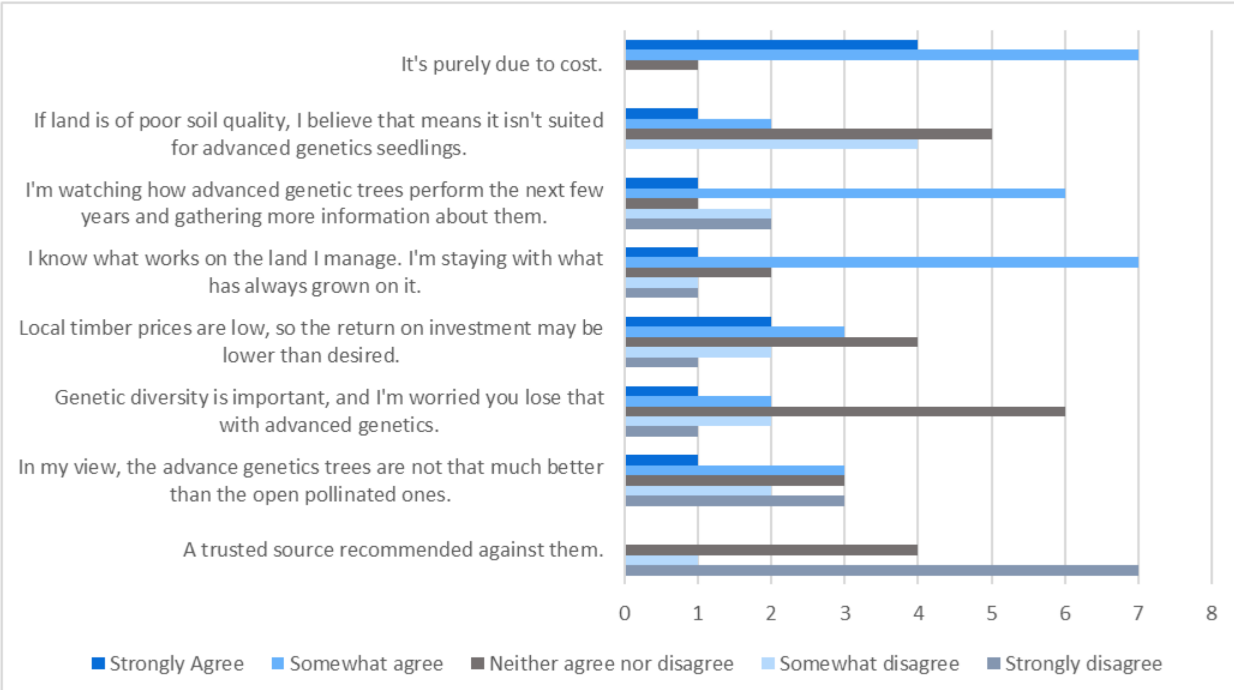
Fig. 3.3. Summary of forester responses to the question "If you have chosen genetically advanced loblolly pine seedlings (controlled mass pollinated and varietal/clonal), what led you to choose these? Please indicate how much you agree with the following statements." (n=30)



explaining their decision, the most common reason cited was cost: 11 (92%) either strongly agreed or somewhat agreed with the statement "It's purely due to cost." Other statements that attracted a high level of agreement include "I'm watching how advanced genetic trees perform the next few years and gathering more information about them" (7, or 58%, either strongly or somewhat agreed) and "I know what works on the land I manage. I'm staying with what has always grown on it" (8, or 67% either strongly or somewhat agreed). See Fig. 3.4.

When asked to select statements that reflected their experiences with controlled mass pollinated or clonal/varietal pine seedlings in the past five years, 36 respondents (86%) indicated that some of their colleagues or peers had chosen such seedlings for lands they managed; 24 (57%) said they had recommended to others that they should plant them; and 30 (71%) indicated they

Fig. 3.4. Summary of forester responses to the question "If you have chosen open pollinated loblolly pine seedlings in the past, then why haven't you selected the more genetically advanced tree seedlings (controlled mass pollinated or varietal/clonal)? Indicate how much you agree with the following statements by choosing one level for each."



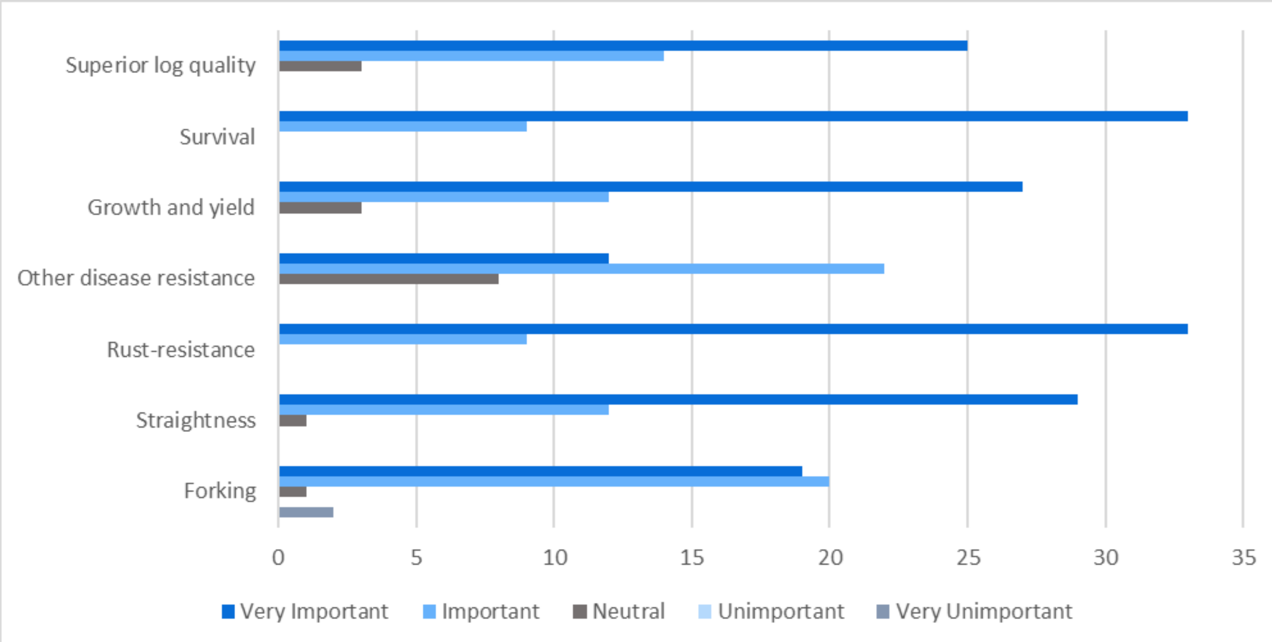
had "heard a lot of discussion and seen a lot of information" about them. Two respondents (5%) said none of those applied to their experiences. Responses were not mutually exclusive.

3.1.4 Importance of Factors in Seedling Selection

In addition to questions related directly to genetically advanced seedlings, respondents were asked more generic questions about loblolly pine seedling selection. When asked to indicate how important certain factors were in the seedling selection, respondents emphasized the importance of survival rate and rust-resistance, with 36 (86%) rating each of those as very important. See Fig. 3.5.

When asked specifically about financial considerations in the selection of loblolly pine seedlings, the choice most commonly marked as very important was "Expected rate of return, revenue, and cash flow" (22 respondents, 52%). All respondents said that seedling cost was either

Fig. 3.5. Summary of forester responses to the question "When selecting loblolly pine seedlings, how important are the following attributes to you? Please select a level of importance for each of the tree attributes below." (n=42)



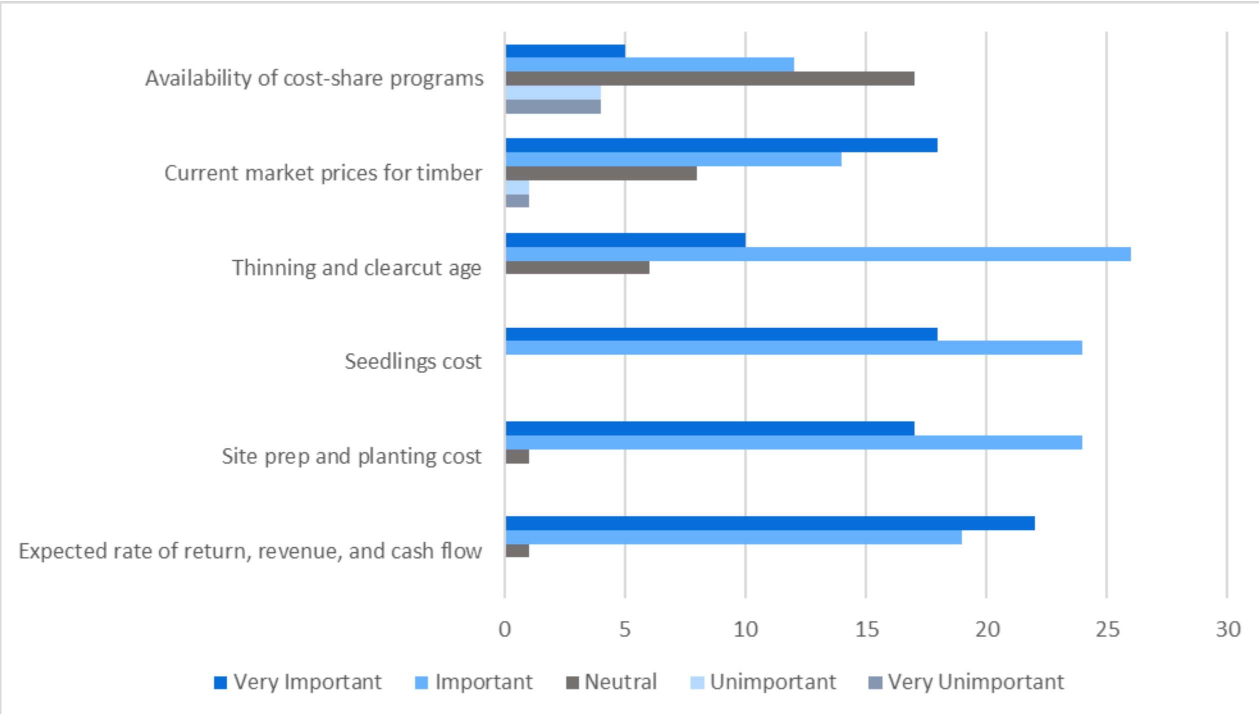
very important (18, 43%) or important (24, 57%). Only 17 respondents (40%) rated "Availability of cost-share programs" as either very important (5) or important (12), the lowest number of such responses for any choice. See Fig. 3.6.

Asked to choose among three statements that reflected how important seedling type was in determining the production and profitability of a stand in comparison to other factors such as site conditions and management, 25 forester respondents (60%) indicated that they are roughly equal in importance. Fifteen (36%) indicated that factors other than seedling type were most important; two respondents (5%) indicated that seedling type is the more important determinant of stand productivity.

3.1.5 Carbon Payment Schemes and Seedling Selection

Respondents were asked to self-report their knowledge of carbon payment schemes. No respondents rated themselves as "Extremely Knowledgeable." Seven (17%) selected "Very

Fig. 3.6. Summary of forester responses to the question "Which of the following financial considerations weigh most heavily when making decisions about planting loblolly pines on the lands you manage or consult on? Please select a level of importance for each of the considerations below." (n=42)

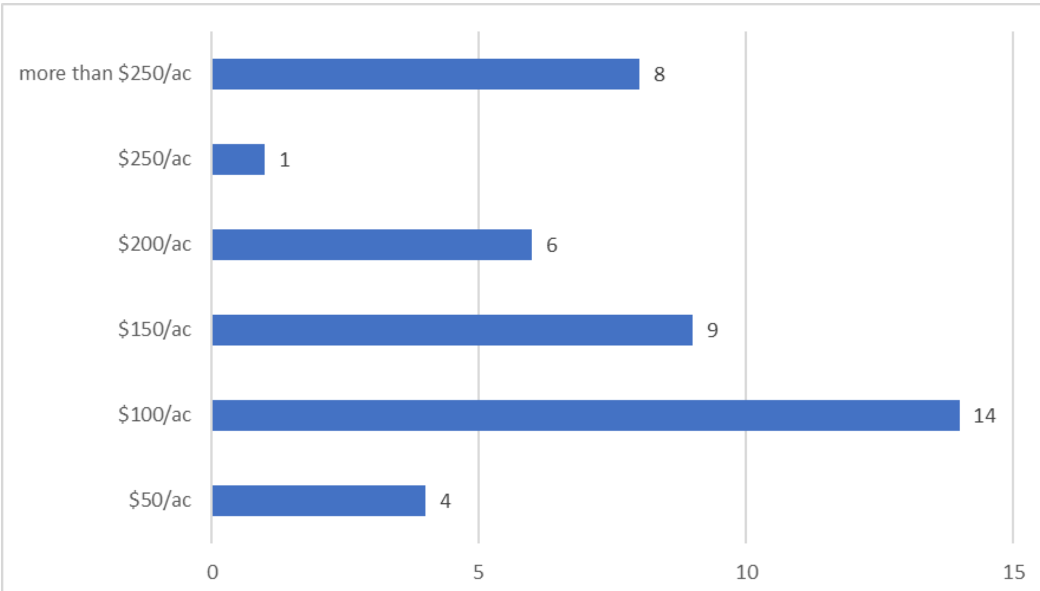


Knowledgeable" and 24 (57%) "Moderately Knowledgeable." Ten respondents (24%) chose "Not very knowledgeable," and one (2%) selected "Not at all knowledgeable."

When asked about their overall opinion of carbon payment schemes, no respondents selected "Extremely Favorable"; 18 (43%) said it was "Somewhat Favorable." Ten respondents (24%) indicated that their opinion was "Somewhat Unfavorable," while three (7%) chose "Extremely Unfavorable." Eleven respondents (26%) indicated they did not know enough to form an opinion.

Respondents were asked whether they would be more likely to recommend the more genetically advanced seedlings if they resulted in greater carbon income; 76% (32) responded "Yes." When asked how much additional revenue would make participation in a carbon scheme worth the administrative burden, 55% of responses were accounted for by the $100/ac and $150/ac options, while nearly 1 in 5 (19%) indicated they would want more than $250/ac. See Fig 3.7.

Fig. 3.7. Summary of responses to the question "If a landowner could receive extra income for the carbon stored on their forested acres, but there were some up-front costs and administrative hurdles involved, what do you think is the minimum amount of additional profit (per acre) that would make it worthwhile?" (n=42)



3.1.6 Willingness to Take Risk

Respondents were prompted to "Please rate your willingness to take risks with your timber operation, such as implementing new technologies or procedures, on a scale from 1 to 10, where 1 is completely unwilling to take risks, and 10 is completely willing to take risks." They recorded responses by sliding a marker along a bar to indicate the number (whole numbers only). The mean response was 6.29, with a median value of 6.

3.2.1 Responses to Landowner Survey

Sixty responses were recorded for the landowner survey. Screening questions at the beginning of the survey asked respondents if they were landholders in Georgia, if they primarily opted for natural regeneration, and if they were involved in selection of seedlings to plant on their land. Only Georgia landholders who did not opt for natural regeneration and were involved in seedling selection were able to complete the survey. Two respondents indicated they were not Georgia landholders; nine said they primarily opted for natural regeneration; and 10 said they were not involved in seedling selection. Thus, the screening questions left 39 eligible respondents; of those, 29 reached the end of the survey, though with some omissions in the demographic/profile section. These 29 responses were the basis for our analysis, for a usable response rate of 3%.

3.2.2 Profile of Landowner Respondents

Table 3.3 summarizes the numeric-response profile data from the landowner survey. Respondents had a median age of 68, with a median tenure of 26 years.

Table 3.3. Summary of demographic and profile data for respondents to landowner survey.

	n	**Median**	**Range**
Age (yrs)	29	68.00	34 – 79
Tenure as landowner (yrs)	29	26.00	5 - 60
Forestland owned in Georgia (ac)	21	322.00	48 - 991
Acres in loblolly (ac)	24	155.00	0 - 721
Acres in genetically advanced loblolly (ac)	28	58.00	0 - 721

Table 3.4 summarizes the non-numeric landowner profile data. As with the forester survey, nearly all the respondents identified as male and white, non-Hispanic. Almost half of all respondents indicated they are retired.

Table 3.4. Summary of non-numeric response data to landowner demographic and profile questions. In some categories, respondents were provided with additional choices not represented here; only responses that were selected are included.

	n	Responses	#	%
Gender	29	Male	27	93%
		Female	2	7%
Race	29	White	27	93%
		Prefer Not to Say	2	7%
	29	Non-Hispanic	27	93%
		Prefer Not to Say	2	7%
Education	29	High School	2	7%
		Associate's	3	10%
		Bachelor's	13	45%
		Graduate	11	38%
Income	29	less than $25,000	1	4%
		$25,000-$49,000	0	0%
		$50,000-$99,999	5	17%
		$100,000-$199,999	9	31%
		$200,000+	5	17%
		Prefer Not to Say	9	31%
Work status	29	Full-Time	13	45%
		Part-Time	2	7%
		Retired	14	48%

.

3.2.3 Knowledge, Experience, and Opinions of Landowners Regarding Genetically Advanced Seedlings

Respondents were asked to describe their knowledge of the varieties of genetically advanced pine seedlings. Four respondents (14%) rated themselves as Extremely knowledgeable; 8 (28%) selected "Very knowledgeable"; and 14 (48%) chose "Moderately knowledgeable." Three respondents (10%) rated themselves as "Not very knowledgeable," and no respondents chose "Not at all knowledgeable."

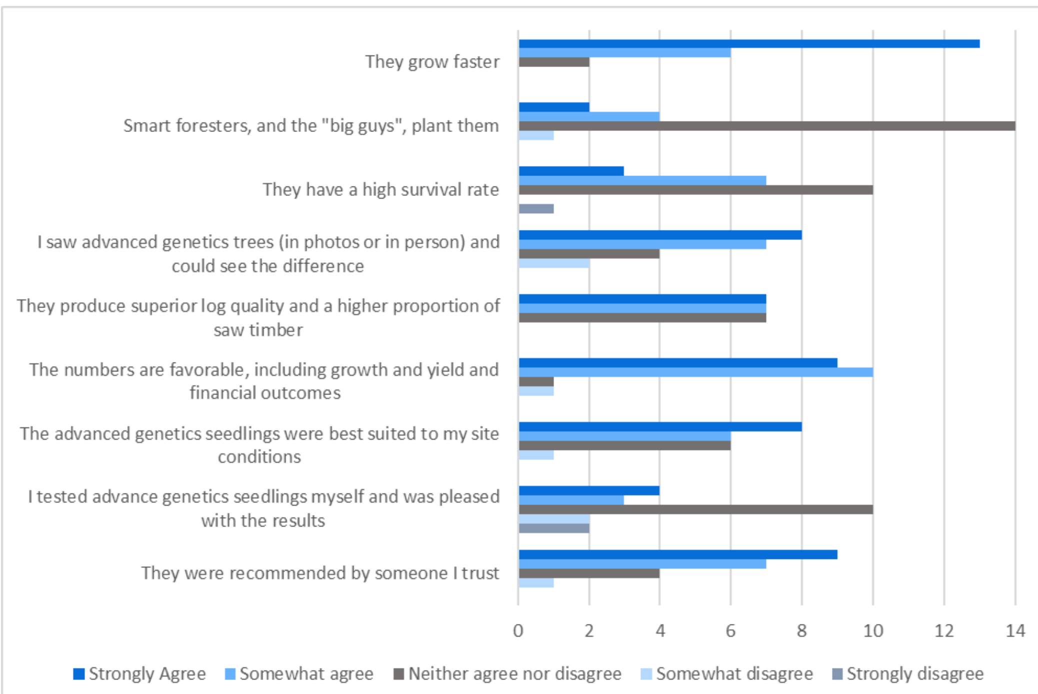
When asked to identify the sources of that knowledge, respondents most frequently pointed to discussions with foresters and professional land managers, with 24 (83%) selecting that option. See Fig. 3.8.

Fig. 3.8. Summary of landowner responses to the question "Where does your knowledge about the different genetic varieties of loblolly pine seedlings come from? Please select all that apply?" (n=29)

Asked to describe their overall opinion of genetically advanced loblolly pine seedlings—specified in this case as controlled mass pollinated or varietals/clonal—90% of landowner respondents expressed a favorable opinion: 12 (41%) rated their opinion as "Extremely favorable," and 14 (48%) as "Somewhat favorable." One respondent (3%) selected "Somewhat unfavorable"; none chose "Extremely unfavorable." Two respondents (7%) indicated that they didn't know enough to form an opinion.

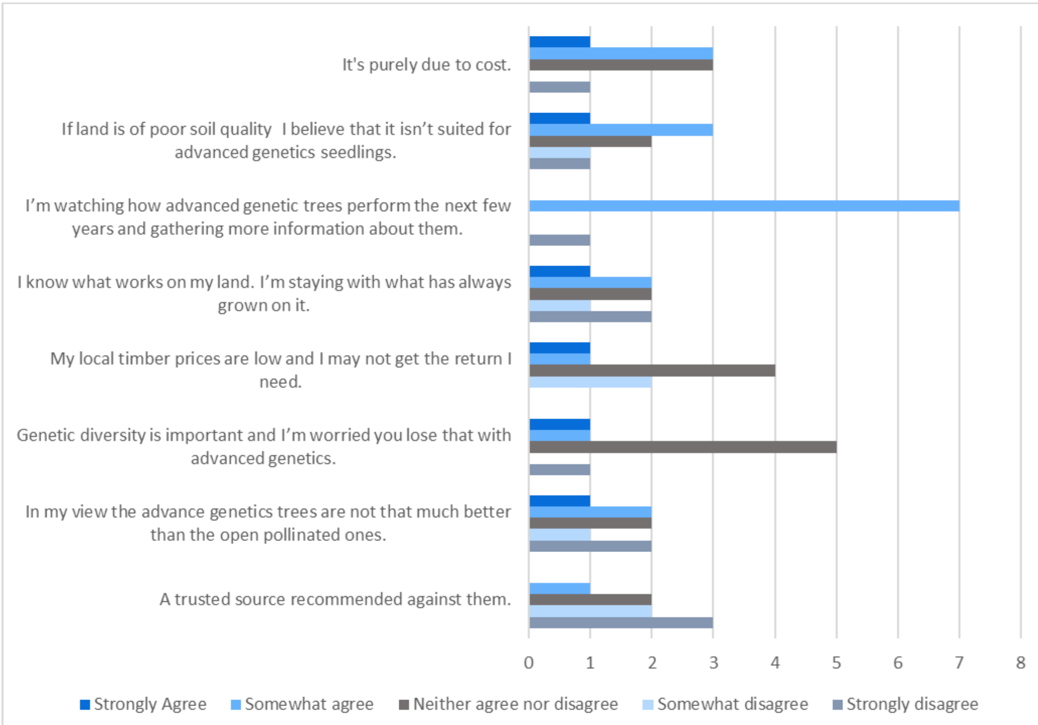
Of the 29 respondents included in our analysis, 21 (72%) answered "Yes" to the question "Have you chosen controlled mass-pollinated loblolly pine seedlings or varietals/clonals to plant on your land?" These respondents were directed to a follow-up question that asked them how strongly they agreed or disagreed with various statements explaining their decision to plant these seedlings. Thirteen respondents (62%) strongly agreed with the statement “They grow faster,” the highest percentage of strong agreement for any choice, with another 6 (29%) somewhat agreeing. The statement “The numbers are favorable, including growth and yield and financial outcomes” generated the next highest number of favorable responses, with nine respondents strongly agreeing and 10 somewhat agreeing. See Fig. 3.9.

Fig. 3.9. Summary of landowner responses to the question “If you have chosen genetically advanced loblolly pine seedlings (controlled mass pollinated and varietal/clonal), what led you to choose these? Please indicate how much you agree with the following statements.” (n=21)



Eight respondents (28%) indicated they had not chosen controlled mass pollinated or clonal/varietals. When asked how strongly they agreed or disagreed with various explanatory statements, 7 (88%) somewhat agreed with the statement “I'm watching how advanced genetic trees perform the next few years and gathering more information about them.” No other statement yielded more than four responses of agreement (Strongly Agree or Somewhat Agree) combined. See Fig. 3.10.

Fig. 3.10. Summary of landowner responses to the question "If you have chosen open pollinated loblolly pine seedlings in the past, then why haven't you selected the more genetically advanced tree seedlings (controlled mass pollinated or varietal/clonal)? Indicate how much you agree with the following statements by choosing one level for each." (n=8)

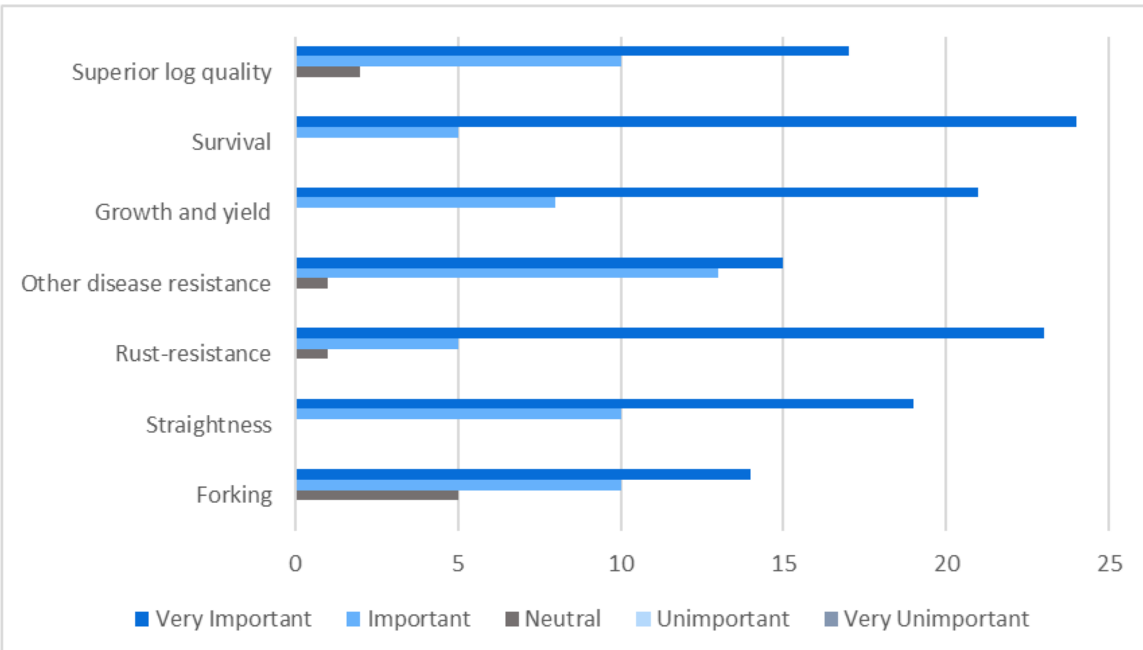


When asked to select statements that reflected their experiences with controlled mass-pollinated or clonal/varietal pine seedlings in the past five years, 17 respondents (59%) indicated that some of their friends, peers, or colleagues had chosen them for lands they managed; 12 (41%) indicated that they had recommended to others that they should plant them; and 17 (59%) indicated that they had "heard a lot of discussion and seen a lot of information" about them. Notably, 6 respondents (21%) said none applied to them. Responses were not mutually exclusive.

3.2.4 Importance of Various Factors in Seed Selection

In addition to questions related directly to genetically advanced seedlings, landowner respondents were asked more generic questions about loblolly pine seedling selection. When asked to indicate how important seven specific factors were in seedling selection, respondents emphasized the importance of survival rate and rust resistance, with 24 (83%) and 23 (79%) respondents, respectively, saying these were very important. See. Fig. 3.11.

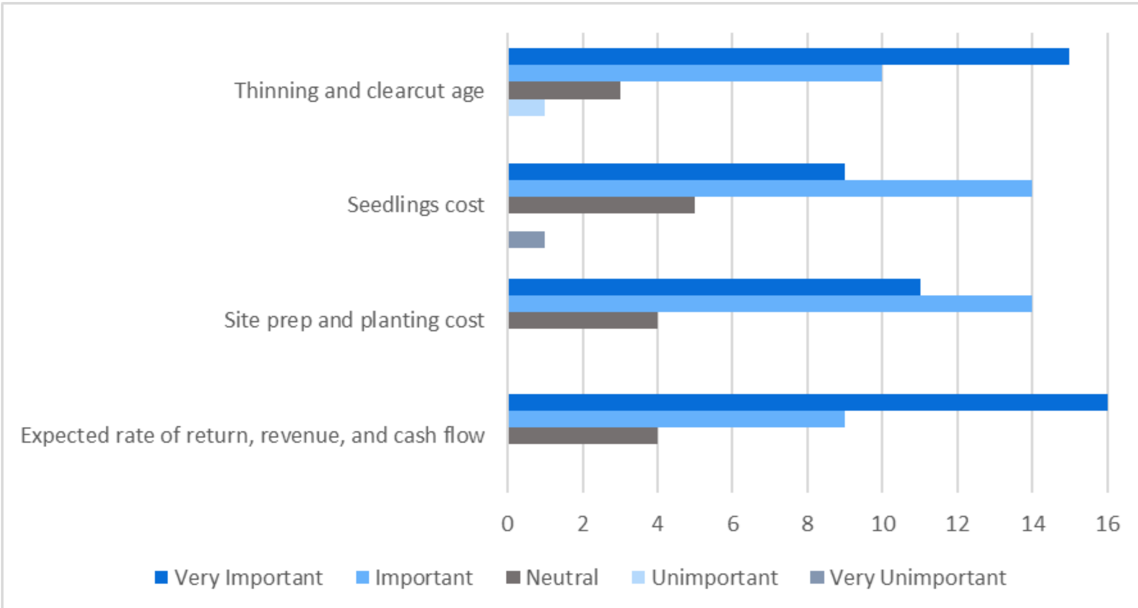
Fig. 3.11. Summary of landowner responses to the question “When selecting loblolly pine seedlings, how important are the following attributes to you? Please select a level of importance for each of the tree attributes below.” (n=29)



When asked about four specific financial considerations in the selection of loblolly pine seedlings, the choice most commonly marked as very important was “Expected rate of return, revenue, and cash flow” (16 respondents, 55%), with another 9 respondents (31%) rating it as important. “Thinning and clearcut age” was very important to 15 (52%) of respondents. See Fig. 3.12.

Asked to choose among three statements that reflected how important seedling type was in determining the production and profitability of a stand in comparison to other factors such as site conditions and management, 16 (55%) indicated that they are roughly equal in importance. Seven

Fig. 3.12. Summary of landowner responses to the question "Which of the following financial considerations weigh most heavily when making decisions about planting trees on your land? Please select a level of importance for each of the considerations below." (n=29)



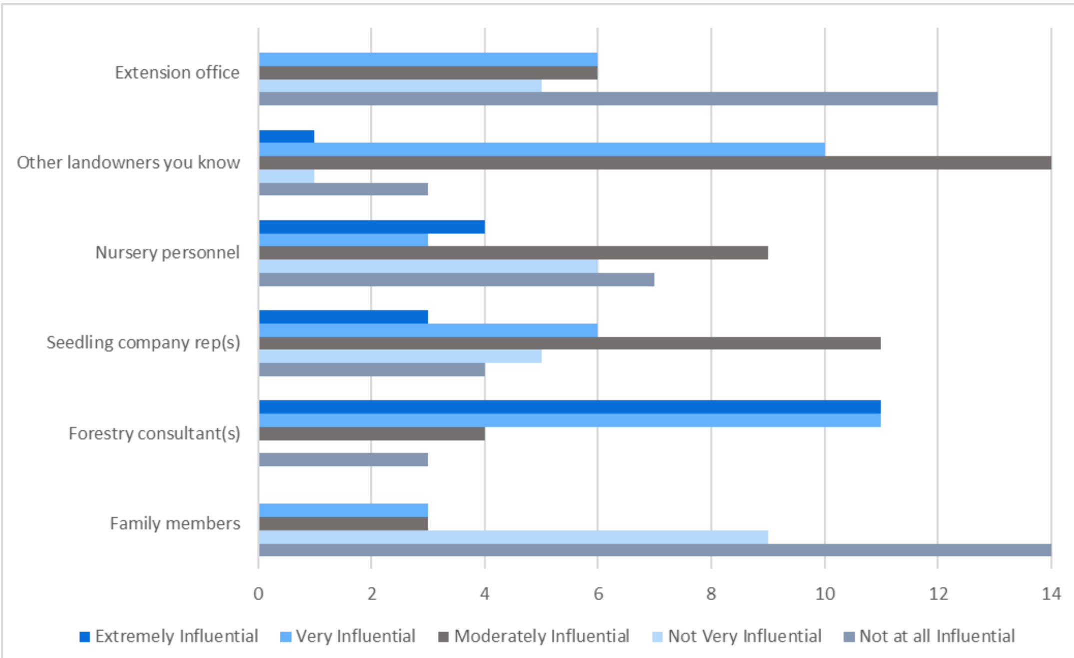
(24%) indicated that factors other than seedling type were most important. Five respondents (17%) indicated that seedling type is the more important determinant of stand productivity.

We asked two questions about the external influences on landowner seed selection. When asked whether they rely heavily on advice from others when choosing seedlings or feel confident in making those decisions on their own, respondents were split nearly evenly, with 14 (48%) and 15 (51%) responses, respectively.

When asked about specific external influences on their seed selection, landowner respondents rated forestry consultants as the most important among the available choices: 22 (76%) marked them as either extremely influential or very influential in their decisions. The next most prominent influence was "Other landowners," with 11 respondents (38%) saying they were either extremely or very influential. At the other end of the spectrum, 17 respondents (59%) indicated that their extension office was either not very influential or not at all influential. Only

“Family members” yielded lower influence ratings, with 23 respondents (79%) not very or not at all influential. See Fig 3.13.

Fig. 3.13. Summary of landowner responses to the question “When evaluating which loblolly pine seedlings to plant, who influences your decision? Please select the level of influence for each choice below that reflects how much input they have.” (n=29)



To determine the role of cost-share opportunities in seed selection, we asked landowners how important cost-share programs were in selecting seedlings. Nine respondents (31%) rated such programs as “Very Important” and 8 (28%) as “Important.” In contrast, two respondents (7%) indicated these programs were “Unimportant” and 4 (14%) as “Very Unimportant” in their decision. Six respondents (21%) selected “Neutral.”

3.2.5 Carbon Payment Schemes and Seedling Selection

Landowner respondents were asked to self-report their knowledge of carbon payment schemes. One (3%) selected “Extremely knowledgeable.” Seven respondents (24%) rated themselves as “Very knowledgeable” and 13 (45%) as “Moderately knowledgeable.” Six respondents (21%) selected “Not very knowledgeable” and two (7%) “Not at all knowledgeable.”

When asked to describe their overall opinion of carbon payment schemes, four respondents (14%) rated it as “Extremely Favorable” and 10 (35%) as “Somewhat Favorable.” In contrast, eight respondents (28%) selected “Somewhat unfavorable” and one (3%) “Extremely unfavorable.” Six (21%) indicated they did not know enough about carbon payment schemes to form an opinion.

Landowner respondents were asked whether they would be more likely to plant the more genetically advanced seedlings if they resulted in higher carbon income; 83% (24) responded “Yes.” When asked how much additional revenue would make participation in a carbon scheme worth the administrative burden, 8 respondents (28%) said more than $250/ac, with the same number choosing $100/ac. The next most common response was $200/ac (7, or 24%). See Fig 3.14.

3.2.6 Other Personality Traits

Respondents were asked to indicate how well nine personality traits and attitudes fit them. Twenty-one respondents (72%) said the descriptor “Independent, self-reliant” fit them perfectly, more than for any other trait. See Fig 3.15.

Fig. 3.14. Summary of landowner responses to the question "If you could receive extra income for the carbon stored on your forested acres, but there were some up-front costs and administrative hurdles involved, what is the minimum amount of additional profit (per acre) that would make it worthwhile?" (n=29)

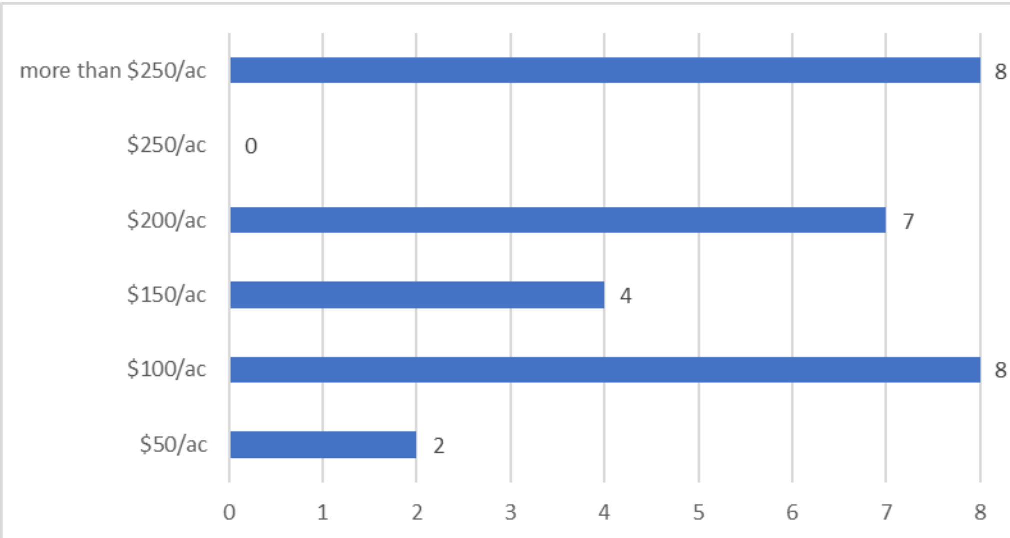
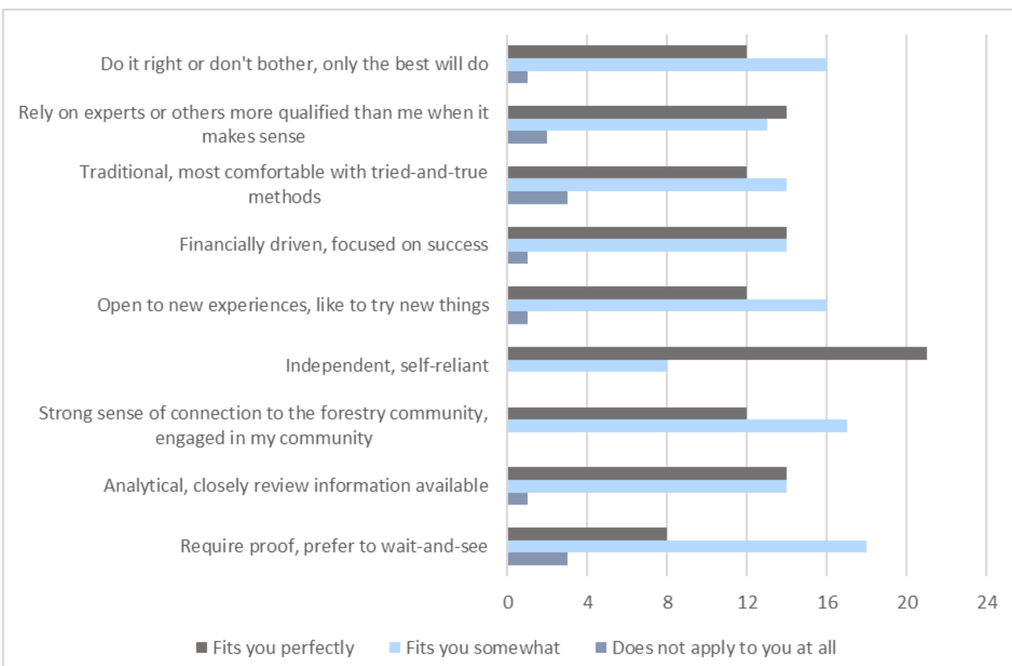


Fig. 3.15. Summary of landowner responses to the question "Please indicate the extent to which each personality trait below describes you. Choose one level for each trait." (n=29)



Finally, respondents were prompted to "Please rate your willingness to take risks with your timber operation, such as implementing new technologies or procedures, on a scale from 1 to 10, where 1 is completely unwilling to take risks, and 10 is completely willing to take risks." They recorded responses by sliding a marker along a bar to indicate the number (whole numbers only). The mean response was 5.75, with a median value of 5.00.

4. Discussion

The adoption rate among respondents of both surveys was far higher than the 15%-20% estimate we posited for family forest lands in the Southeast, with 72% of landowners and 71% of foresters saying they had chosen controlled mass pollinated or varietals/clonals to plant on lands they owned or managed. Furthermore, 86% of foresters and 59% of landowners said they had friends, colleagues, or peers who had planted these seedling types in the past five years. The large gap between the estimate and the survey results may indicate a higher adoption rate than previously thought, though the relatively small sample size prevents us from making strong inferences or broad generalizations.

Part of our aim was to identify potential barriers to wider adoption. Intuitively, potential explanations for a low adoption rate would include a lack of knowledge regarding seedling genetics or negative perceptions of the advanced varieties, e.g., skepticism about their benefits. However, our survey results do not support those explanations. Self-reported knowledge of the genetic varieties of seedlings was high among both groups of respondents. Roughly equal percentages of landowners and foresters (41% and 38%, respectively) considered themselves to be either extremely knowledgeable or very knowledgeable, with roughly half of each group (48% and 55%) deeming themselves moderately knowledgeable. Positive perceptions of the more genetically advanced seedlings were widespread among both groups: 81% of foresters and 90% of landowners classified their overall opinion of these seedlings as either extremely or very favorable. It seems that respondents largely considered themselves knowledgeable enough to form opinions about the more genetically advanced seedlings and that those opinions were predominantly positive.

When asked to identify specific reasons for adopting, both groups of respondents highlighted fast growth and favorable financial outcomes; they also indicated that the more genetically advanced trees passed the “eye test,” i.e., that they could see the advantages for themselves. These responses further indicate familiarity with the more genetically advanced seedlings and a positive perception of them.

Still, 28% of landowners and 29% of foresters in the survey said they had not planted controlled mass-pollinated seedlings or varietals/clonals. Non-adopters contained a greater portion of the respondents who rated themselves as “Not Very Knowledgeable” about the genetic varieties of loblolly pine seedlings: 15% of non-adopters chose that option, versus 6% of adopters. However, given the small absolute number of responses involved, we are not confident in suggesting a strong connection between knowledge level and non-adoption.

Cost was an important factor in non-adoption for both foresters and landowners, though the percentage of foresters who indicated cost was a primary obstacle (92%) was higher than that of landowners (50%). Furthermore, 50% of the non-adopting landowners agreed with a statement indicating that land with poor soil quality wasn’t well suited for advanced genetics seedlings, though only 25% of non-adopting foresters agreed with the same statement.

Along those lines, only 21% of landowners and 5% of foresters thought that the type of seedling planted would be the primary determinant of the productivity or profitability of a stand, as opposed to other factors such as soil quality and stand management. Additionally, 50% of non-adopting landowners and 75% of non-adopting foresters either strongly or somewhat agreed with the statement, “I know what works on the land I manage. I'm staying with what has always grown on it.” This might point to another barrier to adoption: if one believes that other factors are equally or more important than seedling type, paying the higher cost for the more genetically advanced varieties of seedlings may not seem like a worthwhile investment.

The explanatory statement that resonated most with non-adopting landowners was, “I’m watching how advanced genetic trees perform the next few years and gathering more information about them,” with 7 of 8 (88%) somewhat agree. Among non-adopting foresters, 7 of 12 (58%) either somewhat agreed or strongly agreed with the same statement. This uncertainty about the performance of the more advanced genetics may point to a need for continued research and additional evidence of the benefits of the higher genetics, as well as communication of those benefits from trusted sources. This may be especially true for the controlled mass pollinated varieties, which have a shorter history and thus have been less thoroughly researched than the multiple generations of improved open pollinated seedlings.

For the non-adopting foresters, this squares with their self-reported “risk tolerance” score: non-adopters rated themselves on average 5.75 on a scale of 10, lower than the overall group average of 6.29 (n=41). However, that was not the case for the non-adopting landowners: their average self-reported “risk tolerance” was 6.25, higher than the overall landowner average of 5.75 (n=29).

The self-reported knowledge and attitudes surrounding carbon payment schemes offered some points of interest. While self-reported knowledge was high overall, landowners rated themselves as Extremely Knowledgeable or Very Knowledgeable at a higher rate than foresters did. Likewise, a higher percentage of landowners than foresters classified their overall opinion of carbon payment schemes as Extremely Favorable or Somewhat Favorable. Furthermore, a high percentage of each group expressed receptiveness to adopting genetically advanced seedlings as a path to increased carbon revenue: 83% of landowners said the potential for such revenue would make them more likely to adopt, versus 76% of foresters. Given anecdotal skepticism about the potential returns of carbon markets for smaller landholders, the positive perceptions reported here seem noteworthy.

In keeping with previous surveys cited earlier, foresters emerged as an important source of information about genetically advanced seedlings, both for landowners and other foresters. Professional foresters or land managers were the source of information about these seedlings cited most commonly by landowners, who also rated them as Extremely Influential or Very Influential in their decision-making about seedlings—a higher rate than any other group, including other landowners. Likewise, foresters cited discussions with other foresters or land managers as a source of information more frequently than any other source.

On the other hand, state agencies were not presented as an important source of information by these respondents: 59% of landowners said their Extension office was Not Very Influential or Not at all Influential in their seed selection, and fewer than half cited state agencies as a source of their knowledge about genetically advanced seedlings. Among foresters, 24% cited information from state agencies as a source of their knowledge, less than any other choice.

In our attempts to quantify how much additional revenue would be necessary to incentivize participation in carbon markets, no definitive answer emerged. Among forester respondents, 33% said that $100/ac would be sufficient to counteract the upfront costs and administrative hurdles, more than for any other choice. However, the responses were scattered among the other choices, with no clear trend discernible. Among landowners, 28% said they would want $100/ac to participate in a carbon payment scheme, but the same percentage said it would take more than $250/ac. It may be that this threshold is ultimately a matter of personal preference, or a calculation based on individual circumstances. Notably, all responses were within the estimates for NPV derived from the analysis in Chapter 2.

5. Conclusion

We surveyed foresters and landowners in Georgia to learn more about their knowledge and opinions regarding genetically advanced loblolly pine seedlings. Our study suggests that the anecdotal estimates of adoption rates of genetically advanced loblolly pine seedlings—no more than 20%—may be low, at least within the state of Georgia. A much higher percentage of respondents from both the forester and landowner populations in the state reported having planted controlled mass-pollinated seedlings or varietals/clonal.

However, given the relatively small number of respondents, caution is merited in extrapolating these results too widely. Additionally, we must acknowledge the potential for response bias to skew our results, i.e., those with knowledge and experience related to genetically advanced loblolly pine seedlings are more likely to respond to a survey such as ours. Similarly, the channels used to distribute the surveys might have made it more likely that we would attract a more knowledgeable respondent, e.g., foresters involved in SESAF or landowners who attended a carbon workshop.

In future similar studies, it may be worthwhile to explore whether the size of the timber operation correlates to the dollar amount that incentivizes participation in carbon payment schemes. Because not all respondents reported the size of their holdings or land under management, we were unable to perform a regression that would provide meaningful results.

Nonetheless, these results may prompt a reevaluation of adoption rates of the more genetically advanced seedling varieties or spur further systematic examination. Also, for non-adopters, they point to the importance of continued study and further evidence of the benefits of genetic improvement in loblolly pine seedlings, as well as the need to communicate that evidence via trusted sources. Finally, they suggest a new potential avenue for encouraging adoption: increased potential for carbon revenues resulting from stands that grow greater volumes of wood faster.

CHAPTER 4

CONCLUSION

This study centers on two related questions. First, how might planting more genetically advanced loblolly pine seedlings impact family forest landowners' revenue from both timber *and* carbon payments? Second, why have family forest landowners in Georgia not adopted genetically advanced loblolly pine seedlings at a higher rate? These questions have important implications for the timber industry in the U.S. South, where loblolly pine is the dominant species in planted timberlands.

The revenue question was explored by modeling the profitability of a stand generating both timber and carbon revenue for three genetic varieties of loblolly pine seedlings. The model employed growth and yield from an existing model to project timber production for each variety and used publicly available cost and price data to calculate the stand profitability. Carbon storage estimates were derived from the same growth and yield model. The costs of participating in a carbon payment scheme were based on a publicly available fee schedule for participation in the Verified Carbon Standard (VCS) program administered by Verra, a widely used standard for forest carbon projects. Revenues were likewise based on calculation methods employed by Verra under the Voluntary Carbon Standard, using a price estimate derived from publicly available information.

The limitations of this revenue modeling stem primarily from the variability of the inputs. Different growth and yield models may produce different timber volumes and carbon storage quantities, and regardless of the model used, the outputs represent averages, not guaranteed outcomes. Timber prices fluctuate both temporally and regionally, and carbon prices can vary over time and by project type. Likewise, the various carbon verification standards may use different methods for estimating the baseline carbon and determining the monetizable carbon. As such, the specific dollar amounts available to landowners may not be broadly generalizable. Nonetheless, the analysis suggests that landowners could, on average, increase profitability from both timber and carbon by adopting better genetics.

To investigate the second question, Georgia landowners and foresters were surveyed on their knowledge and attitudes about the genetic varieties of loblolly pine seedlings. Two web-based surveys were conducted consecutively, one for landowners and the other for foresters. These groups were asked to self-report their knowledge about these seedlings and answer questions designed to gauge their attitudes toward the more genetically advanced varieties. The surveys also explored the factors that influence seed selection more generally, as well as attitudes toward carbon payment schemes.

The primary limitations of the survey of Georgia landowners and foresters are (a) a relatively small sample size and (b) the possibility that the results were distorted by a respondent pool that was not representative of the larger populations. However, the responses provide useful data points about knowledge and attitudes about genetically advanced seedlings as well as factors that influence seedling selection among landowners and foresters.

The economic modeling employed in this study indicates that the choice of genetic variety of loblolly pine seedling could significantly increase profitability from both timber and carbon revenues. Each step up in genetics resulted in increased profitability, as measured by net present value, whether considering timber only or combined timber and carbon. As such, landowners might be foregoing potential revenue by not adopting the more genetically advanced seedlings.

Efforts to facilitate increased adoption could result in increased productivity throughout the South and increased profitability for landowners.

In the survey of Georgia landowners and foresters, respondents indicated they were knowledgeable about the more genetically advanced loblolly pine seedlings and held an overall favorable opinion. The respondent pool also reported that they had adopted those seedlings at a much higher rate than estimates based on expert opinion, though it is difficult to draw strong conclusions about the adoption rate from this single survey. The relatively higher cost of the more genetically advanced seedlings emerged as a potential barrier to adoption, along with concerns about whether those seedlings will offer increased productivity if the soil is of low quality. Furthermore, responses from non-adopters suggest they may have a conservative tendency to plant what has been successful in the past. Non-adopters in both the landowner and forester group indicated that they are waiting to see how the more genetically advanced seedlings perform over the next few years, pointing to the need for continued study and additional evidence of the value of the higher genetics, as well as a strategy for communicating those benefits through trusted sources.

Both landowner and forester responses reflected overall favorable attitudes toward carbon payment schemes and indicated that increased revenue potential from carbon payments could serve as an incentive to adopt more genetically advanced seedlings. The survey results reinforced the importance of professional foresters in landowner decisions about which seedlings to plant, and in fact, foresters indicated that knowledge-sharing among each other plays a vital role in their own seedling selection.

Future research may seek to extend our understanding of the additional carbon storage that results from adopting more genetically advanced seedlings. Given that not only the amount but also the duration of carbon storage is important to efforts to mitigate climate change, one specific line of inquiry could be to evaluate how the adoption of different seedling varieties might affect the amount of carbon stored in end-products, specifically in long-lived sawtimber. Regarding landowner and forester attitudes, future studies may seek to further explore adoption rates of the more genetically advanced seedlings, to better refine our estimates. Also, it might be useful to investigate correlations between the size of holdings and attitude toward advanced genetics seedlings as well as carbon payment schemes, something this study was unable to analyze due to incomplete responses regarding acres owned or under management.

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APPENDIX A – FORESTER SURVEY QUESTIONS

Advanced Pine Genetics - Forester

Start of Block: Experience with Genetically Advanced Loblolly Pine Seedlings

*

Q38 The goal of this survey is to learn more about the adoption rate and perceptions related to genetically advanced loblolly pine seedlings. We also hope to better understand how landowners or land managers select the tree seedlings that they plant on their land. Your responses will help us gain important insights into what type of seedlings are being planted and the factors that go into choosing a tree seedling. We estimate that this survey will take 10-15 minutes. Participation is voluntary. You can refuse to take part, and you can stop at any time without penalty. The survey is anonymous—it does not ask for your name or other information that could identify you. All of your survey responses will be confidential and will only be used for the research purposes stated above. If you have questions about this research, please feel free to contact Matt Pruitt at 706-542-7180, or at mkpruitt@uga.edu. You can also reach out to Dr. Puneet Dwivedi (puneetd@uga.edu) for clarifications. If you have any complaints or questions about your rights as a research volunteer, contact the University of Georgia's Institutional Review Board (IRB) at 706-542-3199 or by email at IRB@uga.edu.

○ I have read the information above and agree to participate in the survey

Page Break

Q39 For this survey, we are interested in the insights of foresters registered in Georgia. Are you a registered forester in Georgia?

○ Yes

○ No

Skip To: End of Survey If For this survey, we are interested in the insights of foresters registered in Georgia. Are you a... = No

Page Break

Q1 Are you ever involved in the selection of loblolly pine seedlings to plant on privately held land?

- ◯ Yes
- ◯ No

Skip To: End of Block If Are you ever involved in the selection of loblolly pine seedlings to plant on privately held land? = No

Page Break

Q2 How would you rate your knowledge of the different genetic varieties of loblolly pine seedlings (open-pollinated, controlled mass-pollinated, and varietals/clones)?

- ◯ Extremely knowledgeable
- ◯ Very knowledgeable
- ◯ Moderately knowledgeable
- ◯ Not very knowledgeable
- ◯ Not knowledgeable at all

Skip To: Q4 If How would you rate your knowledge of the different genetic varieties of loblolly pine seedlings (... = Not knowledgeable at all

Q3 Where does your knowledge about the different genetic varieties of loblolly pine seedlings come from? Please select all that apply:

- ▢ Direct experience in selecting them for purchase
- ▢ Discussions with other foresters or land managers
- ▢ Information from state agencies
- ▢ Information from seedling companies
- ▢ Education or professional development/training
- ▢ Journals, newsletters, or other industry publications
- ▢ Other ____

Page Break

Q4 Have you chosen controlled mass pollinated loblolly pine seedlings or varietals/clonals for lands you have managed or consulted on?

- ◯ Yes
- ◯ No

Display This Question:

If Have you chosen controlled mass pollinated loblolly pine seedlings or varietals/clonals for lands... = No

Q5 If you have chosen open pollinated loblolly pine seedlings in the past, then why haven't you selected the more genetically advanced tree seedlings (controlled mass pollinated or varietal/clonal)? Indicate how much you agree with the following statements by choosing one level for each statement below.

	Strongly Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
It's purely due to cost.	○	○	○	○	○
If land is of poor soil quality, I believe that means it isn't suited for advanced genetics seedlings.	○	○	○	○	○
I'm watching how advanced genetic trees perform the next few years and gathering more information about them.	○	○	○	○	○
I know what works on the land I manage. I'm staying with what has always grown on it.	○	○	○	○	○
Local timber prices are low, so the return on investment may be lower than desired.	○	○	○	○	○
Genetic diversity is important, and I'm worried you lose that with advanced genetics.	○	○	○	○	○
In my view, the advance genetics trees are not that much better than the open pollinated ones.	○	○	○	○	○
A trusted source recommended against them.	○	○	○	○	○

Display This Question:

If Have you chosen controlled mass pollinated loblolly pine seedlings or varietals/clonals for lands... = Yes

Q6 If you have chosen genetically advanced loblolly pine seedlings (controlled mass pollinated and varietal/clonal), what led you to choose these? Please indicate how much you agree with the following statements by selecting one level for each statement below.

	Strongly Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
They grow faster.	○	○	○	○	○
Smart foresters, and the "big guys", plant them.	○	○	○	○	○
They have a higher survival rate	○	○	○	○	○
I saw advanced genetics trees (in photos or in person) and could see the difference.	○	○	○	○	○
They produce superior log quality and a higher proportion of saw timber.	○	○	○	○	○
The numbers are favorable, including growth and yield and financial outcomes.	○	○	○	○	○
The advanced genetics seedlings were best suited to my site conditions.	○	○	○	○	○
I tested advance genetics seedlings myself and was pleased with the results.	○	○	○	○	○
They were recommended by someone I trust.	○	○	○	○	○

Page Break

Q7 Please select all of the following that apply to you. Assume that “genetically advanced” refers to controlled mass pollinated or varietal/clonal seedlings. In the past five years:

- ☐ Some of my colleagues or peers have chosen genetically advanced loblolly pine seedlings for lands they managed or consulted on
- ☐ I have recommended to others that they should plant genetically advanced loblolly pine seedlings
- ☐ I have heard a lot of discussion and seen a lot of information about genetically advanced loblolly pine seedlings
- ☐ None of these apply to me

Page Break

Q8 How would you describe your overall opinion of genetically advanced loblolly pine seedlings (controlled mass pollinated or varietals/clonals)?

- ○ Extremely Favorable
- ○ Somewhat Favorable
- ○ Don't know enough to form an opinion
- ○ Somewhat Unfavorable
- ○ Extremely Unfavorable

End of Block: Experience with Genetically Advanced Loblolly Pine Seedlings

Start of Block: Factors Influencing Seedling Selection

Display This Question:

If Are you ever involved in the selection of loblolly pine seedlings to plant on privately held land? = Yes

Q9 Which of the following fits you best? (Please choose one.)

- ○ I think the type of seedling you plant will largely determine how productive and profitable a stand will be
- ○ I think factors other than seedling type, such as site conditions and stand management, are more important in how productive and profitable a stand will be
- ○ I think seedling type and the other factors are about the same importance in how productive and profitable a stand will be

Page Break

Display This Question:

If Are you ever involved in the selection of loblolly pine seedlings to plant on privately held land? = Yes

Q10 When selecting loblolly pine seedlings, how important are the following attributes to you? Please select a level of importance for each of the tree attributes below.

	Very Important	Important	Neutral	Unimportant	Very Unimportant
Forking	○	○	○	○	○
Straightness	○	○	○	○	○
Rust-resistance	○	○	○	○	○
Other disease resistance	○	○	○	○	○
Growth and yield	○	○	○	○	○
Survival	○	○	○	○	○
Superior log quality	○	○	○	○	○

Page Break

Display This Question:

If Are you ever involved in the selection of loblolly pine seedlings to plant on privately held land? = Yes

Q11 Which of the following financial considerations weigh most heavily when making decisions about planting loblolly pines on the lands you manage or consult on? Please select a level of importance for each of the considerations below.

	Very Important	Important	Neutral	Unimportant	Very Unimportant
Expected rate of return, revenue, and cash flow	○	○	○	○	○
Site prep and planting cost	○	○	○	○	○
Seedlings cost	○	○	○	○	○
Thinning and clearcut age	○	○	○	○	○
Current market prices for timber	○	○	○	○	○
Availability of cost-share programs	○	○	○	○	○

End of Block: Factors Influencing Seedling Selection

Start of Block: Carbon Revenue

Q14 How would you rate your level of knowledge about programs that pay landowners for carbon stored on their land?

- ○ Extremely Knowledgeable
- ○ Very Knowledgeable
- ○ Moderately Knowledgeable
- ○ Not Very Knowledgeable
- ○ Not at all Knowledgeable

Page Break

Q15 How would you describe your overall opinion of programs that pay landowners for the amount of carbon stored on their land?

- ○ Extremely favorable
- ○ Somewhat favorable
- ○ Don't know enough to form an opinion
- ○ Somewhat unfavorable
- ○ Extremely unfavorable

Page Break

Q12 If a landowner could receive extra income for the carbon stored on their forested acres, but there were some up-front costs and administrative hurdles involved, what do you think is the minimum amount of additional profit (per acre) that would make it worthwhile?

- ○ $50/ac
- ○ $100/ac
- ○ $150/ac
- ○ $200/ac
- ○ $250/ac
- ○ more than $250/ac

Page Break

Display This Question:

If Are you ever involved in the selection of loblolly pine seedlings to plant on privately held land? = Yes

Q13 If planting controlled mass pollinated seedlings or varietals/clonals increased the amount of money a landowner could make from the carbon stored on his land, would that make you more likely to recommend them or choose them for planting?

- ○ Yes
- ○ No

End of Block: Carbon Revenue

Start of Block: Landowner Profile

Q16 How long have you been working as a forestry professional? Please slide the bar to the appropriate number.

	0	10	20	30	40	50	60
number of years							

Q17 How many years have you been registered as a forester in Georgia? Please slide the bar to the appropriate number.

	0	10	20	30	40	50	60
number of years							

Page Break

Q18 How many acres of forestland in Georgia are you currently managing? Please slide the bar to the appropriate number.

More than 25000

	0	5000	10000	15000	20000	25000
number of acres						

Q19 How many acres of the forestland you are managing in Georgia is planted loblolly pine? Please slide the bar to the appropriate number.

More than 25000

	0 5000 10000 15000 20000 25000
number of acres	

Page Break

Q20 How many acres of the loblolly pine you are managing is planted with advanced genetics seedlings (either controlled mass pollinated or varietals/clones)? Please slide the bar to the appropriate number.

More than 25000

	0 5000 10000 15000 20000 25000
number of acres	

Page Break

Q21 Do you own your own forestland in GA?

- ○ Yes
- ○ No

Display This Question:

If Do you own your own forestland in GA? = Yes

Q22 How many acres of forestland you currently own (Georgia only)? Please slide the bar to the appropriate number.

	More than 1000
	0 200 400 600 800 1000
number of acres	

Page Break

Display This Question:

If Do you own your own forestland in GA? = Yes

Q23 How many land parcels is your land divided into? Please slide the bar to the appropriate number.

	More than 20
	0 5 10 15 20
number of parcels	

Display This Question:

If Do you own your own forestland in GA? = Yes

Q24 Across how many counties is your land distributed? Please slide the bar to the appropriate number.

	More than 10
	0 2 4 6 8 10
number of counties	

Page Break

Q27 Please indicate your gender:

○ Male

○ Female

○ Other ____

Q28 Please indicate your current age by sliding the bar to the appropriate number.

	Over 100
	18 34 51 67 84 100
age in years	

Page Break

Q29 What is your current employment status?

- Full-Time
- Part-Time
- Retired
- Unable to work due to disability
- Unemployed
- Prefer Not to Say

Page Break

Q30 Please indicate your current annual income

- less than $25,000
- $25,000-$49,000
- $50,000-$99,999
- $100,000-199,999
- $200,000+
- Prefer Not to Say

Page Break

Q31 Please indicate the highest level of education you have completed:

- ○ High School
- ○ Associate
- ○ Bachelors
- ○ Graduate
- ○ Prefer Not to Say

Page Break

Q32 Please indicate your race.

- ○ Asian
- ○ Black
- ○ Native American
- ○ White
- ○ Prefer Not to Say

Q33 Please indicate your ethnicity

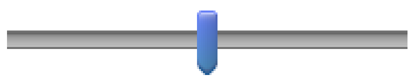
◯ Hispanic

◯ Non-Hispanic

◯ Prefer Not to Say

Page Break

Q34 Please rate your willingness to take risks with your timber operation, such as implementing new technologies or procedures, on a scale from 1 to 10, where 1 indicates completely unwilling to take risks and 10 indicates completely willing to take risks. (Slide the marker along the bar to indicate the number.)



012345678910

End of Block: Landowner Profile

APPENDIX B – LANDOWNER SURVEY QUESTIONS

Advanced Pine Genetics - Landowner

Start of Block: Experience with Genetically Advanced Loblolly Pine Seedlings

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Q41 The goal of this survey is to learn more about the adoption rate and perceptions related to genetically advanced loblolly pine seedlings. We also hope to better understand how Georgia landowners select the tree seedlings that they plant on their land. Your responses will help us gain important insights into what type of seedlings are being planted and the factors that go into choosing a tree seedling. If you have already responded to the related survey sent to Georgia foresters between Mar. 22 and Apr. 12, please do not respond to this one. Likewise, if you receive this survey from more than one source, please only respond once. We estimate that this survey will take 10-15 minutes. Participation is voluntary. You can refuse to take part, and you can stop at any time without penalty. The survey is anonymous—it does not ask for your name or other information that could identify you. All of your survey responses will be confidential and will only be used for the research purposes stated above. If you have questions about this research, please feel free to contact Matt Pruitt at 706-296-9457, or at mkpruitt@uga.edu. You can also reach out to Dr. Puneet Dwivedi (puneetd@uga.edu) for clarifications. If you have any complaints or questions about your rights as a research volunteer, contact the University of Georgia's Institutional Review Board (IRB) at 706-542-3199 or by email at IRB@uga.edu.

○ I have read the information above and agree to participate in the survey.

Page Break

Q42 This survey is seeking information from landowners who own forestland in Georgi. Do you own forestland in Georgia?

- Yes
- No

Skip To: End of Survey If This survey is seeking information from landowners who own forestland in Georgia. Do you own fore... = No

Page Break

Q46 Are you a registered tree farmer with the American Tree Farm System (ATFS)?

- Yes
- No

Page Break

Q2 Do you primarily opt for natural regeneration on your forestlands?

- Yes
- No

Skip To: End of Survey If Do you primarily opt for natural regeneration on your forestlands? = Yes

Page Break

Q1 Are you ever involved in the selection of loblolly pine seedlings to plant on your land?

- ◯ Yes
- ◯ No

Page Break

Display This Question:

If Are you ever involved in the selection of loblolly pine seedlings to plant on your land? = No

Q3 Who selects the loblolly pine seedlings to plant on your land?

- ◯ Land manager
- ◯ Professional forester/forestry consultant
- ◯ Other ____

Skip To: End of Survey If Who selects the loblolly pine seedlings to plant on your land? = Land manager

Skip To: End of Survey If Who selects the loblolly pine seedlings to plant on your land? = Professional forester/forestry consultant

Skip To: End of Survey If Who selects the loblolly pine seedlings to plant on your land? = Other

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Page Break

Q4 How would you rate your knowledge of the genetic varieties of loblolly pine seedlings (open-pollinated, controlled mass-pollinated, and varietals/clones)?

- ◯ Extremely knowledgeable
- ◯ Very knowledgeable
- ◯ Moderately knowledgeable
- ◯ Not very knowledgeable
- ◯ Not knowledgeable at all

Skip To: Q6 If How would you rate your knowledge of the genetic varieties of loblolly pine seedlings (open-polli... = Not knowledgeable at all

---

Q5 Where does your knowledge about the different genetic varieties of loblolly pine seedlings come from? Please select all that apply:

- [ ] Direct experience in selecting them for purchase
- [ ] Discussions with other landowners
- [ ] Information or presentations from state agencies
- [ ] Information or presentations from seed companies
- [ ] Discussions with professional foresters or land managers
- [ ] Journals, newsletters, or other industry publications
- [ ] Other ____

Page Break

Display This Question:

If Are you ever involved in the selection of loblolly pine seedlings to plant on your land? = Yes

Q6 Have you chosen controlled mass pollinated loblolly pine seedlings or varietals/clonals to plant on your land?

- ○ Yes
- ○ No

Page Break

Display This Question:

If Have you chosen controlled mass pollinated loblolly pine seedlings or varietals/clonals to plant... = No

Q7 If you have planted open pollinated loblolly pine seedlings in the past, then why haven't you purchased the more genetically advanced tree seedlings (controlled mass pollinated or varietal/clonal)? Indicate how much you agree with the following statements by choosing one level for each statement below.

	Strongly Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
It's purely due to cost.	○	○	○	○	○
If land is of poor soil quality, I believe that it isn't suited for advanced genetics seedlings.	○	○	○	○	○
I'm watching how advanced genetic trees perform the next few years and gathering more information about them.	○	○	○	○	○
I know what works on my land. I'm staying with what has always grown on it.	○	○	○	○	○
My local timber prices are low, and I may not get the return I need.	○	○	○	○	○
Genetic diversity is important, and I'm worried you lose that with advanced genetics.	○	○	○	○	○
In my view, the advance genetics trees are not that much better than the open pollinated ones.	○	○	○	○	○
A trusted source recommended against them.	○	○	○	○	○

Display This Question:

If Have you chosen controlled mass pollinated loblolly pine seedlings or varietals/clonals to plant... = Yes

Q8 If you have planted genetically advanced loblolly pine seedlings (controlled mass pollinated and varietal/clonal), what led you to choose these? Please indicate how much you agree with the following statements by selecting one level for each statement below.

	Strongly Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
They grow faster.	○	○	○	○	○
Smart foresters, and the “big guys”, plant them.	○	○	○	○	○
They have a higher survival rate	○	○	○	○	○
I saw advanced genetics trees (in photos or in person) and could see the difference.	○	○	○	○	○
They produce superior log quality and a higher proportion of saw timber.	○	○	○	○	○
The numbers are favorable, including growth and yield and financial outcomes.	○	○	○	○	○
The advanced genetics seedlings were best suited to my site conditions.	○	○	○	○	○
I tested advance genetics seedlings myself and was pleased with the results.	○	○	○	○	○
They were recommended by someone I trust.	○	○	○	○	○

Page Break

Q9 Please select all of the following that apply to you. Assume that “genetically advanced” refers to controlled mass pollinated or varietal/clonal seedlings. In the past five years:

- ☐ Some of my friends, peers, or colleagues have chosen to plant genetically advanced loblolly pine seedlings on their land
- ☐ I have recommended to others that they should plant genetically advanced loblolly pine seedlings
- ☐ I have heard a lot of discussion and seen a lot of information about genetically advanced loblolly pine seedlings
- ☐ None of these apply to me

Page Break

Q10 How would you describe your overall opinion of genetically advanced loblolly pine seedlings (controlled mass pollinated or varietals/clonals)?

- ○ Extremely favorable
- ○ Somewhat favorable
- ○ Don't know enough to form an opinion
- ○ Somewhat unfavorable
- ○ Extremely unfavorable

End of Block: Experience with Genetically Advanced Loblolly Pine Seedlings

Start of Block: Factors Influencing Seedling Selection

Display This Question:

If Are you ever involved in the selection of loblolly pine seedlings to plant on your land? = Yes

Q11 Which of the following fits you better? Please choose one.

- ◯ I feel confident in making decisions on my own about what type of tree seedlings to buy.
- ◯ I rely heavily on advice and guidance from others when choosing what seedlings to plant.

Page Break

Q45 Which of the following fits you best? Please choose one.

- ◯ I think the type of seedling you plant will largely determine how productive and profitable a stand will be
- ◯ I think factors other than seedling type, such as site conditions and stand management, are more important in how productive and profitable a stand will be
- ◯ I think seedling type and the other factors are about the same importance in how productive and profitable a stand will be

Page Break

Display This Question:

If Are you ever involved in the selection of loblolly pine seedlings to plant on your land? = Yes

Q12 When selecting loblolly pine seedlings, how important are the following attributes to you? Please select a level of importance for each of the tree attributes below.

	Very Important	Important	Neutral	Unimportant	Very Unimportant
Forking	○	○	○	○	○
Straightness	○	○	○	○	○
Rust-resistance	○	○	○	○	○
Other disease resistance	○	○	○	○	○
Growth and yield	○	○	○	○	○
Survival	○	○	○	○	○
Superior log quality	○	○	○	○	○

Page Break

Display This Question:

If Are you ever involved in the selection of loblolly pine seedlings to plant on your land? = Yes

Q13 When evaluating which loblolly pine seedlings to plant, who influences your decision? Please select the level of influence for each choice below that reflects how much input they have.

	Extremely Influential	Very Influential	Moderately Influential	Not Very Influential	Not at all Influential
Family members	○	○	○	○	○
Forestry consultant(s)	○	○	○	○	○
Seedling company rep(s)	○	○	○	○	○
Nursery personnel	○	○	○	○	○
Other landowners you know	○	○	○	○	○
Extension office	○	○	○	○	○

Page Break

Display This Question:

If Are you ever involved in the selection of loblolly pine seedlings to plant on your land? = Yes

Q14 Which of the following financial considerations weigh most heavily when making decisions about planting trees on your land? Please select a level of importance for each of the considerations below.

	Very Important	Important	Neutral	Unimportant	Very Unimportant
Expected rate of return, revenue, and cash flow	○	○	○	○	○
Site prep and planting cost	○	○	○	○	○
Seedlings cost	○	○	○	○	○
Thinning and clearcut age	○	○	○	○	○

Q44 How important is the availability of cost-share programs, such as those offered by NRCS or state agencies, in selecting which type of trees to plant on your land?

	Very Important	Important	Neutral	Unimportant	Very Unimportant
Importance of cost-share	○	○	○	○	○

End of Block: Factors Influencing Seedling Selection

Start of Block: Carbon Revenue

Q17 How would you rate your level of knowledge about programs that pay landowners for carbon stored on their land?

- ○ Extremely knowledgeable
- ○ Very knowledgeable
- ○ Moderately knowledgeable
- ○ Not very knowledgeable
- ○ Not knowledgeable at all

Page Break

Q18 How would you describe your overall opinion of programs that pay landowners for the amount of carbon stored on their land?

- ○ Extremely favorable
- ○ Somewhat favorable
- ○ Don't know enough to form an opinion
- ○ Somewhat unfavorable
- ○ Extremely unfavorable

Page Break

Q15 If you could receive extra income for the carbon stored on your forested acres, but there were some up-front costs and administrative hurdles involved, what is the minimum amount of additional profit (per acre) that would make it worthwhile?

◯ $50/ac

◯ $100/ac

◯ $150/ac

◯ $200/ac

◯ $250/ac

◯ more than $250/ac

Page Break

Q16 If planting controlled mass pollinated seedlings or varietals/clonals increased the amount of money you could make from the carbon stored on your land, would that make you more likely to plant them?

◯ Yes

◯ No

Page Break

End of Block: Carbon Revenue

Start of Block: Landowner Profile

Q19 Please indicate how long you have owned your current forestland(s) in Georgia by sliding the bar to the appropriate number. Include only your tenure as owner, not previous family generations.

	0	15	30	45	60
number of years					

Q20 Please indicate the total forestland you currently own in Georgia by sliding the bar to the appropriate number.

More than 1000

	0	200	400	600	800	1000
number of acres						

Page Break

Q21 a. How many land parcels is this land divided into? Please slide the bar to the appropriate number.

More than 20

	0	5	10	15	20
number of parcels					

Q22 b. Across how many counties is this land distributed? Please slide the bar to the appropriate number.

	More than 10
	0 2 4 6 8 10
number of counties	

Page Break

Q23 How many acres of your forestland in Georgia is planted loblolly pine? Please slide the bar to the appropriate number.

	More than 1000
	0 200 400 600 800 1000
number of acres	

Q24 How many acres of the planted loblolly pine were planted with advanced genetics seedlings (either controlled mass pollinated or varietals/clones)? Please slide the bar to the appropriate number.

	More than 1000
	0 200 400 600 800 1000
number of acres	

Page Break

Q25 Do you reside on your forestland located in Georgia?

◯ Yes

◯ No

Display This Question:

If Do you reside on your forestland located in Georgia? = Yes

Q26 How many months per year do you reside at your forestland? Please slide the bar to the appropriate number.

	0 1 2 4 5 6 7 8 10 11 12
number of months	

Page Break

Display This Question:

If Do you reside on your forestland located in Georgia? = No

Q27 How far do you live from your forestland in Georgia (or the forestland you visit the most if you have multiple parcels)? Please slide the bar to the appropriate number.

	0 100 200 300 400
distance in miles	

Page Break

Q28 Overall, does the majority (higher than > 50%) of your annual income come from your forestland?

◯ Yes

◯ No

Page Break

Q29 Please indicate your gender:

◯ Male

◯ Female

◯ Other ____

Q30 Please indicate your current age by sliding the bar to the appropriate number.

	Over 100
	18 34 51 67 84 100
age in years	

Page Break

Q31 What is your current employment status?

- ○ Full-Time
- ○ Part-Time
- ○ Retired
- ○ Unable to work due to disability
- ○ Unemployed
- ○ Prefer Not to Say

Page Break

Q32 Please indicate your current annual household income:

- less than $25,000
- $25,000 - $49,000
- $50,000 - $99,999
- $100,000 - 199,999
- $200,000+
- Prefer Not to Say

Page Break

Q33 Please indicate the highest level of education you have completed:

- ○ High School
- ○ Associate
- ○ Bachelors
- ○ Graduate
- ○ Prefer Not to Say

Page Break

Q34 Please indicate your race.

- ○ Asian
- ○ Black
- ○ Native American
- ○ White
- ○ Prefer Not to Say

Page Break

Q35 Please indicate your ethnicity

- ○ Hispanic
- ○ Non-Hispanic
- ○ Prefer Not to Say

Page Break

Q36 Please indicate the extent to which each personality trait below describes you. Choose one level for each trait.

	Fits you perfectly	Fits you somewhat	Does not apply to you at all
Require proof, prefer to wait-and-see	○	○	○
Analytical, closely review information available	○	○	○
Strong sense of connection to the forestry community, engaged in my community	○	○	○
Independent, self-reliant	○	○	○
Open to new experiences, like to try new things	○	○	○
Financially driven, focused on success	○	○	○
Traditional, most comfortable with tried-and-true methods	○	○	○
Rely on experts or others more qualified than me when it makes sense	○	○	○
Do it right or don't bother, only the best will do	○	○	○

Page Break

Q37 Please rate your willingness to take risks with your timber operation, such as implementing new technologies or procedures, on a scale from 1 to 10, where 1 is completely unwilling to take risks and 10 is completely willing to take risks. Slide the marker along the bar to indicate the number.

End of Block: Landowner Profile