Virginia Logging Business Economic Sustainability Survey Including Perspectives from Across the Forest-based Supply Chain.

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ABSTRACT

Logging businesses are an essential component of the forest-based supply chain. They are the connection between forest landowners, who grow the raw materials, and forest product mills that produce primary forest products. They are confronted with many operational challenges and issues that can make operating sustainably, producing a profit, and obtaining long-term economic viability seem unattainable. Although other businesses have similar operational challenges, logging businesses are somewhat unique in that they have minimal influence over delivered prices or the cost of stumpage, so changes in variable input costs can have large impacts on businesses' economic sustainability. Logging business operational challenges include increasing input costs such as equipment purchase costs, fuel costs, and equipment maintenance and repair costs. The economic sustainability of logging businesses affects the entire forest-based supply chain because one segment cannot function successfully without the others. This project evaluated operational characteristics, challenges, and issues related to the economic sustainability of logging businesses in Virginia from May through July 2023. A comparison was conducted using opinions and perspectives from professionals in other segments of the forest-based supply chain, on their outlook for the logging industry in Virginia concerning economic sustainability. Mail questionnaires, following the *Dillman Method,* were used to collect data from the survey populations which included logging business owners,

consulting foresters (landowner representatives), and mill owners or procurement representatives.

The response rates for logging businesses, mills, and consultant foresters were 27, 40, and 69 percent respectively. The top two challenges logging businesses faced in Virginia were fuel related. The number one challenge reported by logging businesses was fuel costs for in-woods harvesting equipment followed by fuel costs for trucks. Only 32.9% of logging businesses reported they were profitable in the past year. Only 26.1% of businesses had an outlook that their business was economically sustainable while 38.8% reported that their business was not sustainable. A greater percentage of mills (56.3%) and consultants (68.9%) reported their outlook for logging businesses was not economically sustainable. There were many neutral perspectives from all populations, however small positive changes in market conditions could move responses to the positive side of neutral. This study identifies the challenges in the industry as well as perspectives on the future of the forest industry's economic sustainability. The results of the study should be used as a catalyst encouraging segments of the industry to work together to address challenges and find solutions.

Virginia Logging Business Economic Sustainability Survey Including Perspectives from Across the Forest-based Supply Chain.

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GENERAL AUDIENCE ABSTRACT

Logging businesses are an essential component of the forest-based supply chain as they are the connection between forest landowners, who grow the raw materials, and forest product mills that produce primary forest products. They are confronted with many operational challenges and issues that can make operating sustainably, producing a profit, and obtaining long-term economic viability seem unattainable. However, the economic sustainability of logging businesses affects the entire forest-based supply chain because one segment cannot function successfully without the others. This project evaluated operational characteristics, challenges, and issues related to the economic sustainability of the logging businesses, including the perspectives from professionals across the forest-based supply chain. A mail survey, following the Dillman method, was used to collect data from the three populations; logging business owners, consulting foresters (landowner representatives), and mill owners or procurement representatives.

The response rates for logging businesses, mills, and consultants were 27, 40, and 69 percent respectively. The number one challenge reported by logging businesses was fuel costs for in-woods harvesting equipment. Logging businesses reported that only 32.9% were profitable in the past year. Only 26.1% of businesses had an outlook that their business was economically sustainable while 38.8% reported that their business was not sustainable. A

greater percentage of mills (56.3%) and consultants (68.9%) reported their outlook for logging business economic sustainability was not sustainable. There were many neutral perspectives from all populations, and small positive changes in market conditions could move responses to the positive side of neutral. This study identifies the challenges in the industry as well as perspectives on the future of the forest industry's economic sustainability. The results of the study should be used as a catalyst encouraging segments of the industry to work together to address challenges and find solutions.

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INTRODUCTION

Virginia has approximately 16 million acres of forestland, the largest percentage (59%) owned by private individuals followed by corporate, public entities, and forest industry (Forest Resource Information 2023). Forestry is the third largest industry in Virginia contributing more than 23.6 billion dollars annually to the commonwealth and employing over 108,000 Virginian's (Rephann 2022). The forest-based supply chain includes landowners involved in growing timber, logging businesses harvesting and delivering wood to mills, and the mills producing primary wood products. Logging businesses are the essential link connecting the landowners to mills and supplying the raw materials needed to satisfy the demand in the supply chain. However, there are many who are concerned about the future of the forest industry in Virginia. Challenges include an aging workforce coupled with difficulty recruiting new employees, and difficulty making a profit due to increased operational costs (Kingsley 2022). Additionally, operating at reduced capacities, load quotas, lack of markets, and mill closures raise concern within the industry (Altizer 2024). These operational challenges, along with others, have affected areas of the forest-based supply chain (O'Hara 2021).

The three pillars of sustainability are environmental, social, and economic. The forest-based supply chain experiences challenges in all three areas of sustainability, especially logging businesses. They operate in continuously changing environments caused by seasonal shifts and unexpected weather conditions. Numerous studies have been conducted focused on the environmental sustainability of logging practices such as soil and water quality impacts (Aust and Blinn 2004) and Best Management Practice implementation (Cristan et al. 2018) Research has also been conducted that focused on social impacts regarding logging activities (Minter et

al. 2023), and a few studies included small sections with results on challenges related to economic sustainability with ranked challenges (Allen et al. 2008, Baker and Greene 2008).

Most research regarding the challenges faced by loggers simply list the challenges, problems, or concerns mentioned by survey respondents, usually to open ended type questions. A Southern New England survey found fuel prices, equipment and insurance costs, stumpage prices, shrinking forestland, and harvesting regulations were challenges faced by the logging industry (Egan 2011). In Virginia, logging business owners reported a wide range of answers when asked what the biggest problem they were confronted with was such as markets for their products, increasing operational costs, declining wood markets, fuel prices, and the future of the profession such as recruiting qualified employees (Bolding et al. 2010). However, no research found during the literature review focused specifically on obtaining perspectives from the entire forest-based supply chain regarding the economic state of logging businesses or the entire logging industry. The survey would provide a current snapshot and insight into the economic sustainability of the logging industry. It will provide the industry with a starting point which will help bring together different groups to work together to address the current perceived challenges and find solutions. The hope is that the survey is a catalyst for change and that results show areas of need for follow-up research.

For this study, the main focus was on logging businesses and their perspectives on economic sustainability and economic challenges. However, all segments of the supply chain rely on each other to operate successfully and without one producing final forest products would be extremely difficult. Therefore, we believed that it was important to gain perspectives from forest landowners and mills related to their perspectives on the economic sustainability of

logging businesses and the logging industry. The segments of the forest-based supply chain were defined as Virginia logging business owners, consulting foresters (landowner representatives), and procurement representatives or mill owners. The segments of the forest-based supply chain became the three survey populations used for the study. The primary goal of this study was to evaluate perspectives on the economic sustainability of logging businesses in Virginia from participants across three segments of Virginia's forest-based supply chain. Additionally, we determine opinions and perspectives of logging business owners related to the challenges and issues surrounding the economic sustainability of logging businesses in Virginia. The study also focused on comparing perspectives from professionals across segments of the forest-based supply chain, on their outlook for logging businesses and the logging industry in Virginia concerning their economic sustainability.

1.1 Literature Review

No logging operations are exactly the same. There are many system characteristics that make each individual logging business different. The harvesting equipment or systems they use are selected based on several characteristics such as products they harvest, terrain where they work, and even mill specifications (e.g. ability to unload trucks). The production rate of each operation can be vastly different and depends on a set of characteristics such as number of machines, number of employees, and downtime (seasonal or mechanical). The different characteristics of logging businesses found during the literature review process were used in creating the list of challenges logging businesses face (Table 2.3). The characteristics were also used to determine if differences in responses to questions were present throughout the survey.

1.1.1 Forest Harvesting Operations

1.1.1.1 Harvesting Systems

The type of harvesting system a logging business uses is an operational characteristic that could be a factor in the business economic sustainability. There are three major categories of harvesting systems which include whole-tree, tree-length, and cut-to-length (Conrad et al. 2018). The harvesting system used varies by region of the United States. In Wisconsin and Michigan's upper peninsula cut to length operations using harvesters and forwarders consisted of 39% of logging businesses (Rickenbach et. al 2005). However, approximately one third of those businesses utilize chainsaws as their method of felling (Rickenbach et al. 2005, Abbas et al. 2014). In West Virgnia 83% and 63% of logging businesses used chainsaw as their primary method used for felling and delimbing and bucking respectively (Milauskas and Wang 2006). Topography in the Mountains of Virginia makes chainsaws the dominant felling equipment (Bolding et al. 2010).

The most common harvesting system in Virginia and the Southeast is a whole tree harvesting system. The Piedmont and Coastal Plain of Virginia as well as much of the Southeastern United States is dominated by fully mechanized high production operations in order to meet the demand of forest product mills. Harvesting system functions include felling, extraction, in-woods processing, loading, and transportation. In Georgia, more than 80% of harvesting systems utilized feller-buncher and grapple skidders (Baker and Greene 2008). Throughout the Southeast a whole-tree harvesting system consists of rubber-tired feller-bunchers for felling, grapple skidders for extraction, pull-through delimber and slasher saw for in-woods processing, trailer mounted knuckleboom for loading, and tractor trailer for

transportation (Bolding et al. 2010). Differences associated with the amount the business has invested in their equipment could have an effect on logging businesses' profitability and economic sustainability.

1.1.1.2 Production Rates

Production rates per logging businesses and per logging crew members vary greatly across regions of the United States. Based on published research, the most productive logging businesses are in the Southeast. Operations in Georgia and South Carolina harvest over 70,000 tons of wood annually (Conrad et al. 2018). Meanwhile in Minnesota, logging businesses harvest between 100 and 138,393 cords and average 9,518 cords annually (Blinn et al. 2015). According to *Keegan et al. 2006*, the annual harvest volume for Montana and Idaho in 2004 was 702,394 and 1,236,985 board feet respectively (Allen et al. 2008). Logging production rates as well as harvest type also vary within states. In Virginia, the logging operations in the Mountains were the least productive at 13,750 tons annually, followed by the Piedmont (28,125 tons), and the most productive region, the Coastal Plain (40,250 tons) (Bolding et al. 2010). Environmental and topographical conditions influence these varying production rates. Moderate terrain, and pine plantation harvests are the main reasons for the high production rates in the Southeastern United States.

Annual production is affected by seasonal downtime. In the northern regions, logging businesses have always experienced seasonal downtime due to spring thaw, but recent research indicates that seasonal downtime is increasing, which in turn causes the number of productive days to decrease (Conrad et al. 2018). Forty-nine percent of loggers from Minnesota reported that they did not produce any volume during the spring (Blinn et al. 2019). According

to *Conrad et al. 2018*, nearly three-quarters of loggers in a recent Wisconsin study did not harvest timber during six weeks of spring thaw. The expectation for the study was to find results similar to Bolding et al. 2010, with the Mountains region being the least productive and the Coastal Plain being the most productive. Production rate (tons per week) was used in the study along with other general logging business characteristics when analyzing survey responses.

1.1.2 Utilizing Surveys to Characterize Logging Businesses

1.1.2.1 Logging Surveys

Surveys, especially mail surveys, are a common way to obtain information from logging businesses. One of the most common mail survey methods, and the one used for this survey, is the Dillman Method with multiple points of contact (Dillman 1991). Mail surveys are common in the forest industry because many loggers don't regularly use email for business communication. Surveys are used because they are a cost-effective way to gather information from a large group of individuals at the same time. However, surveys are more useful if you can generalize the responses to the entire population and response rates are a good measure of generalizability. Survey response rates have varied across the United States and show no consistent patterns (Conrad et al. 2018). Logger survey response rates range from 19.5 to 24% in South Carolina and Georgia (Baker and Greene 2008, Conrad et al. 2018), 57.3% in Minnesota (Blinn 2015), 28% in Michigan (Abbas et al. 2014), 59% in Wisconsin and Michigan's Upper Peninsula, 21% to 32% in the Northeast (Egan 2005, 2009, 2011), 35% in the Northwest (Allen 2008), 4% to 27.4% in West Virginia (Egan et al. 1997, Luppold et al. 1998, Milauskas and Wang 2006), 47% to 58.8% in Virginia (Barrett et al. 2014, Barrett et al. 2017, Bolding et al. 2010).

What is considered to be an acceptable response rate varies based on factors such as whether it is a mail or email survey. According to one source, a response rate between five percent and 30% is considered acceptable and above 30% is considered excellent (Masson 2023). While another source says an acceptable response rate for mail surveys falls between 30% and 40% (What is a good response rate for a mail survey 2020). There are no defined thresholds for “good” or “great” response rates. However, the presence of nonresponse bias can be tested using wave analysis (Armstrong and Overton 1977). Wave analysis is commonly used to assess nonresponse bias when conducting survey research (Conrad et al. 2018, and Bowman et al. 2023). If there is no presence of nonresponse bias found, then the responses to the survey can be generalized to the entire population.

Logger surveys have been conducted to capture a broad range of information such as assessment of the logging sector (Blinn et al. 2015, Rickenbach et al. 2005, Allen 2008, G.C. and Potter-Witter 2011), sustainability and best management practice implementation (Kelly et al. 2017, McConnell 2013, Montgomery et al. 2005), harvesting practices (Egan 2001, McNeel and Dodd 1996), and harvesting residues and bioenergy (Dirkswager et al. 2011, Barrett et al. 2014). Surveys have been conducted that focus on logging business succession (Egan and Taggart 2004, Broussard Allred 2009), challenges to the logging sector (Egan 2011, Bowman et al. 2023), logger certification and training (Egan 1997, Egan 2005), parcelization (Moldenhauer and Bolding 2009), and other areas that impact logging (Abbas 2014, Bolding et. al 2010). Not only have surveys been conducted by universities (Barrett et al. 2017, Conrad et al. 2018), but they have also been conducted by industry associations such as the American Pulpwood Association (Cubbage and Carter 1994 and Munn et al. 1998) to study changes in the logging industry.

Surveys of logging businesses and logging business owners have been conducted for decades to characterize and track changes over time (Baker and Greene 2008, Barrett et.al. 2017, Conrad et al. 2018).

1.1.2.2 Logging Employment

A publication by Conrad et al. 2018 indicated that logging employment overall has decreased from 1990 to 2016. In the 26 years between 1990 to 2016, logging employment decreased from approximately 86,000 to approximately 51,000, a decline of 2.0% per year (Conrad et al. 2018). Although the number of loggers has been decreasing overtime factors have been attributed to accelerating the decline including three recessions (1990 to 1991, 2001, and 2007 to 2009) and increased labor productivity due to improved mechanization (Conrad et al. 2018). According to a Minnesota logging business survey, "the percentage of volume felled using a chainsaw has continued to drop over time from a high of 27% in the 1991 survey. The percentage of volume felled with a cut-to-length harvester has tripled since the 1996 survey" (Blinn et al. 2015). The outlook for logging employment is not expected to increase. The number of logging workers (fellers, equipment operators, graders and scalers, and all others) in 2023 was 49,800 and projected employment for the year 2033 is 47,600 a decrease of four percent (-2,200) (U.S. BLS 2024). The ability to find and retain logging employees could be a factor affecting economic sustainability and is a challenge logging businesses have been facing for years.

1.1.2.3 Operational Challenges and Concerns

There are many economic and operational challenges logging businesses encounter. In Virginia, logging business owners reported a wide range of answers when asked what the

biggest problem their business was confronted with. Responses included markets for their products, increasing operational costs, declining wood markets, fuel prices, and the future of the profession such as recruiting qualified employees (Bolding et. al 2010). A Southern New England survey found fuel prices, equipment and insurance costs, stumpage prices, shrinking forestland, and harvesting regulations were all challenges to the logging industry (Egan 2011). Many studies have listed operational challenges but very few have provided an overall ranking to determine a number one challenge. According to the logging sector of the Inland Northwest (Idaho, Montana and Eastern Washington), the highest rated constraint affecting contract logging operations in 2004 was timber sale availability, followed by quality employees, and then stumpage costs (Allen et al. 2008). A 2006 mail survey of New York logging businesses found fuel costs to be the number one barrier to maintaining or expanding business followed by insurance costs and then equipment costs (Egan 2009). A study of Georgia's logging contractors conducted by *Baker and Greene 2008* ranked the largest problems facing logging businesses from 1992 and 2007. The number one challenge in 1992 was insurance, followed by labor, and then general finances. In 2007, fuel price was the number one challenge, followed by labor (remained the same), then logging rates. The challenges and issues identified throughout previous studies were used during the creation of the survey.

1.2 Research Objectives

The primary research objective was to evaluate perspectives on the economic sustainability of logging businesses in Virginia from participants across three segments of Virginia's forest-based supply chain. This was accomplished through the following three subobjectives.

1) Determine opinions and perspectives of logging business owners related to the challenges and issues surrounding the economic sustainability of their businesses.
2) Compare the differences in opinions and perspectives on logging business economic sustainability based on business owner characteristics such as number of years in business, region, size and type of operation, as well as primary markets for products they harvest.
3) Compare opinions and perspectives from across the forest supply chain (landowners, loggers, and mills) on their outlook for logging businesses and the logging industry in Virginia.

Chapter two focuses on the first two subobjectives while chapter three focuses on the third subobjective. However, some data and visual aids discussed in chapter two will also appear in chapter three.

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2.0 PERCEIVED OPERATIONAL CHALLENGES AND ISSUES RELATED TO THE ECONOMIC SUSTAINABILITY OF LOGGING BUSINESSES IN VIRGINIA.

2.1 Abstract

Logging businesses may struggle to be profitable and remain economically sustainable due to the many operational challenges they face. To evaluate the operational challenges and issues related to economic sustainability of logging businesses in Virginia, a survey of all full-time Virginia logging business owners was conducted. Virginia logging business owners reported that less than one third (32.9%) were profitable in the past year while even fewer business owners (26.1%) have an outlook that their business will be economically sustainable. The number one challenge that owners were most concerned about impacting the economic sustainability of their business was fuel costs for in-woods harvesting equipment. The study found that logging business profitability, in the mountains, is driven by markets and significantly depends on the products which they harvest.

Keywords. Logging Business, Survey, Economic Sustainability, Forest-based Supply Chain, Operational Challenges.

2.2 Introduction

Forestry is the third largest industry in Virginia contributing more than twenty-one billion dollars annually to the commonwealth and employing over 100,000 Virginian's (Rephann 2022). However, logging businesses are concerned about the future of the forest industry in Viriginia. They are in a unique position in the forest-based supply chain, where they have minimal control over input costs, or the revenue generated through outputs produced when

wood is delivered to mills. Logging businesses are generally “high-volume, low-margin businesses”, where production is crucial in order to make a profit (Baker 2022). With higher production, an increase in variable input costs such as fuel, regular maintenance, and repairs are needed to operate. Due to inflation, those input costs as well as wages, and insurances make it difficult for businesses to offset costs and make a profit (Baker 2022).

In addition, logging businesses also face challenges such as an aging workforce, difficulty recruiting new employees, decreases in market demand caused by reduced consumption and substitution of forest products, as well as mill quotas, mill closures, and trucking. These challenges have affected all areas of the forest-based supply chain, especially the businesses responsible for harvest and delivery of raw materials. The three pillars of sustainability are environmental, social, and economic. Logging businesses experience operational challenges in all three areas of sustainability. They operate in constantly changing environments with seasonal shifts and unexpected weather conditions. Numerous studies have focused on the environmental sustainability of logging such as soil and water quality impacts (Anderson and Lockaby 2011, Aust and Blinn 2004), and Best Management Practice implementation and implementation costs (Kelly et al. 2017, Cristan et al. 2016, Montgomery et al. 2005, and Cubbage 2004). However, few studies have focused on economic sustainability (Allen et al. 2008), and even fewer have rated the economic challenges (Baker and Greene 2008). Baker and Greene (2008) found that fuel prices, financial returns and finding qualified employees were listed as concerns in Georgia which changed over time from 1992 (Baker and Greene 2008). Other studies have simply listed challenges mentioned by logging business. A Southern New England survey found fuel prices, equipment and insurance costs, stumpage prices, shrinking

forestland, and harvesting regulations were all challenges to the logging industry (Egan 2011). In Virginia, logging business owners reported a wide range of answers when asked what the biggest problem was they were confronted with. Responses included markets for their products, increasing operational costs, declining wood markets, fuel prices, and the future of the profession such as recruiting qualified employees (Bolding et al. 2010). However, no studies found have focused specifically on obtaining perspectives from logging businesses on long-term economic sustainability of logging businesses and ranking logging business challenges in Virginia. The survey provides a snapshot and insight into the economic sustainability of logging businesses. It also provides the industry with a starting point which could help bring together different groups to work together to address the current perceived challenges logging businesses are facing and find solutions. The hope is that the survey is a catalyst for change and that results show areas of need for follow-up research.

Logging businesses are a critical link in the forest supply chain connecting forest landowners, who supply the raw materials, with forest product mills, which produce primary forest products. For this study, we targeted Virginia logging business owners and included two other segments of the supply chain to capture the perspectives of the forest industry as a whole. This research survey was conducted due to the heightened concern for the future of the industry and the minimal economic sustainability research conducted in Virginia.

2.3 Research Objectives

The study's primary research objective was to evaluate perspectives on the economic sustainability of logging businesses in Virginia from participants across the three segments of Virginia's forest-based supply chain. The economic sustainability of logging businesses and the

logging industry implies general profitability and long-term financial viability. The primary research objective had two subobjectives covered in this chapter. 1.) Determine opinions and perspectives of logging business owners related to the challenges and issues surrounding the economic sustainability of their businesses. 2.) Compare the differences in opinions and perspectives on logging business economic sustainability based on business owner characteristics such as number of years in business, region, size and type of operation, as well as primary markets for products they harvest.

2.4 Methods

2.4.1 Area and Population of Interest

A survey of Virginia logging businesses was conducted during the summer of 2023. The questionnaire used for this survey was part of a larger project that will result in the publication of two research papers. The logging business owner survey was the focus of this publication; however, data and visuals used in another publication (Barkman et. al in preparation) will also be discussed, when necessary, throughout this publication.

For this study, we targeted logging businesses primarily operating in Virginia. Loggers that harvest timber in Virginia are required to notify the Virginia Department of Forestry (VDOF) to inform them where and when they are harvesting. The VDOF notification list includes all known timber harvests in Virginia and was assumed to include the entire population of logging businesses operating in Virginia. We focused on full-time logging businesses, so we excluded part-time operations which are generally small-scale and only produce a small proportion of total production. We also wanted one response per business and for the logging business owner or the individual with the most economic understanding of the business to complete the

survey. We selected all full-time logging businesses that reported a harvest for the thirteen months prior to sending out the questionnaires (March 2022– March 2023). After removing duplicates, the final survey population consisted of 655 potential logging businesses.

2.4.2 Survey contents, development, and distribution

A 2017 Virginia logging survey showed that just over half of logging businesses regularly utilize email for their business operations (Barrett et al. 2017). Therefore, we believed that a hard copy mail survey would be the most effective. The questionnaire consisted of one printed tabloid-sized paper (11”x 17”) folded in half (11”x 8.5”) with instructions on the cover page and questions on the remaining two inside pages and back page. There was a total of 28 questions encompassing several question types including multiple choice, fill-in-the-blank, and open-ended. The questions covered a broad range of topics such as business characteristics, challenges and issues logging businesses undergo, relationships with other segments of the forest-based supply chain, and perspectives on the outlook for the logging industry overall.

The survey questionnaires were developed and distributed based on the Dillman Method (Dillman 1991). The Dillman Method is commonly used for survey research within the forest industry (Barrett et al. 2014, Barrett et al. 2017, Bolding et al. 2010, and Bowman et al. 2023). The survey protocol was approved by the Virginia Tech IRB. After receiving IRB approval, the pre-notice letter was mailed May 12th, 2023. The first wave of questionnaires, the follow-up letters, and the second wave of questionnaires (final mailing) were mailed approximately five days, two weeks, and five weeks after the pre-notice letter, respectively. The final return deadline for questionnaires was July 19th, 2023.

2.4.3 Terminology

The survey authors created a list of terminology utilized throughout the questionnaire. Some of the terms were created based on knowledge of the field and others were based on prior definitions used in industry related publications, such as "forest-based supply chain." Prior to creating an entirely new definition, a search was done to determine if the terminology existed in peer reviewed or other literature. The list of terminology is also used in the publication *Barkman et al. in preparation.*

Economic sustainability of logging businesses and the logging industry implies general profitability and long-term financial viability.

Forest-based supply chain refers to the activities involved in forest management, harvesting operations, and transporting of raw materials (Feng and Audy 2020). The definition utilized in this study includes the manufacturing of primary forest products in the supply chain sequence.

Segments of the forest-based supply chain: In this study the three segments refer to logging businesses, forest product mills, and consulting foresters (landowner representatives).

Logging business: Within this paper the term logging business(es) can be used interchangeably or in place of logging business owners.

2.4.4 Data Analysis

Data was de-identified so that no information in the dataset could be used to determine the identity of an individual respondent from the population. The data set was then coded using a numerical sequence and compiled in an Excel spreadsheet (Microsoft Corp 2023). Data was then analyzed using JMP statistical analysis software (JMP® Pro. 2021). The analysis

included descriptive statistics and means testing using parametric methods. Relationships between descriptive statistics and a categorical question were analyzed using a nonparametric (because the data is not normally distributed) multiple comparison, Steel-Dwass All Pairs at an alpha = 0.05 level (Table 2.5). Categorical data was analyzed using a Chi-squared test, and when necessary, such as the Likert type data (sustainability 1-10 and concern 1-5), were transformed, and analyzed using continuous data techniques. The presence of nonresponse bias was tested using wave analysis (Armstrong and Overton 1977). Wave analysis is commonly used to assess nonresponse bias when conducting survey research (Conrad et al. 2018, and Bowman et al. 2023). Independent sample t-tests as well as likelihood ratio Chi-square tests were used, when applicable, to compare the responses from early versus late responders.

2.4.5 Physiographic Regional Designation

Respondents were separated into physiographic regions based on the county they indicated as their center of operation. The counties were grouped into physiographic regions using the U.S. Forest Service regional designations, with the northern and southern Piedmont regions combined into one Piedmont region as well as the northern and southern mountain regions combined into one Mountains region (Cooper et al. 2011). The Mountains region is located on the western side of Virginia (pink), Piedmont is in the center of the state (yellow), and on the eastern side adjoining the Atlantic Ocean, is the Coast Plain (blue) (Figure 2.1). The same physiographic regional boundaries were used in other survey research such as Barrett et al. 2017.

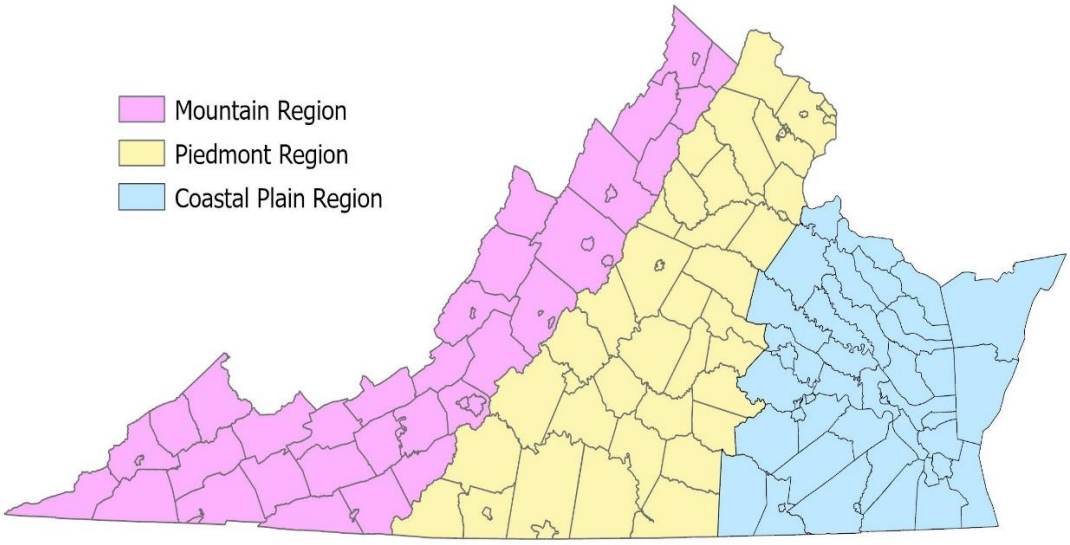

Figure 2.1 Virginia county and regional boundaries used to group logging businesses into physiographic regions (map not to scale).

2.4.6 Unit Conversions Utilized Throughout Survey

Respondents were asked to report their average production in units that they most commonly use, which were tons or truck loads produced per week. However, due to the differences in payload for different truck combinations used, all reported production was converted to a commonly used unit (tons). Production reported in truckloads was converted to tons based on the reported truck configuration the business most commonly uses. A payload conversion factor of 25 tons per truckload was used for tractor-trailers, and tandem or tri-axle trucks with pup trailer (Barrett et al 2017). A payload conversion factor of 9 tons per load was used for single-axle trucks, 14 tons for tandem-axle trucks, and 19 tons for tri-axle trucks (Barrett et al 2017). Based on regional harvesting practices, all production reported by logging businesses was assumed to be green weights.

2.5 Results and Discussion

A total of 168 questionnaires were completed and returned, 26 were undeliverable, and 11 were returned indicating that they were not the owner or primary decision maker of a full-time logging business that primarily operates in Virginia, for a 27.1% response rate. The response rate was comparable to other surveys conducted in the forest industry providing the study with a valid representative sample that is generalizable across the entire population of logging businesses in Virginia (Bowman et al. 2023, Egan and Targgart 2004, Conrad et. at. 2018).

All respondents were asked what county they considered to be the center of their work area and based on the responses; they were separated into a region (Figure 2.1). Of the 168 responses; 44 were located in the Mountains, 85 were located in the Piedmont, and 34 were located in the Coastal Plain. There were no significant differences between early and late responders found when testing age ($p=0.3360$), weekly production ($p=0.2753$), years operating their own business ($p=0.9720$), current equipment investment ($p=0.8043$), outlook for their business ($p=0.6972$), and profitability in the past year ($p=0.5078$). Based on this comparison of early versus late responders, we did not detect any significant differences that would imply substantial concerns related to non-response bias.

Virginia logging business owners are an average of 55 years old. Respondents indicated they have been managing their business for an average of 26.9 years. Average production (tons/week) was reported to be over six times more in the Coastal Plain (2049 tons/week) compared to the Mountains (317 tons/week) region of Virginia. Investment in operation, number of trucks, number of full-time employees, and logging crews were all reported to follow

a similar trend of increasing from the western Mountains region to the eastern Coastal Plain region of Virginia. The trend of increasing investment supports the high production fully mechanized (97%) businesses operating in the Coastal Plain (Table 2.1).

Table 2.1 Reported logging business characteristics for Virginia, overall and by region.

	Mountains		**Piedmont**		**Coastal Plain**		**Overall**	
	Mean	**Standard Deviation**	**Mean**	**Standard Deviation**	**Mean**	**Standard Deviation**	**Mean**	**Standard Deviation**
Age	53	15.5	55	13.7	57	11.8	55	14.0
Tons/week	317	511	707	818	2,049	1,970	872	1,247
Years operated/managed your own business	26.7	16.5	26.7	15.1	24.0	13.0	26.9	15.5
Investment in operation, excluding trucks ($)	573,421	1,107,380	641,753	796,299	1,477,742	1,924,847	802,767	1,225,928
Number of Trucks	2.4	2.8	2.8	2.8	5.9	6.6	3.3	4.1
Number of full-time employees	3.8	9.2	4.7	5.9	12.4	15.4	5.9	9.9
Number of Logging crews per Business	1.1	0.5	1.2	0.6	1.8	1.2	1.3	0.8
Mechanized felling (% of businesses primarily using mechanized felling)	21	-	70	-	97	-	62	-

Respondents were asked to describe the overall profitability of their logging business over the past year using a categorical question given three choices (not profitable, somewhere near break-even, and profitable) (Figure 2.2). Overall, the logging businesses reported that less than one third (32.9%) were profitable over the past year and approximately half (49.7%) indicated that they were somewhere near break-even. The somewhere near break-even category represented the highest population percentages for all regions Mountains (47.7%), Piedmont (47.6%), Coastal Plain (50.0%). The Mountain logging businesses also reported a higher percentage (38.6%) of businesses were profitable when compared to the other regions of Virginia.

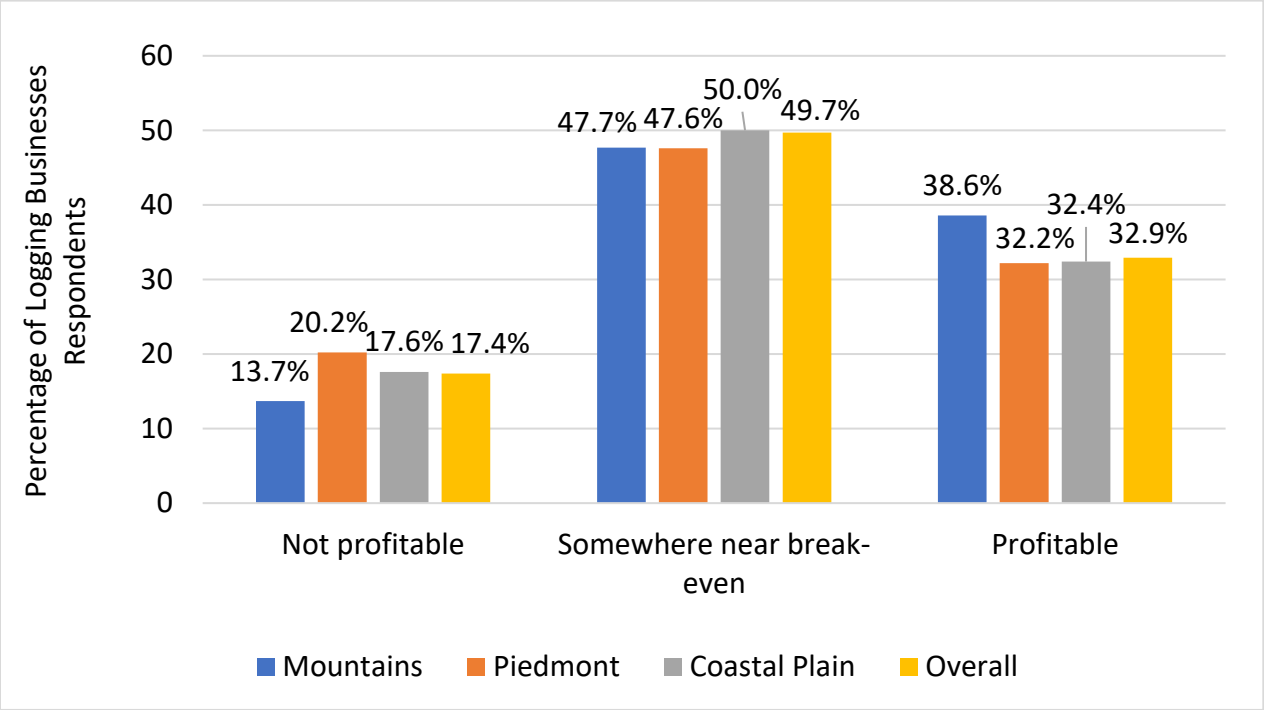

Figure 2.2 Reported logging business profitability in the past year, overall and by region.

In addition to asking logging businesses how profitable they were in the past year; they were also asked how often they calculate profitability. Responses were selected from five predetermined choices: For each tract I harvest, Monthly, Quarterly, Annually, and Rarely. 28.5 percent of logging business respondents indicated that they calculate profitability For each tract they harvest, followed by Monthly (27.9%), Annually (23.0%), Rarely (12.1%) and Quarterly (8.5%) (Table 2.2). The responses for all five categories were analyzed by region. The logging Business respondents from the Piedmont were most like the overall logging business population, the highest percentage indicated they calculate profitability For each tract they harvest (28.1%), followed by Monthly (25.6%), and Annually (19.5%). Businesses located in the Mountains indicated that most of them calculate profitability Annually (36.3%) or For each tract they harvest (34.1%) then on a Monthly (18.2%) basis. In the Coastal Plain, the majority of businesses calculate profitability Monthly (44.1%), followed by For each tract I harvest (26.5%). The majority of logging businesses reported calculating profitability more often which would likely provide them with a better idea of what operational characteristics and challenges are most impactful to their economic sustainability.

Table 2.2 How often logging business owners calculate their profit margins or profitability

	Overall %	Mountain %	Piedmont %	Coastal Plain %
For each tract I harvest	28.5	34.1	28.1	26.5
Monthly	27.9	18.2	25.6	44.1
Quarterly	8.5	2.3	8.5	14.7
Annually	23.0	36.3	19.5	11.8
Rarely	12.1	9.1	18.3	2.9

Logging business owners were asked their perspectives regarding the outlook for the economic sustainability of their own logging businesses using a scale of 0-10. The largest single response (35.2%) was that their outlook on the economic sustainability of their business was neutral (Figure 2.3). If a business's profitability is break-even then the expectation for future economic sustainability would reasonably fall between very sustainable (0) and very unsustainable (10), at neutral (5). The overall average for the logging business owner's outlooks on the economic sustainability of their businesses was reported as a 4.63 using the scale of the 0= Very unsustainable to 10= Very sustainable.

Further analysis was conducted by combining responses of 0-4 into one category labeled "Not Sustainable" and 6-10 as "Sustainable." The percentage of respondents that selected neutral (5) remained the same and the category was labeled "Neutral" (Figure 2.4). The Not sustainable category included the highest percentage of logging businesses (38.8%), followed by Neutral (35.2%), and Sustainable (26.0%). Just over a quarter of logging business owners had an outlook that their business was economically sustainable.

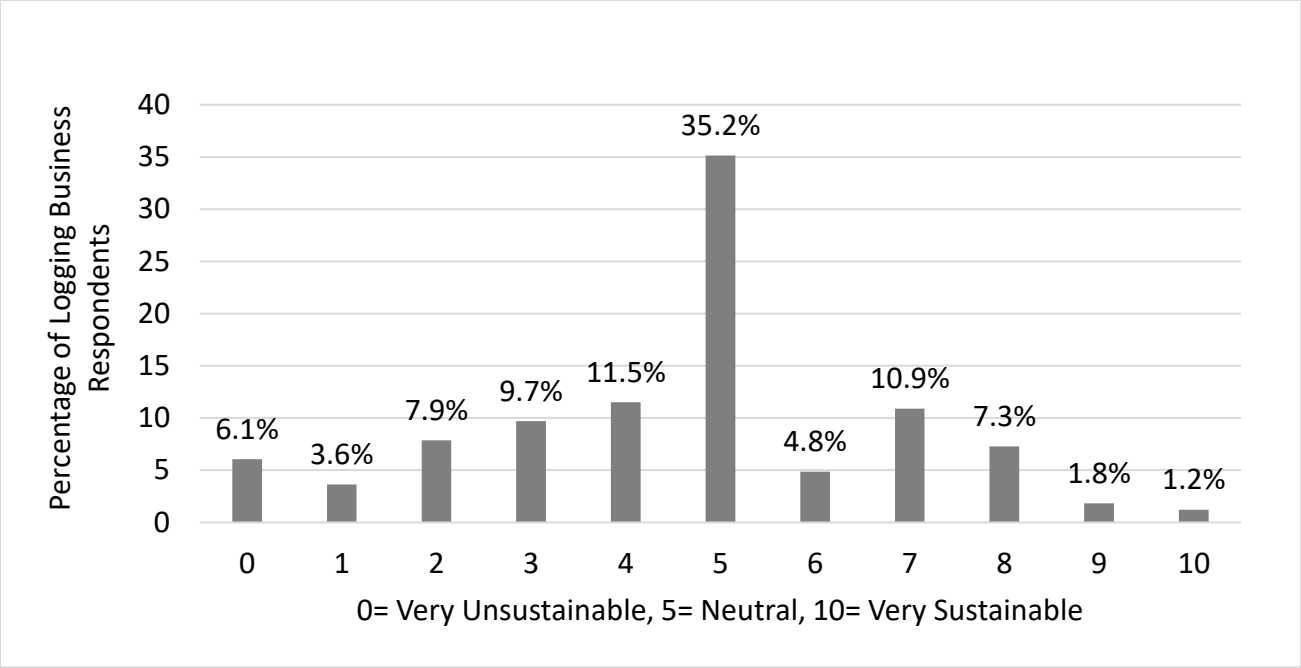

Figure 2.3 Reported logging business owner's outlooks on the economic sustainability of their business.

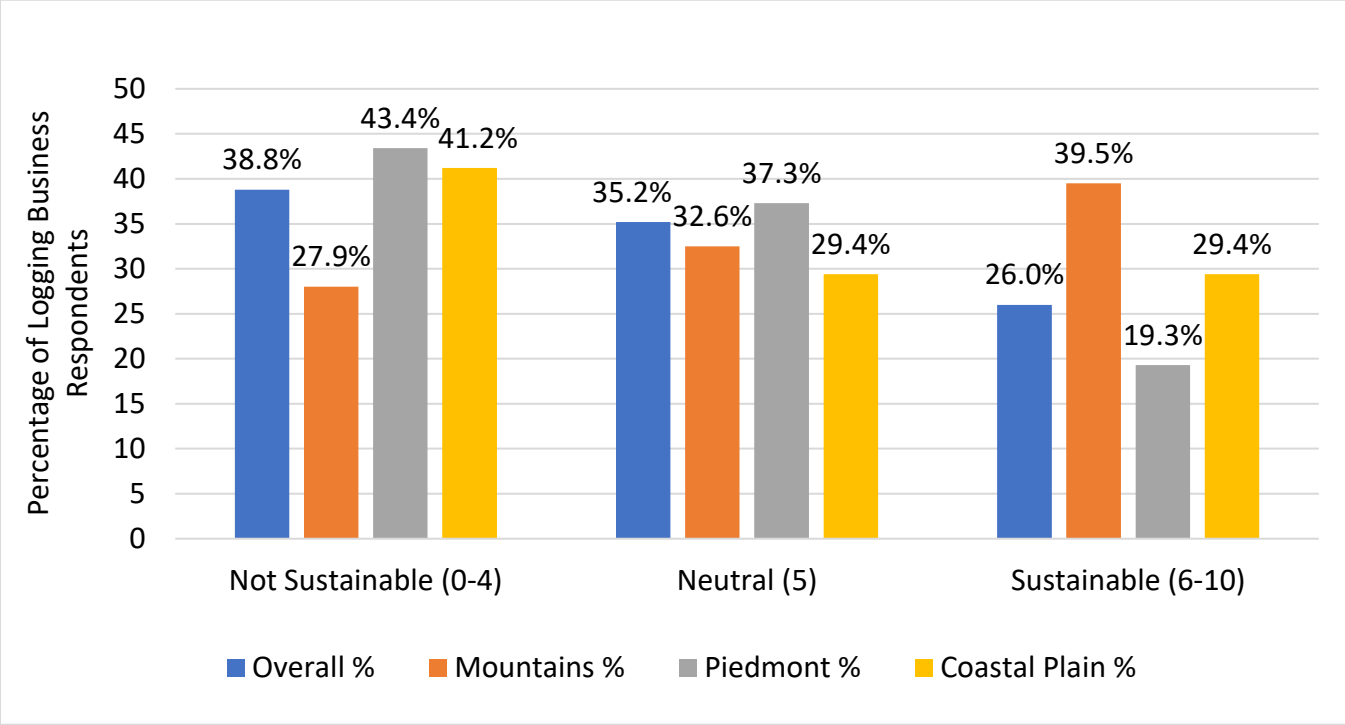

Figure 2.4 Reported logging business owner's outlooks on the economic sustainability of their business overall and by region using categories: Not Sustainable (0-4), Neutral (5), and Sustainable (6-10).

Logging business owners were asked to rate their perspectives on statements related to the potential impact it had on the economic sustainability of their business using a Likert type scale of concern (Table 2.3). The Likert scale response anchors used in Table 2.3, were created based on response anchors used in a sample Likert scale (Vagias 2006). A five point Likert scale was used because it provided a range of response options that captured the options and perspectives from respondents without overwhelming them with too many choices. A five point scale also provided a neutral point allowing the respondents the choice to be somewhat concerned (which was the neutral response). The statements were separated into five categories based on the study team's knowledge of harvesting challenges and included Acquiring suitable tracts to harvest, In-woods harvesting operations, Transportation and delivery of wood to mills, Logging business management, and Business relationships with landowners.

Out of all the statements provided, the top two challenges logging businesses face in Virginia are fuel related; fuel costs for in-wood harvesting equipment had the highest average response (4.44) followed by fuel costs for trucks (4.42). These results are similar to Egan 2009 where they found that high fuel costs along with insurance costs, and equipment costs were all listed as challenges to maintaining or expanding logging businesses. Fuel prices were also included in a list of biggest problems logging businesses face by a 2009 survey of logging businesses in Virginia (Bolding et. al 2010). The third highest challenge rated by logging businesses was harvesting equipment repair and maintenance costs.

Fuel costs for in-woods harvesting equipment and harvesting repair and maintenance costs, challenges that were rated number one and three, are both from the same category, In-

woods harvesting operations. Along with those, the fourth highest rated challenge, in-woods harvesting equipment cost (purchase), is also included in the same category. Out of the five statements listed under the category In-woods harvesting operations, three are represented in the top four (Table 2.4).

The category with the most statements in the top ten doesn't include the number one challenge, fuel costs for in-wood harvesting equipment. Transportation and delivery of wood to mills has five of the top ten rated challenges (Table 2.4). The five challenges include fuel costs for trucks, truck repair and maintenance costs, availability and cost of insurance for trucks, finding qualified and insurable drivers, and truck costs which are the second, sixth, eighth, ninth, and tenth respectively.

In addition, the percentage of respondents who selected moderately concerned (4) or very concerned (5) were averaged together providing a total percentage for each statement above the somewhat concerned level (3) (Table 2.3). Fuel costs for in-woods harvesting equipment remains the top challenge selected by the largest percentage of respondents (87.9%) followed by fuel costs for trucks (86.3%) and harvesting equipment repair and maintenance costs (81.8%). Although the top three challenges are the same by mean response and percentage of respondents who selected the statement, the data could have varied due to the percentage being calculated by the number of responses to each statement and not the total number of survey respondents (n=168). Statements "Truck repair and maintenance costs" and "Availability and cost of insurance for trucks" show that the mean response can cause one statement to be rated higher (4.20 and 4.15, respectively) while percentage of respondents causes the other statement to be rated higher (75.5 and 77. 5, respectively).

Table 2.3 Logging business owner's perspectives on statements related to the potential impact it has on the economic sustainability of their business. Responses are based on a scale of 1= not at all concerned, 2= slightly concerned, 3= somewhat concerned, 4= moderately concerned, 5= very concerned.

	Mean Response	Median Response	% of respondents who selected moderately or very concerned (4 or 5)
Acquiring suitable tracts to harvest	3.15		
Stumpage market prices that make it challenging to make a profit	4.04	4	74.5
Lack of public understanding regarding timber harvesting	3.38	4	50.9
Finding tracts within a reasonable distance of your normal work area	2.77	3	27.5
Finding tracts that are large enough for your harvesting operations	2.41	3	16.5
In-woods harvesting operations	3.96		
Fuel costs for in-woods harvesting equipment	4.44	5	87.9
Harvesting equipment repair and maintenance costs	4.34	5	81.8
In-woods harvesting equipment cost (purchase)	4.24	5	78.9
Availability and cost of insurance for harvesting equipment	3.99	4	71.3
BMP implementation costs	2.75	3	24.5
Transportation and delivery of wood to mills	3.96		
Fuel costs for trucks	4.42	5	86.3
Truck repair and maintenance costs	4.20	5	75.5
Availability and cost of insurance for trucks	4.15	5	77.5
Finding qualified and insurable drivers	4.09	5	73.0
Truck cost (purchase)	4.06	5	71.4
Mill unloading turn times	2.87	3	32.9
Logging business management	3.34		
Availability of employees with desired work ethic, skills, and training	3.76	4	65.4
Availability and cost of workers compensation insurance	3.52	4	51.0
Regulatory compliance with employment, trucking, and other laws	3.50	4	53.4
Employee recruitment and retention	3.27	3	46.4
Obtaining financing for equipment purchases or other business needs	2.70	3	29.1
Business relationships with landowners and mills	3.35		
Current delivered wood prices relative to logging costs	4.23	5	76.1
Amount of quota I am given when mills are limiting wood deliveries	4.17	5	76.8
The way in which quotas are implemented	3.93	4	68.1
Ability to negotiate delivered wood prices based on changes in harvest conditions (such as hauling distance) or input costs (such as fuel)	3.89	4	65.5
Business relationships with paper mills you supply wood to	3.24	3	43.2
Developing positive relationships within wood procurement networks	2.93	3	36.0
Business relationship with other mills you deliver wood to	2.81	3	32.0
Business relationship with sawmills you deliver wood to	2.62	2	26.7
Business relationships with landowners and consulting foresters you work with	2.25	2	17.0

Table 2.4 Top 10 ranked operational challenges based on logging businesses' mean responses from Table 2.3.

Ranking	Operational Challenges	Mean	Median
1	Fuel costs for in-woods harvesting equipment	4.44	5
2	Fuel costs for trucks	4.42	5
3	Harvesting equipment repair and maintenance costs	4.34	5
4	In-woods harvesting equipment cost (purchase)	4.24	5
5	Current delivered wood prices relative to logging costs	4.23	5
6	Truck repair and maintenance costs	4.20	5
7	Amount of quota I am given when mills are limiting wood deliveries	4.17	5
8	Availability and cost of insurance for trucks	4.15	5
9	Finding qualified and insurable drivers	4.09	5
10	Truck cost (purchase)	4.06	5

The profitability question and a list of business characteristics were further analyzed using Steel-Dwass All Pairs multiple comparisons to determine if any specific characteristics significantly differed with how profitable businesses reported they were. Only one characteristic, the percentage of total production that was hardwood sawtimber (Table 2.5), was significantly different (0.0118) between profitability categories. In the Mountains, the higher the proportion of hardwood sawtimber a business produced the more profitable they reported they were. Although not significantly different, the difference between profitability categories for the percentage of hardwood pulpwood produced was notable, 55.7% hardwood pulpwood for those that indicated they were not profitable and 14.7% hardwood pulpwood for those that indicated they were profitable. Overall, this indicated that the more hardwood sawtimber a logging business located in the Mountains produces the more profitable they will perceive their business to be.

Another takeaway to note was the percentage of timber purchased by businesses, as opposed to contract logging of timber purchased by someone else, and how profitable the respondents indicated they were. The mean percentages of timber purchased by the business reported for the categories not profitable (66.9%) and near break-even (70.2) were both over ten percent lower than the profitable (82.7%) category. Indicating that if businesses purchase the timber themselves, they are likely to be more profitable. This is similar to a study by Conrad et al. that found that "Loggers that purchase their own timber set their own cut-and-haul rate based on the difference between the price they are paid by mills. Purchasing their own timber affords loggers greater flexibility and profit opportunity but introduces greater risk and complexity because of the additional skills and capital required" (Conrad et al. 2018). Although not significantly different ($p=0.0915$), businesses purchasing their own timber could be a factor in the overall success and profitability of businesses and may be something to consider for additional studies on logging business profitability.

Table 2.5 Relationship between logging business characteristics and how profitable the businesses were over the past year.

	Mountain %			Piedmont %			Coastal Plain %			Virginia Overall %		
	Not Profitable	Near Break-even	Profitable	Not Profitable	Near Break-even	Profitable	Not Profitable	Near Break-even	Profitable	Not Profitable	Near Break-even	Profitable
% Hardwood Sawtimber	24.3, a	55.0, b	62.1, a	31.3	35.7	42.1	23.4	19.8	16.3	28.3	37.8	43.1
% Hardwood Pulpwood	55.7	26.8	14.7	25.7	17.7	16.1	8.4	11.1	11.3	29.2	18.7	14.7
% Pine Sawtimber	18.3	12.4	15.3	15.3	19.6	21.9	19.0	39.4	27.8	16.7	22.2	21.0
% Pine Pulpwood	1.7	3.9	6.8	15.6	18.5	16.4	45.0	18.2	28.8	17.9	14.1	15.9
% Clean/pulp Chips	0.0	0.7	0.0	1.9	2.4	0.2	0.0	3.5	0.0	1.1	2.1	0.1
% Dirty/fuel Chips	0.0	1.2	1.2	10.2	6.2	3.4	5.2	7.9	15.9	7.0	5.2	5.2
Production (tons/week)	233.8	418.1	216.6	653.9	706.5	661.7	1,953.7	1,767.2	2,583.8	880.4	840.1	881.6
($) Current equipment investment	266,000	733,421	466,071	577,333	652,500	628,696	1,967,500	947,000	1,980,000	838,269	741,250	867,766
% Timber purchased by businesses	83.3	69.3	85.6	59.9	73.2	83.5	70.0	67.4	76.4	66.9	70.2	82.7
Years operating a business	34.0	22.3	29.4	21.2	29.8	25.5	20.0	25.5	23.6	23.6	28.3	26.5
Full-time employees	2.3	5.2	2.5	4.5	4.6	4.6	15.7	8.6	16.7	6.4	5.5	6.2

Relationships were analyzed using (nonparametric multiple comparison) Steel-Dwass All Pairs at an alpha = 0.05 level.

2.6 Conclusion

Logging businesses operate in a somewhat unique business where they have very little to no control over the prices of input costs, the market value of stumpage, or the prices they are paid for products delivered to mills. Due to the challenges, they face, less than one third (32.9%) of the businesses in Virginia reported being profitable in the past year. That percentage is higher compared to a 2004 Southern New England study where only 11% of the respondents rated their business' profitability above average and 27% were below average (Egan 2011). However, a Minnesota survey found that nearly 61% of respondents said that their business' profitability was worse in 2011 than in 2008 (Blinn et al. 2015). The overall market conditions for the forest industry have owners concerned about the future of their businesses. Only 26.1% of businesses reported having an outlook that their business will be economically sustainable in the future. If the future of logging businesses is concerning for so many loggers, this may greatly affect the future of the forest-based supply chain. However, a larger number of logging businesses reported a break-even level of profitability in the last year (49.7%) and a neutral outlook for the economic sustainability of their business (35.2%). Relatively small shifts in the market pricing could potentially cause substantial changes for logging businesses, in either a positive or negative direction.

The study found that in the Mountains businesses that were profitable harvested less hardwood pulpwood and more hardwood sawtimber than those that were not profitable. The highest rated challenge for logging businesses was fuel costs for in-woods harvesting equipment followed by fuel costs for trucks and harvesting equipment repair and maintenance costs. The highest rated challenges are not surprising given that if everything remains constant

and one input costs such as fuel increase, even slightly, their profit margins narrow, making it difficult to operate sustainably in the long-term (Baker 2022). According to Baker (2022) logging businesses often sell to many different markets and those markets prices can impact whether a business is profitable or not. According to *Timber Mart South*, "South-wide average stumpage prices decreased for all five major timber products in the 1st Quarter of 2023. In particular, since 1st Quarter 2022, Southwide average prices are down more than $2 per ton (-7%) for pine sawtimber and more than $3 per ton (-14%) for pine chip-n-saw. Pulpwood prices have also experienced a notable decrease since 1st Quarter 2022, with pine pulpwood price down 15% and hardwood pulpwood price down 25% Y/Y "(TimberMart South First Quarter 2023).

The concerns over increasing input costs such as fuel costs and repair and maintenance costs are not unique to Virginia. In the southeastern United Sates, increases for input costs continue to exceed average logging rates, that have hovered around the same values since 2012 (Baker 2022). Increasing input costs as well as the market prices for the products harvested are major factors in logging business profitability, and are part of a nationwide trend, much of which is driven by market changes and the economy as a whole.

This study showed that there are substantial concerns across Virginia's logging industry related to economic sustainability of logging businesses. Many of the challenges relate to market prices for input costs and delivered log products. These factors are often tied to the broader economy and are difficult to control. Virginia's forest industry is an important component of the overall economy and logging businesses are essential to the forest-based supply chain. Market changes could have further adverse effects on logging businesses which could further threaten the economic sustainability of the logging industry.

The study shows the challenges but not solutions, the hope is that it will be the catalyst bringing together different groups to work to address those challenges and identify possible solutions. However, a proposed idea could be to come up with a fuel or cost index which would provide logging businesses more stable market prices and a way to plan longer-term. This survey is a snapshot in time providing valuable information and a starting point to evaluate logging industry economic sustainability in the future. Future studies could focus on the addition of new mills and markets increasing competition and wood consumption within Virginia. Additional potential research could focus on recruitment and retention of a younger workforce entering the logging industry. A continuation of this survey could focus on how challenges and issues faced by logging businesses change over time with fluctuating market conditions. Continuing this survey would allow researchers the ability to compare perspectives on how logging business outlooks for the economic sustainability of their businesses change over time and what challenges affect them the most.

Future studies may want to continue monitoring the profitability and economic sustainability of the logging industry and further study specific factors related to businesses that report being profitable versus those that are not.

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3.0 PERSPECTIVES ON THE ECONOMIC SUSTIANABILITY OF LOGGING BUSINESSES FROM ACROSS THE FOREST SUPPLY CHAIN IN VIRGINIA.

3.1 Abstract

The three pillars of sustainability are environmental, social, and economic. The forest-based supply chain, which includes landowners involved in growing timber, logging businesses harvesting and delivering wood to mills, and the mills producing primary wood products, all experience challenges in these three areas of sustainability. Logging businesses are an essential link connecting landowners with forest product mills within the forest-based supply chain. Due to the rising concern for the future of logging businesses, a mail survey was conducted to evaluate perspectives on the economic sustainability of the logging industry from across the segments of the forest-based supply chain in Virginia. The survey populations included logging business owners, consulting foresters (landowner representatives) and mill owners or procurement representatives, response rates were 27.1%, 69.1%, and 39.7%, respectively.

Sixty percent of logging businesses respondents are descendants of logging families while 56% of logging business owners would not encourage their child to entry the logging or forest industry. Additionally, 44.9% of mills representatives and 32.6% of consulting foresters would not encourage their own child to pursue a career in the logging or forest industry. Based on responses, the number of employed individuals could become a larger industry challenge due to the large percentage of respondents that wouldn't encourage their child(ren) to enter the industry. Results also indicated that over a third of logging businesses (38.8%) rated the outlook for their business as not economically sustainable. Across the other two segments including consulting foresters and mills, an even larger percentage of respondents (68.9% and

56.3% respectively) viewed logging operations as not economically sustainable. Over fifty-five percent of logging businesses reported there being too much logging capacity in Virginia, while almost sixty percent of mills (59.2%) indicated that there is just the right amount of logging capacity. Mill survey respondents indicated that their business has experienced no effect (42%) to minor effect (32%) due to a lack of logging capacity in the past year. However, mill and consulting foresters expect, in the next five years, that their businesses will experience a greater negative effect due to a lack of logging capacity available to harvest and deliver wood.

Keywords: Logging business, Survey, Economic Sustainability, Forest-based supply chain, Challenges.

3.2 Introduction

The forest industry in Virginia contributes more than 21 billion dollars to the economy and provides over 100,000 jobs (Raphann 2022). Within the forest industry, the forest-based supply chain is made up of three segments including landowners, logging businesses, and forest product mills. Virginia has approximately 16 million acres of forestland, the largest percentage (59%) owned by private individuals (Forest Resource Information 2023). Due to the largest percentage of forests being owned by private individuals, logging businesses rely on landowners to manage their forests and sell their timber, so they can continue operating. Consulting foresters are typically used to advise landowners when making forest management decisions and conduct timber sales on the landowner's behalf. After the timber has been bought and harvested, it is then transported to the appropriate forest product mill. The sustainability of the forest industry is dependent on each segment of the forest-based supply chain.

The three pillars of sustainability are environmental, social, and economic. All segments of the forest-based supply chain experience challenges in the areas of sustainability, especially logging businesses. There are numerous studies that focus on environmental sustainability surrounding logging practices such as soil and water quality impacts (Aust and Blinn 2004) and Best Management Practice implementation (Cristan et al. 2016). Research has also been conducted that focused on social impacts regarding logging activities (Minter et al. 2023), and a few studies included small sections of data on economic sustainability (Allen et al. 2008, Baker and Greene 2008). However, no research found during the literature review focused specifically on obtaining perspectives from the entire forest-based supply chain regarding the economic state of logging businesses or the entire logging industry. The survey would provide a current snapshot and insight into the economic sustainability of the logging industry. It will provide the industry with a starting point which will help bring together different groups to work together to address the current perceived challenges and find solutions. The hope is that the information gathered from this survey is a catalyst for change and that results indicate areas of need for follow-up research.

Logging businesses have reported difficulties recruiting qualified employees and retaining them due to opportunities in other industries and with the aging workforce the average logger is 51 years old (Barrett et al. 2017). They have reported challenges including increasing input costs that exceed average logging rates, decreases in market demand, reduced consumption and substitution of forest product goods, increasing quotas, and mill closures. All these changes can cause economic instability in the industry and make it difficult to be profitable long-term. Logging businesses are a vital segment in the supply chain and the

increasing challenges l that they face, has been raising concerns regarding the future of logging businesses and the forest industry for decades (Egan and Taggart 2004, Broussard Allred 2009, Bowman et. al 2023).

There are many operational challenges logging businesses encounter. In Virginia, logging business owners reported a wide range of answers when asked what the biggest problem they were confronted with. Common responses included markets for their products, increasing operational costs, declining wood markets, fuel prices, and the future of the profession such as recruiting qualified employees (Bolding et al. 2010). Fuel prices, financial returns and finding qualified employees were also concerns found in a study of Georgia loggers (Baker and Greene 2008). A Southern New England survey found fuel prices, equipment and insurance costs, stumpage prices, shrinking forestland, and harvesting regulations were all challenges to the logging industry (Egan 2011). There have been a few logging surveys that discussed challenges and issues related to economic sustainability. However, this is possibly one of the first to look at challenges and issues related to economic sustainability across the forest-based supply chain and to focus on the supply chain's outlooks related to economic sustainability of the forest industry.

For this study, in addition to logging businesses, we were interested in perspectives across the segments of the forest-based supply chain. Therefore, we believed that it was important to gain perspectives from forest landowners and mills related to their perspectives on the economic sustainability of logging businesses. Obtaining perspectives from other segments of the supply chain provides a more comprehensive understanding of logging business economic sustainability that could uncover opinions and perspectives that might have

been missed by only studying one population. The segments of the supply chain and the three populations included in this study were Virginia logging business owners, consulting foresters (proxies for landowners), and procurement representatives or mill owners. The primary research objective was to evaluate perspectives on the economic sustainability of logging businesses in Virginia from participants across the three segments of Virginia's forest-based supply chain.

3.3 Research Objectives

The primary research objective was to evaluate the economic sustainability of logging businesses in Virginia. The economic sustainability of logging businesses and the logging industry implies general profitability and long-term financial viability. The primary research objective had two subobjectives. 1.) Compare the differences in opinions and perspectives from across segments of the forest-based supply chain (landowners, loggers, and mills) on the challenges and issues related to the economic sustainability of logging businesses in Virginia. 2.) Compare opinions and perspectives across segments of the forest supply chain on their outlook of logging businesses and the logging industry in Virginia.

3.4 Methods

3.4.1 Area and Populations of Interest

Surveys were conducted during the summer of 2023. We utilized three different, but related mail survey questionnaires, one for each segment of the forest-based supply chain: logging businesses, consulting foresters, and forest product mills. This publication focuses on perspectives from across the supply chain and was part of a larger survey project which

includes an additional publication focused on challenges logging businesses face and the outlook on logging business economic sustainability (Barkman et al. in preparation).

Logging businesses in Virginia that are harvesting timber must notify the Virginia Department of Forestry (VDOF) where and when they are harvesting. The VDOF maintains a timber harvest notification list that includes all reported timber harvests and is assumed to include the entire population of logging businesses conducting harvests in Virginia. For this study, we focused on full-time logging businesses, excluding part-time operations, that are smaller and produce a small portion of the state's total production. In addition, the study team decided to gather only one response per business and wanted to hear from the individual with the greatest economic understanding of the business. We selected all full-time logging businesses that reported a timber harvest in the thirteen months prior to the survey (March 2022-March 2023). All duplicates were removed from the list, and the final logging survey population consisted of 655 potential participants.

Consulting foresters represent landowners in timber sales in Virginia. Due to the relatively low proportion of individual forest landowners who sell timber in any given year, we used consulting foresters as landowner representatives. Utilizing consulting foresters as representatives for landowners is a unique aspect of this study, in that no other studies reviewed applied this technique. We included all consulting foresters listed on the VDOF's website as offering their services to administer timber sales to landowners, along with professional contacts of our research team. We also included consulting foresters who are members of the Virginia Forestry Association. After combining, cross-checking, and removing

duplicates, the final consulting forester survey population consisted of 73 potential participants.

We used the US Forest Service listing of sawmills in Virginia along with professional contacts from our research team to identify mills buying wood in Virginia. We also identified procurement foresters purchasing wood for mills in Virginia from the Virginia Forestry Association membership list. This combined list included all commercial-scale sawmills operating in Virginia, plus procurement representatives, representing other mills such as paper, wood structural panels, or biomass mills in Virginia. After cross-checking lists, the final mill survey population consisted of 159 potential participants.

3.4.2 Survey Contents, Development, and Distribution

A 2017 Virginia logging business survey showed that just over half of logging businesses regularly utilize email for their business operations (Barrett et. al 2017). Therefore, we believed that a hard copy mail survey was the most effective method for all three questionnaires. The logging business questionnaire consisted of one printed tabloid-sized paper (11”x 17”) folded in half (11”x 8.5”) with instructions on the cover page and questions on the remaining two inside pages and back page. The consultant and mill surveys each consisted of one letter-sized piece of paper (11”x 8.5”) printed front and back. There were a total of 28, 12, and 16 questions on the logging business, consulting forester and mill questionnaires respectively, encompassing several question types that include multiple choice, fill-in-the-blank, and open-ended. The questions covered a broad range of topics such as business characteristics, challenges and

issues the forest industry faces, relationships across the forest supply chain, and outlooks for the forest industry overall.

The Dillman Method was used in the development and distribution of this survey (Dillman 1991). The Dillman Method was chosen because it is commonly used and is an effective method used in the forest industry when conducting survey research (Barrett et al. 2014, Barrett et al. 2017, Bolding et al. 2010, and Bowman et al. 2023). The Virginia Tech IRB approved the survey protocol, and after approval was received, the pre-notice letters were mailed on May 12th, 2023. The first wave of questionnaires, the follow-up letters, and the second wave of questionnaires (final mailing) were mailed approximately five days, two weeks, and five weeks after the pre-notice letters, respectively. The final return date selected for all questionnaires was July 19th, 2023.

3.4.3 Terminology

A list of terminology was organized by the research team when preparing the survey. Prior to creating new definitions, the terms were researched to determine if they were previously defined. Some terms, such as forest-based supply chain, were already defined by another party, so the team decided to use a variation of the previously defined term. The list includes defined terms used throughout this publication and *Barkman et. al in preparation.*

Economic sustainability of logging businesses and the logging industry implies general profitability and long-term financial viability.

Forest-based supply chain refers to the activities involved in forest management, harvesting operations, and transporting of raw materials (Feng and Audy 2020). The definition utilized in this study includes the manufacturing of primary forest products in the supply chain sequence.

Segments of the forest-based supply chain: In this study the three segments refer to logging businesses, forest product mills, and consulting foresters (landowner representatives).

Logging business: the term logging business(es) can be used interchangeably or in place of logging business owners.

Mills: the term Mills can be used interchangeably or in place of mill owners and mill representatives.

Consulting foresters: Consulting foresters were used as landowner representatives, so Consulting foresters can be used interchangeably or in place of the term consultants or landowners.

3.4.4 Data Analysis

Data was de-identified, coded, and compiled in an Excel spreadsheet (Microsoft Corp. 2023). Data was analyzed using JMP statistical analysis software (JMP® Pro. 2021). The analysis included descriptive statistics and means testing using parametric methods. Continuous data was analyzed to determine if the mean responses were significantly different than neutral using the Wilcoxon signed-rank test (Table 3.8). Categorical data was analyzed using a Chi-squared test. Numerical Likert type responses (e.g., 0-10), were analyzed as continuous data. The presence of nonresponse bias was tested using wave analysis (Armstrong and Overton 1977). Wave analysis is a common and effective method used to assess nonresponse bias when conducting survey research (Conrad et al. 2018, and Bowman et al. 2023). Independent sample

t-tests and likelihood ratio Chi-square tests were both used, when applicable, to compare the responses from early to late responders. The process used to analyze data for this paper was the same process used in *Barkman et. al in preparation* because they both include data from the same questionnaire for logging businesses.

3.4.5 Physiographic Regional Designation

Respondents for all three questionnaires were separated into physiographic regions based on the county they indicated as their center of work area, the center of wood procurement area, or the center of the area(s) they sold timber in the past year. The counties were then grouped into physiographic regions (Figure 3.1) based on the U.S. Forest Service's regional designation, with the northern and southern Piedmont regions combined into one Piedmont region as well as the northern and southern mountain regions combined into one mountain region (Cooper et al. 2011). The same physiographic regional boundaries can also be found in other survey research such as Barrett et al 2017.

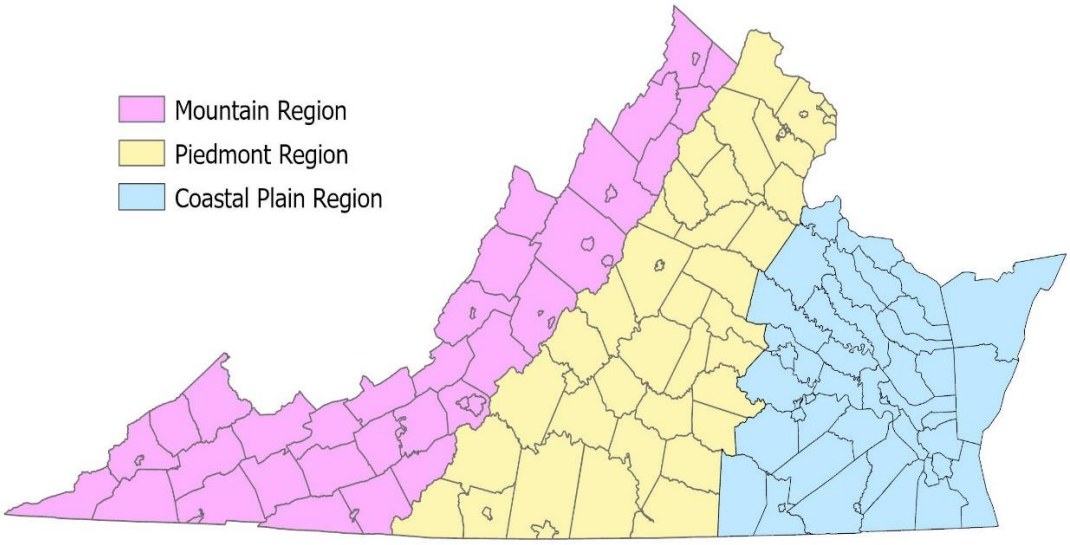

Figure 3.1 Virginia county and regional boundaries used to group respondents (logging businesses, consulting foresters, and mills) into physiographic regions (map not to scale).

3.5 Results

Of the 655 logging business questionnaires mailed, 26 were undeliverable and 11 returned indicating that they were not a full-time logging business operating in Virginia. After revising, the survey population consisted of 618 logging businesses, 168 questionnaires were completed and returned, resulting in a logging business response rate of 27.2%. The mill mailing list consisted of 159 addresses, 21 were returned undeliverable, 11 were returned indicating they were not involved with wood procurement at a mill located in Virginia, and one mill representative that was moved from the mill to logger population, which better fit their business. The adjusted survey population included 126 mill questionnaires, 50 were completed and returned, resulting in a final mill response rate was 39.7%. Of the 73 consulting forester "forest landowner" questionnaires mailed out, three were undeliverable and two were returned indicating that they were not a consulting forester that had represented a landowner

on a timber sale in Virginia in the past year. After adjusting, the survey population included 68 consulting foresters, 47 questionnaires were completed and returned, resulting in a final consulting forester response rate of 69.1%.

Respondents were asked what Virginia county they would consider to be the center of their work area and the responses were used to separate them into regions (Figure 3.1). Of the 168 logging business respondents, Mountains, Piedmont, and Coastal Plain responses were 44, 85, and 34, respectively. Of the 50 mill respondents, Mountains, Piedmont, and Coastal Plain responses were 10, 28, and 11, respectively. Of the 47 consultant respondents, Mountains, Piedmont, and Coastal Plain responses were 10, 13, and 22, respectively.

Non-response bias testing was conducted for all three surveys, logging businesses, mills, and consulting foresters, and no significant differences between early and late responders were found. The logging business survey tested age ($p=0.3360$), weekly production ($p=0.2753$), the number of years' operating their own business ($p=0.9720$), and their outlook for their business (0.6972). The mill survey tested the number of years' buying wood for a mill ($p=0.2204$), average annual production ($p=0.5439$) and their outlook for logging businesses ($p=0.9967$). The mill survey tested the number of years working as a consultant ($p=0.4651$), average tract size they work with ($p=0.9594$) and their outlook for logging businesses ($p=0.7542$). Based on the comparative analysis of early versus late responders, for all three surveys, no significant differences were found that would imply substantial concerns related to non-response bias.

The mill questionnaires were to be completed by someone who interacts with loggers and is knowledgeable about wood procurement for mills operating in Virginia. The mill

questionnaire population was asked how they would categorize their role within the mill and were given instructions to select one of the three provided responses: mill owner, employee involved with wood procurement, other: please describe (e.g. secretary) (Table 3.1). The largest response percentage was employees involved with wood procurement (63%) followed by mill owners (33%) and others (4%).

Table 3.1 Response to mill questionnaire by role type within the mill.

	Count	Percent
Employee involved with wood procurement	31	63
Mill Owner	16	33
Others	2	4

*Other such a bookkeeper, president etc.

Response to the mill questionnaire was also assessed by receiving wood type. Respondents were asked what type of mill they are primarily associated with and were given instructions to select one of the three responses provided: hardwood sawmill, pine sawmill, pulpwood/residue using facility (e.g. paper, OSB or biomass) (Table 3.2). The largest percentage of responses were provided by hardwood consuming mills (38%), followed by pulpwood/residue facilities (28%), then pine mills (22%). Due to the number of respondents (six) who answered both hardwood and pine, a Hardwood and Pine category was added when analyzing data. The hardwood and pine mills accounted for 12 percent of the final mill survey response percentage.

Table 3.2 Response to mill questionnaire by receiving wood type.

	Count	Percent
Hardwood Sawmill	19	38
Pulpwood/residue using Facility	14	28
Pine Sawmill	11	22
Hardwood and Pine Sawmill	6	12

The survey populations were asked several operational characteristic questions. Respondents to the logging business survey were on average 55 years old, operated or managed their own business for 27 years, harvested 872 tons/week, and currently have approximately 800,000 dollars invested in their operations (Table 3.3). The logging business respondents also averaged three on-road trucks, six full-time employees, and approximately one full harvesting crew. The consulting forester survey respondents on average had been working as consultants for 22 years, and the average tract size they commonly work with was 73 acres (Table 3.3). The mill survey respondents on average had been involved with buying wood for a mill for 22 years (Table 3.3). Sawmill respondents were asked for the average annual production for the mill they were associated with, in million board feet (MMBF), and were given instructions to select one of three categories. The highest representation was mills that have an average annual production rate of 5-20 MMBF/year (47%), followed by both 1-5 MMBF/year and >20 MMBF/year at 25%, and the last category less than 1 MMBF/year (3%).

Table 3.3 Forest-based supply chain operational characteristics.

	Mean	Median	Standard Deviation
Logging Business			
Age	55	57	14.07
Tons/week	872	375	1246.88
Years operated/managed your own business	27	26.5	15.53
Current Investment in operation (excluding trucks) ($)	$802,767	400,000	1,225,928
Number of Trucks	3.3	2	4.07
Number of full-time employees	5.9	3	9.87
Number of logging crews	1.3	1	0.76
Consultant			
Number of Years as a Consultant	22	23	11.51
Tract Size They Work With (acres)	73	60	57.31
Mill Representative			
Number of Years involved in buying wood	22	20	11.76

*Some information displayed in this table can also be found in Barkman et al. in preparation.

The statements provided on the questionnaires that gathered data for Figure 3.2 and Figure 3.7 were part of a larger set of statements asked to all survey populations. The data displayed in both figures better illustrates the perspectives from each population, however the data also appears in Table 3.8 to make it easily comparable across like questions with the scale: 1=Strongly Disagree to 5= Strongly Agree.

Fifty-six percent of logging business owners agreed to the statement “I would not encourage my own child to pursue a career in the logging or forest industry because of factors

related to economic sustainability," while over eighty percent of businesses selected neutral or agreed to the statement (Figure 3.2). The study found similar results for the mill respondents, 44.9% selected agree to the statement. While the consultant responders were found to be slightly more encouraging, 43.5% disagree with the statement provided. However, almost one third (32.6%) of the consultant population agreed with the statement.

The responses to the statement "I would not encourage my own child to enter the logging or forest industry because of factors related to economic sustainability," were analyzed by region for each segment of the forest-based supply chain. The Logging business questionnaire indicated that within each region Mountains (50%), Piedmont (56%), and Coastal Plain (57.6%) over fifty percent of the respondents agreed with the statement (Table 3.4). The mill questionnaire showed higher percentages of agreement to the statement in the Mountains (60%) and Coastal Plain (60%), when compared to the logging business responses. The consultant survey showed that a higher percentage of consultants disagree with the statement overall. The consultants from the Mountains (60%) are more likely to encourage their child to enter the industry compared to the Piedmont (38.5%) and Coastal Plain (40.9%) regions. However, consultants located in the Piedmont were as likely to discourage (38.5%) as they were to encourage (38.5%) their child to enter the industry.

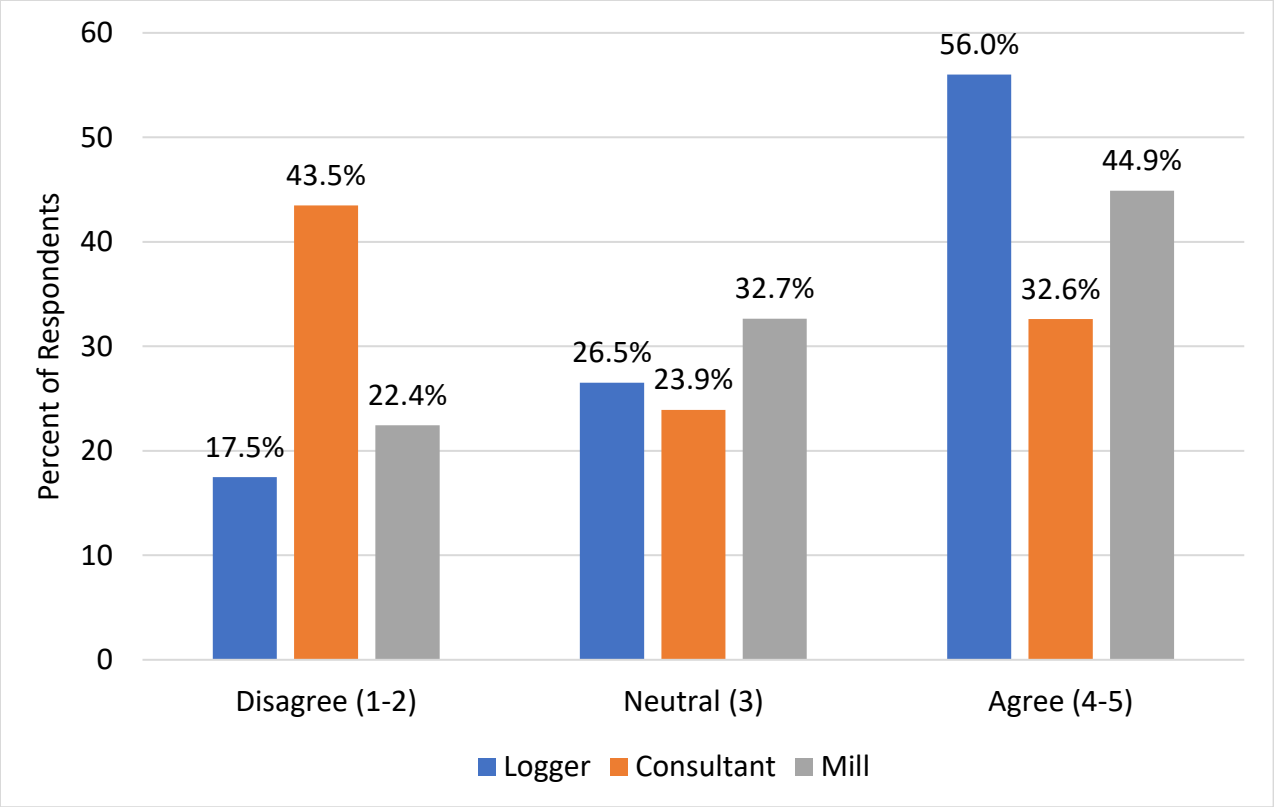

Figure 3.2 Forest-based supply chain responses to "I Would NOT Encourage My Child to Pursue a Career in the Logging or Forest Industry because of Factors Related to Economic Sustainability."

Table 3.4 Forest-based supply chain survey responses by Virginia region to "I Would NOT Encourage My Child to Pursue a Career in the Logging or Forest Industry because of Factors Related to Economic Sustainability."

	Mountains %	Piedmont %	Coastal Plain %
Logging Businesses			
Disagree (1-2)	22.7	17.8	12.1
Neutral (3)	27.3	26.2	30.3
Agree (4-5)	50.0	56.0	57.6
Mills			
Disagree (1-2)	20.0	28.6	0.0
Neutral (3)	20.0	35.7	40.0
Agree (4-5)	60.0	35.7	60.0
Consultants			
Disagree (1-2)	60.0	38.5	40.9
Neutral (3)	20.0	23.0	22.7
Agree (4-5)	20.0	38.5	36.4

Logging businesses were asked their perspectives regarding the outlook for the economic sustainability of their own logging business using a scale of 0-10, and analysis was conducted combining responses into three categories. Respondents that selected 0-4 were put into one category labeled “Not Sustainable,” respondents that selected five were in the “Neutral” category, and respondents that selected 6-10 became the “Sustainable” category. On the original 0-10, 0= Very unsustainable to 10= Very sustainable, scale the overall average for logging business owner’s outlook for their business was on the unsustainable side of neutral at a 4.63 (Barkman et al. in preparation). The Not Sustainable category represented the largest percentage of logging businesses (38.8%), followed by Neutral (35.2%), and Sustainable (26.0%) (Figure 3.3).

The Mill and Consulting forester questionnaires contained a very similar question, they were asked their perspectives regarding the outlook for the economic sustainability of logging businesses instead of “their own logging business.” Like the logging business survey responses, both the mill and consultant surveys indicated that the Not Sustainable category represented the largest percentage (56.3% and 68.9%, respectively) of responses (Figure 3.3). However, unlike the logging businesses, the next highest category was Sustainable for both the mill and consultant surveys (22.9% and 22.2% respectively) responses, followed by the final category Neutral (20.8% and 8.9% respectively).

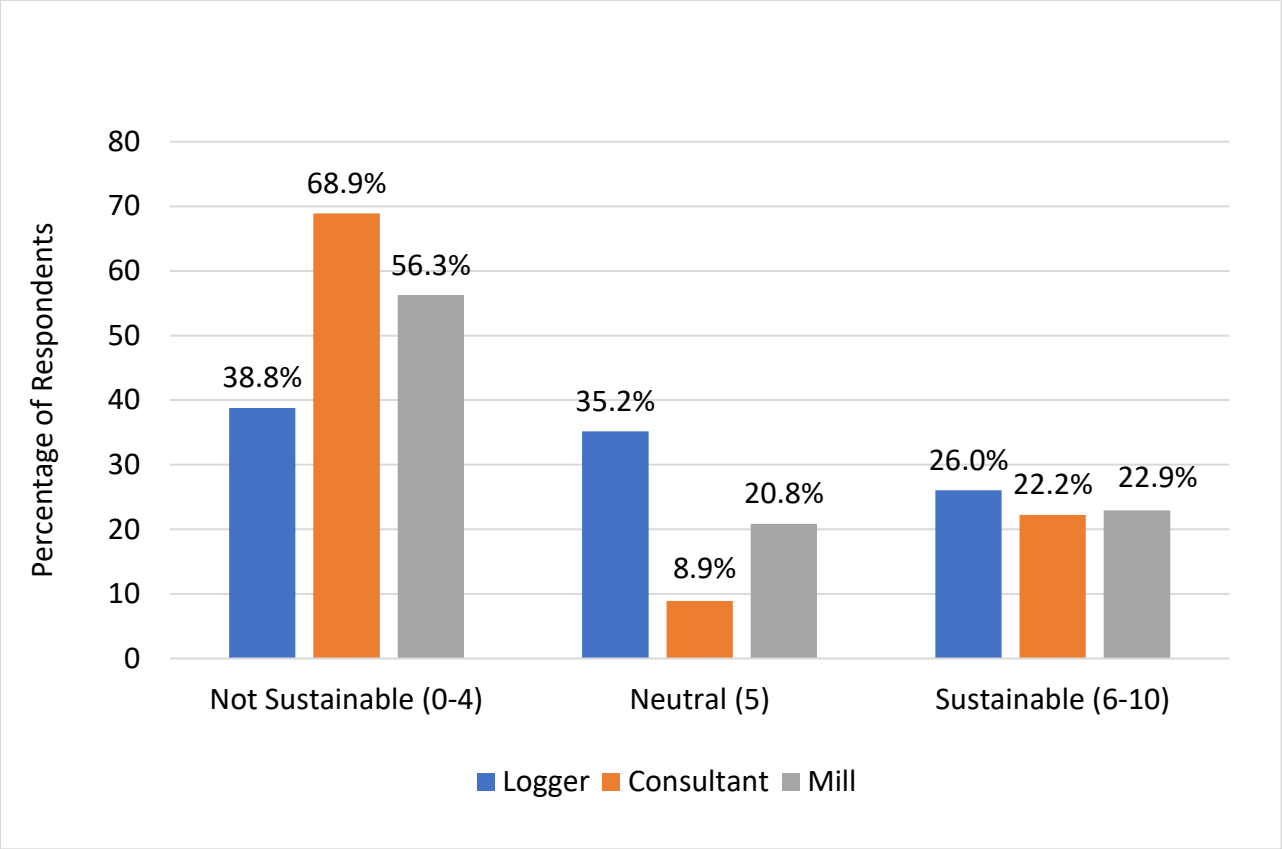

Figure 3.3 Forest-based supply chain's outlook on logging business economic sustainability.

In this study, the three segments of the supply chain were asked their perspectives regarding the amount of logging capacity in the industry and were told to select one of the three provided categories: not enough logging capacity, about the right amount of logging capacity, and too much logging capacity. Logging businesses reported having too much (55.1%) or about the right amount (36.7%) of logging capacity (Figure 3.4). Mill responses were the opposite of the logging businesses, indicating that there was about the right amount (59.2%) or not enough (30.6%) logging capacity. The consultants were more evenly split, with the highest

being too much logging capacity (37%), followed by about the right amount (34.8%), and not enough logging capacity (28.2%).

The amount of industry logging capacity was analyzed by region to detect differences in perspectives. One hundred percent of the consultant respondents and 77.8% of the mill respondents working in the Mountains felt that there is “not enough logging capacity” (Table 3.5). While the largest percentage (65.1%) of logging businesses primarily operating in the Mountains felt that there is “about the right amount of logging capacity.” Of the individuals working in the Piedmont, over fifty percent of the mill (67.8%) and consultant (53.8%) responders felt there is “about the right amount of logging capacity.” However, 65.4% of the logging businesses working in the Piedmont believed that there is “too much logging capacity.” Of the individuals working in the Coastal Plain region, 78.1% of logging businesses and 54.5% of consultants felt that there is “too much logging capacity” and 63.6% of mill responders believe there is “about the right amount of logging capacity.”

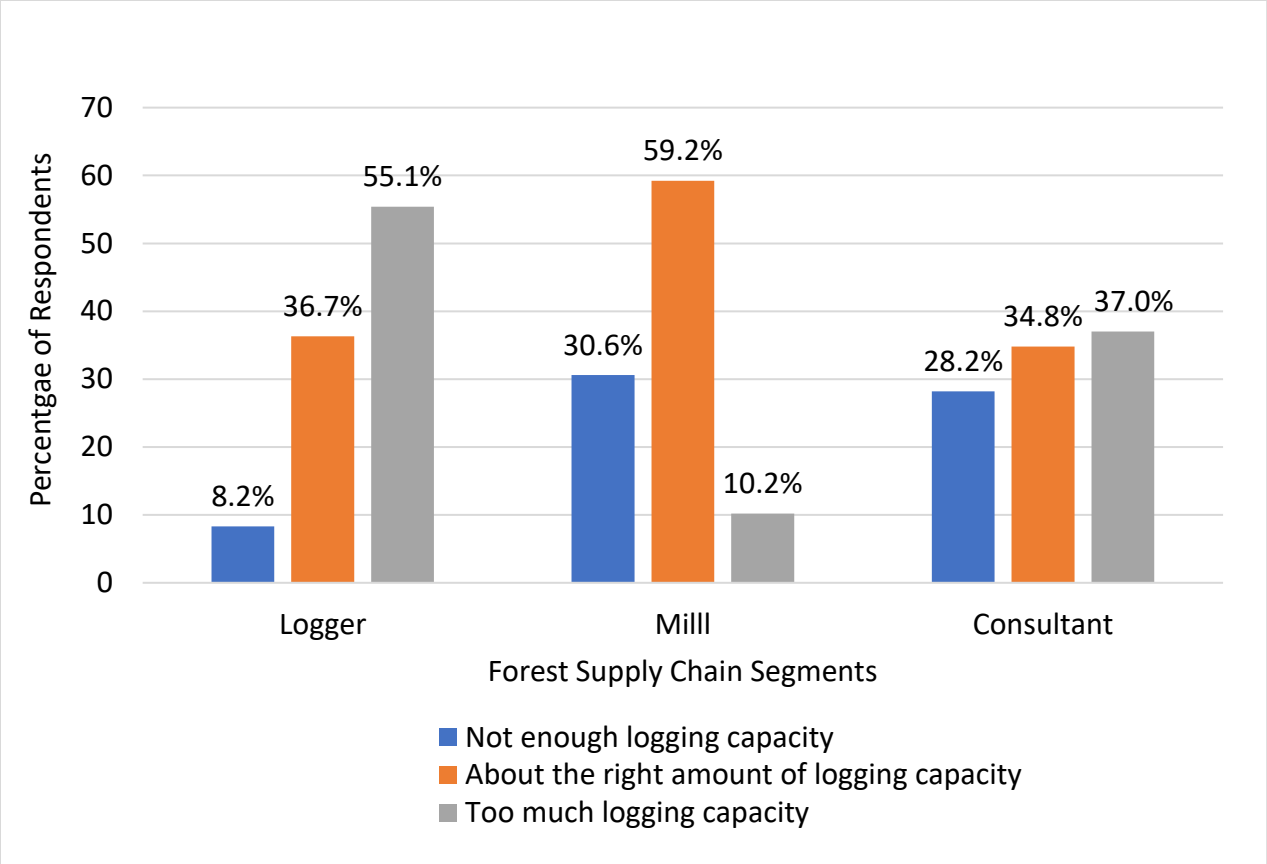

Figure 3.4 Forest-based supply chain's responses to the amount of logging capacity in the industry.

Table 3.5 Forest-based supply chain's responses to the amount of logging capacity in the industry by region.

	% Mountains	% Piedmont	% Coastal Plain
Logging Businesses			
Not enough logging capacity	16.3	7.7	0.0
About the right amount of logging capacity	65.1	26.9	21.9
Too much logging capacity	18.6	65.4	78.1
Mills			
Not enough logging capacity	77.8	17.9	27.3
About the right amount of logging capacity	22.2	67.8	63.6
Too much logging capacity	0	14.3	9.1
Consultants			
Not enough logging capacity	100.0	7.7	9.1
About the right amount of logging capacity	0.0	53.8	36.4
Too much logging capacity	0.0	38.5	54.5

The mill and consultant populations were asked questions regarding how much their operations have been affected due to lack of logging capacity. In the past year, 42% of the mill respondents indicated that the lack of logging capacity available to harvest and deliver wood had no effect on their operation and 32% reported a minor effect (Figure 3.5). Only 2% of the mill population indicated that lack of logging capacity, in the past year, had a major effect on mill operations. The consultant population indicated that the lack of logging capacity affected their operations slightly more with over one third (39%) selecting Moderate Affect, followed by Minor Affect (32%), No Affect (23%), and like the mill population, only 4% indicated that the lack of logging capacity had a major effect on consulting operations.

However, when asked in the next five years, how much they expect their operations to be affected due to a lack of logging capacity available to harvest and deliver wood, both populations indicated the lack of capacity will have a greater affect compared to the past year. The mill population shifted from No Affect to Moderate Affect (37%). The second highest selected category was Minor Affect (33%), followed by Major Affect (18%), and No Affect (12%) (Figure 3.6). The consultant population perspectives for both Moderate Affect (41%) and Minor Affect (27%) changed very little from the past year to the next five years. However, a much larger percentage indicated that the lack of logging capacity will have a Major Affect (21%) on consultant operations five years from now.

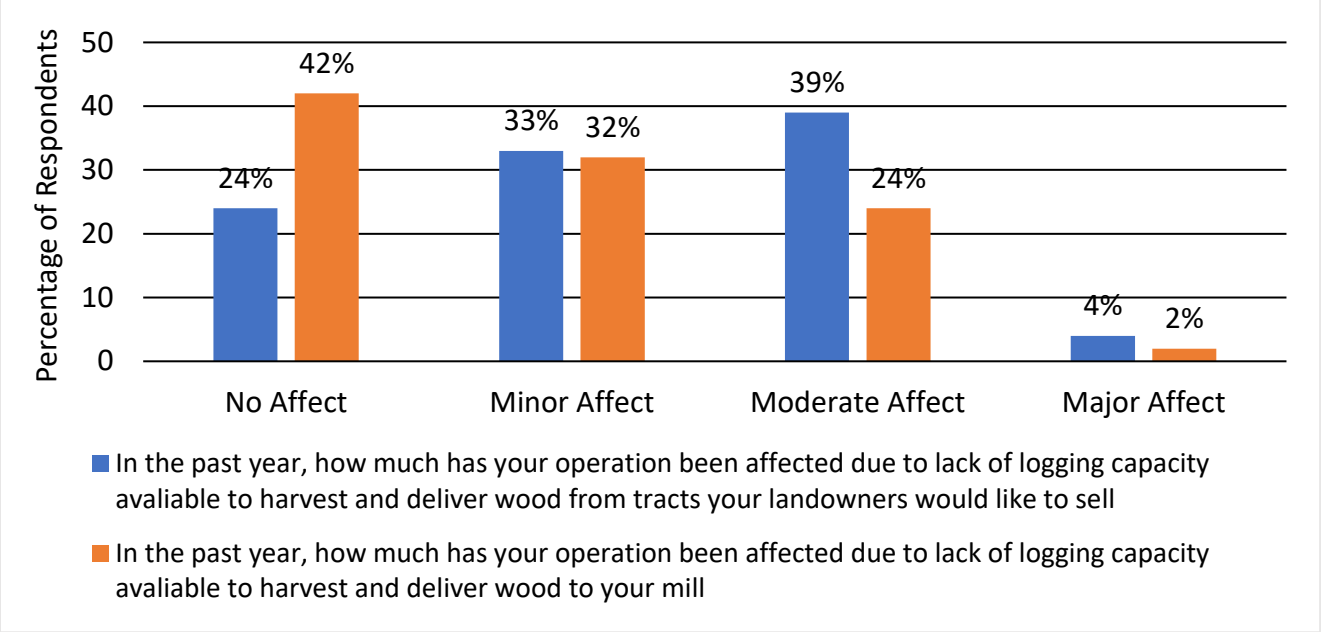

Figure 3.5 The effect that lack of logging capacity had on consultant and mill operations, in the past year.

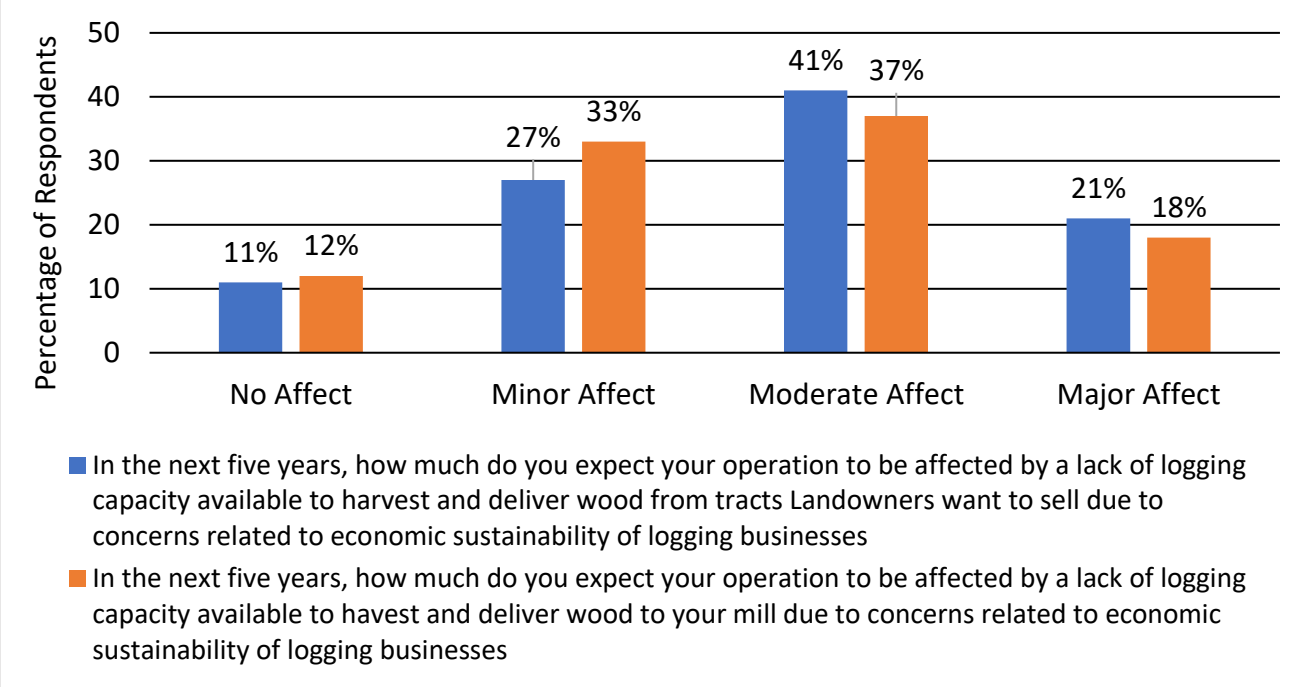

Figure 3.6 The effect that lack of logging capacity is likely to have on consultant and mill operations, in the next five years.

The question asked to both mill and consultant populations regarding how much their operations were affected in the past year due to a lack of logging capacity available to harvest and deliver wood was also analyzed by region. The majority of mill (70%) and consultant (50%) responders, located in the Mountains, indicated that the lack of logging capacity had a Moderate Affect on operations (Table 3.6). Consultant respondents in the Piedmont were split between No Affect (46%) and Moderate Affect (39%) while most mills indicated No Affect (57%). The respondents for both populations located in the Coastal Plains had split responses. 82% of the mill respondents indicated No or Minor Affect while the consultant population indicated that the lack of logging capacity affected their operations more, 77% selected Minor or Moderate Affect. Also analyzed by region were the responses to the statement "In the next five years, how much do you expect your operation to be affected by a lack of logging capacity..." Overall the responses from "In the past year" to "In the next five years" indicate that mills and consultants predict their operations will likely be more affected by a lack of logging capacity in the next few years.

Table 3.6 The effect that lack of logging capacity had and is likely to have on consultant and mill operations by region for the past year and the next five years.

	% Mountains				% Piedmont				% Coastal Plain			
	No Affect	Minor Affect	Moderate Affect	Major Affect	No Affect	Minor Affect	Moderate Affect	Major Affect	No Affect	Minor Affect	Moderate Affect	Major Affect
In The Past Year												
In the past year, how much has your operation been affected due to lack of logging capacity available to harvest and deliver wood **from tracts your landowners would like to sell**	10	30	50	10	46	15	39	0	18	41	36	5
In the past year, how much has your operation been affected due to lack of logging capacity available to harvest and deliver wood **to your mill**	10	10	70	10	57	32	11	0	36	46	18	0
In The Next Five Year												
In the next five years, how much do you expect your operation to be affected by a lack of logging capacity available to harvest and deliver wood from **tracts your landowners would like to sell** due to concerns related to economic sustainability of logging businesses	0	20	40	40	25	17	41	17	10	38	38	14
In the next five years, how much do you expect your operation to be affected by a lack of logging capacity available to harvest and deliver wood **to your mill** due to concerns related to economic sustainability of logging businesses	0	0	20	80	15	48	37	0	18	27	46	9

Within the year predating this study, logging businesses reported knowing an average of approximately three (2.96) logging businesses, in their area, that had gone out of business due to economic conditions and not because of retirement or death (Table 3.7). The Mill survey reported an even larger average (3.41) number of logging businesses going out of business within the past year. The consultant survey had the lowest reported average number (2.73) of businesses exiting the industry. While the consultant survey had the lowest overall average, the largest percentage (80.6%) indicated that they knew of 1-3 logging businesses that had gone out of business within the year prior to this study. The other two segments, logging business and mill surveys, both reported that over fifty percent (72.7% and 58.8% respectively) knew of 1-3 logging businesses that had exited the industry.

Table 3.7 Reported number of logging businesses exiting the industry in the year prior to the study.

	Mean	(1-3)	(4-6)	(7-9)	(10-12)
Logging Businesses	2.96	72.7	23.9	1.7	1.7
Mills	3.41	58.8	38.3	2.9	0.0
Consultants	2.73	80.6	19.4	0.0	0.0

Survey respondents were asked to rate the statement “the long-term outlook for the economic sustainability of the logging industry in my area is good” using the following scale: 1= strongly disagree, 2= disagree, 3= neutral, 4= agree, and 5= strongly agree. All population averages were on the disagree side of neutral, the consultant average was the lowest (2.6), followed by logging businesses (2.7), and mills (2.9).

The same 1-5 disagree/agree scale was used to obtain participant perspectives towards several other similar statements (Figure 3.7). When asked to rate the statement “the long-term outlook for the economic sustainability of landowners growing timber for harvest is good” both logging businesses and mills had neutral averages (3.1 and 3.5, respectively), while the consultant average was slightly less than neutral, at a disagree rating of 2.9. Another statement the respondents were asked to rate was “the long-term outlook for the economic sustainability of forest products mills is good.” Average responses from all three populations were neutral, the logger average was the lowest (3.0), followed by the consultant (3.1), and mill (3.2).

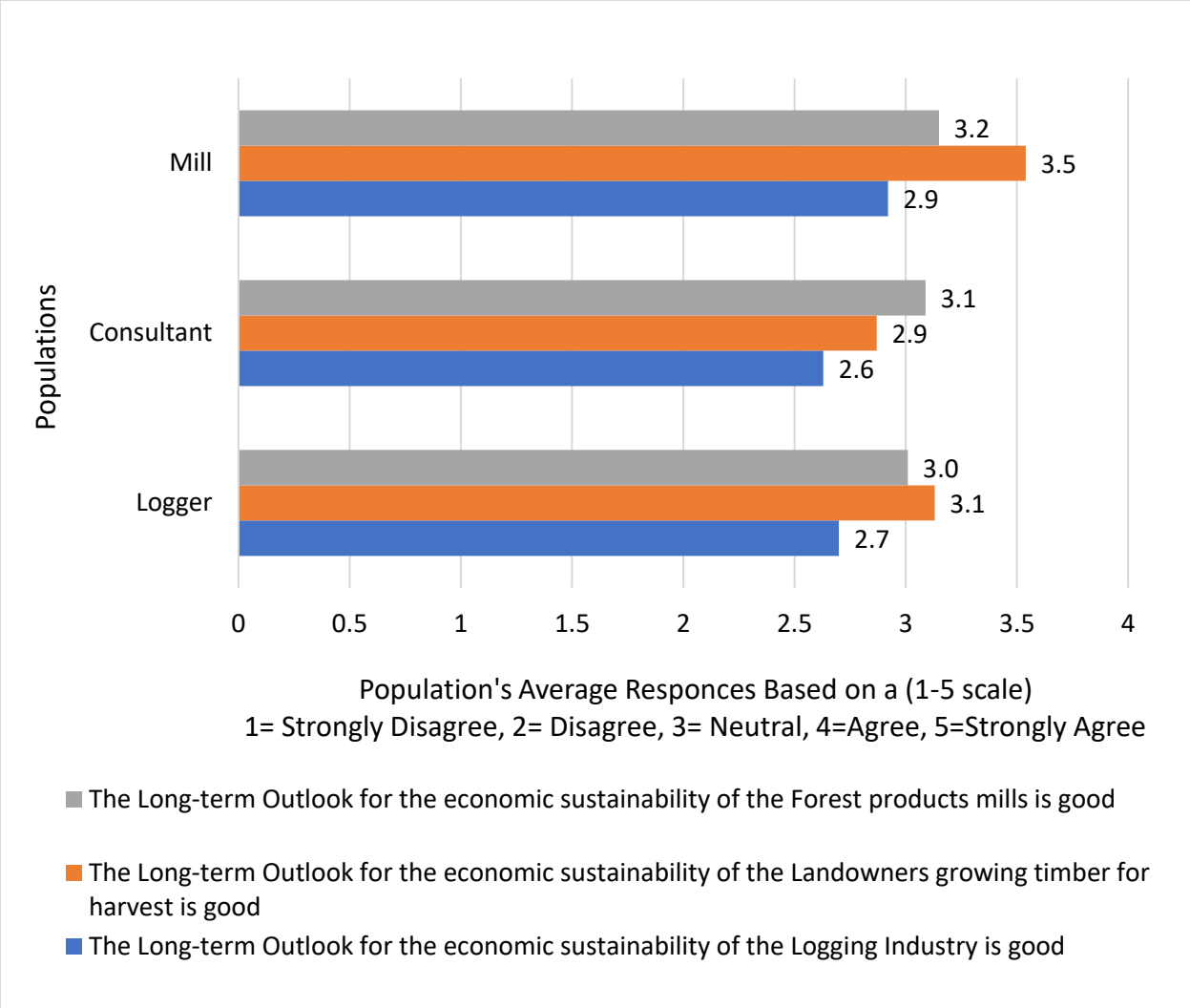

Figure 3.7 Economic sustainability outlook based on perspectives from the forest-based supply chain

Each population was asked if their relationship with the other survey populations (individually) was good. When the logging businesses were asked about their relationship with consuming mills where they deliver wood, the population average was on the agree side of neutral (3.9) (Table 3.8). However, when the mill population was given the same statement regarding logging businesses their population average was higher (4.5). When testing to determine if the averages are significantly different than neutral (3) both population averages were found to be significant. The consultant population was given the same statement

regarding their relationship with logging businesses and mills. The consultants on average agree (4.4) and have a good relationship with logging businesses. The population averages rated highest on the agree side of neutral, for both consultants and mills, were the questions about their relationship with logging businesses (Table 3.8). The consultants agreed that they had a good relationship with mills (3.9) and their population average was on the positive side of neutral.

Although their relationship averages were all rated on the positive side of neutral (3) to agree (4), both mills and logging businesses indicated that there could be changes implemented to improve the business relationship between loggers and consuming mills. The mill respondents had a higher average (3.8). However, the average was only slightly higher than the logging business average (3.8). It's likely that one of those changes for logging businesses could be related to mill quotas. The statement most agreed with for logging businesses was "Implementation of mill quotas affects the overall economic sustainability of my logging business" and the logging business population's average to the statement was a 4.2.

The consulting forester survey population was given the statement "Finding respectable and qualified logging businesses is relatively easy" and were asked to provide their opinion regarding the statement on the strongly disagree (1) to strongly agree (5) scale. The overall population average was neutral (3.1) (Table 3.8). Analyzing the data further, 50% of the population selected agree (4) or strongly agree (5), 37% selected strongly disagree (1) or disagree (2), and 13% selected neutral (3). So, half of the consultant population either disagrees or had a neutral perspective that finding respectable and qualified logging businesses is easy.

Table 3.8 Forest-based supply chain responses to statements using a scale: strongly disagree (1) to strongly agree (5). Mean Responses were analyzed using a Wilcoxon signed-rank test to determine if they were significantly different than neutral (3) indicated by the asterisk (*).

		Percent of Responses				
Logging Business	Mean/ Average	Strongly Disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly Agree (5)
Implementation of mill quotas affects the overall economic sustainability of my logging business	4.2*	0.6	3.6	13.8	42.5	39.5
I have a good working relationship with consuming mills where I deliver wood	3.9*	2.4	3.6	14.4	62.7	16.9
There are changes that could be implemented to improve the business relationship between loggers and consuming mills	3.8*	3.0	2.4	30.1	44.6	19.9
I would NOT encourage my child to pursue a career in the logging or forest industry because of factors related to economic sustainability	3.7*	4.8	12.7	26.5	21.7	34.3
I am not going to be able to continue operating my logging business if market conditions don't improve	3.6*	3.6	10.8	35.3	28.1	22.2
I plan to continue my logging business five years from now	3.5*	5.4	10.2	27.1	39.8	17.5
The long-term outlook for the economic sustainability of the **landowners growing timber for harvest** is good	3.1	5.4	25.2	25.7	38.9	4.8
The long-term outlook for the economic sustainability of the **forest products mills** is good	3.0	4.9	24.2	39.4	28.5	3.0
The long-term outlook for the economic sustainability of the **logging industry** is good	2.7*	13.3	30.7	30.7	23.5	1.8
Mill						
I have a good working relationship with logging businesses that supply wood to my mill(s)	4.5*	0.0	0.0	2.0	42.0	56.0
There are changes that could be implemented to improve the business relationship between loggers and consuming mills	3.8*	0.0	0.0	39.6	43.8	16.6
The long-term outlook for the economic sustainability of the **landowners growing timber for harvest** is good	3.5*	2.1	10.4	31.2	43.8	12.5
I would NOT encourage my child to pursue a career in the logging or forest industry because of factors related to economic sustainability	3.3	6.1	16.3	32.7	32.7	12.2
The Long-term Outlook for the economic sustainability of the **forest products mills** is good	3.2	0.0	27.1	33.3	37.5	2.1
The Long-term Outlook for the economic sustainability of the **logging industry** is good	2.9	4.2	39.6	22.9	27.1	6.2
Consultant						
I have a good working relationship with logging businesses where I work with	4.4*	4.3	0.0	4.3	32.7	58.7
I have a good working relationship with consuming mills where the logging businesses I work with deliver wood to	3.9*	4.3	2.2	21.7	43.5	28.3
Finding respectable and qualified logging businesses is relatively easy	3.1	10.9	26.1	13.0	39.1	10.9
The Long-term Outlook for the economic sustainability of the **forest products mills** is good	3.1	6.5	26.1	23.9	39.1	4.4
The Long-term Outlook for the economic sustainability of the **landowners growing timber for harvest** is good	2.9	8.7	43.5	8.7	30.4	8.7
I would NOT encourage my child to pursue a career in the logging or forest industry because of factors related to economic sustainability	2.9	10.9	32.6	23.9	26.1	6.5
The Long-term Outlook for the economic sustainability of the **logging industry** is good	2.6*	10.9	41.3	23.9	21.7	2.2

3.6 Discussion

3.6.1 Challenges Related to Logging Business Economic Sustainability

The future of the forest industry, specifically logging businesses, has been a concern for decades. This study focused on comparing perspectives of individuals working in forest-based supply chain on the economic sustainability and outlook for the forest industry. Over fifty percent of loggers (56%) would not encourage their child to enter the logging or forest industry because of factors related to economic sustainability. A concern for workforce sustainability within the industry arises because 60 percent of the respondents were descendants of logging families. These results are similar to *Egan and Taggart 2004*, who found that 69 percent of loggers would not encourage their child to become a logger, while 61 percent of the loggers were descendants of logging families themselves. 45% of mill respondents wouldn't encourage their child to enter the forest industry. If the next generation is encouraged to pursue careers outside of the forest industry, who will be the next loggers, foresters, and mill operators?

3.6.2 Outlook for the Forest-based Supply Chain

Only 26.1 % of businesses had an outlook that their business was economically sustainable, while over a third (38.8%) rated the outlook for their business as not economically sustainable. Across the other two segments, consultants and mills, an even larger percentage of respondents (68.9% and 56.3% respectively) felt that the future for logging businesses was not economically sustainable. Mills and consultants also seemed concerned about the economic sustainability of logging businesses, maybe even more so than loggers. However, in the short term, mills and consultants don't seem as concerned about their segments of the forest-supply chain. Their responses to "how much their operation has been affected in the past year and will

be affected in the next five years," due to a lack of logging capacity indicates that they aren't as concerned about the present as they are about the future logging capacity. All segments of the forest supply chain indicated concern regarding the entire forest industry, not just the logging businesses. Logging businesses, consultants, and mills felt that the long-term outlook for the economic sustainability of forest product mills was neither good nor bad, averages were slightly about neutral at best (3.01, 3.09, and 3.15 respectively). The statement with the highest population average was "the long-term outlook for the economic sustainability of landowners growing timber for harvest is good," reported by the mill population. The logging business population also rated landowners' long-term outlook on the positive side of neutral however only slightly about neutral (3.13), while the consultants had the lowest rating (2.87), falling on the negative side of neutral. This indicates that consultants are more worried about the long-term outlook for the economic sustainability of landowners growing timber for harvest than the mills and loggers. Consulting foresters are the individuals most often working close with the landowners, so there is an assumption that consultants would understand the availability of timber grown on private forest land better than the other segments.

Out of the statements provided in Table 3.8 "I have a good working relationship with logging businesses that supply wood to my mill(s)" was the highest rated statement for the mill respondents and "I have a good working relationship with consuming mills where I deliver wood" was the second highest rated statement reported by logging businesses. Overall, this indicated that relationships between mills and logging businesses are positive throughout the state. However, mill and logging business respondents agreed that "There are changes that could be implemented to improve the business relationship between loggers and consuming

mills." Mills and logging businesses rated the statement second and third highest, respectively, which provides opportunity to work together to improve business relationships and the industry dynamic overall. A possible area to work on from the logging business point of view would be implementation of quotas. The statement "implementation of mill quotas affects the overall economic sustainability of my logging business" was the top statement and a possible area for discussion that could benefit both segments. Consultants indicated that they have a good working relationship with consuming mills and logging businesses. Although they have a good working relationship, all segments should work together to discuss problems within the industry.

All respondent averages, for the long-term economic sustainability of the logging industry, fell on the negative side of neutral and were the lowest population averages for each individual statement. This indicated that each segment of the supply chain had concerns regarding the future of the industry and felt that the long-term economic sustainability is not good. No segment of the supply chain had positive outlooks towards their own segment or another segment. Mill and Consultant respondents' outlooks for the economic sustainability of logging businesses were more unsustainable (56.3% and 68.9%, respectively reported it as unsustainable) than the outlooks logging businesses had for themselves (38.8%) (Figure 3.3). In addition, mill and consultant responses to "how much their operations were affected in the past year (two and four percent, respectively) and will be affected in the next five years (18% and 21%) due to a lack of logging capacity," predicted that they will likely be more affected in the next few years due to a decrease in logging capacity. The degree of concern captured in the study for not only logging businesses, but the industry overall (mills and consultants included)

provides an opportunity for all supply chain segments to work together to find ways to improve the industry and implement a more economically sustainable future.

3.7 Conclusion

The economic sustainability of logging businesses and the logging industry implies general profitability and long-term financial viability. The objective of this study was to compare opinions and perspectives from professionals in three segments of the forestry supply chain, on their outlook for logging businesses in Virginia concerning economic sustainability. Logging businesses are the essential link connecting landowners with forest product mills within the forest-based supply chain. The segments of the supply chain rely on each other to operate successfully, without one producing final forest products would be extremely difficult. Forest consultants and primary forest product mills indicated that they are more concerned than logging businesses regarding the future of the logging businesses in Virginia. However over one third of logging businesses reported that their outlook for their own logging businesses was not economically sustainable. Mills and consultants have also expressed concern regarding the lack of logging capacity in the upcoming years. In the year prior to the study, mills indicated having very little operational problems due to the lack of logging capacity available to harvest and deliver wood. However, in the next five years both mills and consultants expect the lack of logging capacity to have a greater effect on their operations. Additionally, the long-term outlook for the forest industry overall is not good according to each segment of the supply chain.

The study shows the challenges but not solutions, the hope is that it will be the catalyst bringing together different groups to work to address those challenges and identify possible solutions. This survey is a snapshot in time providing valuable information and a starting point to evaluate logging industry economic sustainability in the future. Future studies could focus on the addition of new mills and markets increasing competition and wood consumption within Virginia. Additional potential research could focus on recruitment and retention of a younger workforce entering the logging industry. A study focused on the relationships between forest-based supply chain segments would be beneficial to the long-term sustainability of the forest industry. Additional research focused on logging business characteristics that affect profitability would help in the understanding of logging business long-term economic sustainability. A continuation of this survey to determine how supply chain perspectives on economic sustainability change as markets and the economy fluctuate. Continuing this survey would allow researchers the ability to compare perspectives on economic sustainability and outlooks for the future of the industry.

An important factor to note is that forest product market conditions at the time of the survey likely had a strong influence on the survey results and changes in markets would likely have an impact on the outlook for many of the respondents. There were a lot of neutral responses, and changes in market conditions or the addition of new markets in Virginia could quickly move perspectives to have more positive outlooks. The degree of concern portrayed throughout the study for not only logging businesses, but the industry overall (mills and landowners included) provides an opportunity for all supply chain segments to work together to find ways to improve the industry and implement a more economically sustainable future.

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4.0 Conclusion of Master's Project; Virginia Logging Business Economic Sustainability Survey

4.1 Study Objectives

The primary research objective was to evaluate perspectives on the economic sustainability of logging businesses in Virginia. Three subobjectives were used to accomplish the main objective. The first subobjective was to determine opinions and perspectives of logging business owners related to challenges surrounding the economic sustainability of their businesses. Subobjective two was to compare differences in opinions and perspectives based on business owner characteristics such as number of years in business, region they primarily operate, size and type of operation, as well as primary markets for products they harvest. Chapter two primarily focused on subobjective one and two while chapter three focused on subobjective three. The third subobjective was to compare opinions and perspectives from across the forest supply chain (landowners, loggers, and mills) on their outlook for logging businesses in Virginia. Some similar data presented in chapter two also appears in chapter three.

4.2 Summary and Conclusion

The economic sustainability of logging businesses and the logging industry implies general profitability and long-term financial viability. This survey is a snapshot in time providing valuable information and a starting point to evaluate logging industry economic sustainability in Virginia. We determined the most effective way to obtain data from three sperate populations across the state of Virginia was to conduct a mail survey based on the Dillman method. Data was collected from the three populations: logging business owners, consulting foresters

(landowner representatives), and mill owners or wood procurement representatives. The logging business owner questionnaire was the largest and their population was the main focus of the study. Although logging businesses are the essential link connecting landowners to forest product mills within the forest-based supply chain, not one segment could function successfully without the others. Due to the segment's dependency, the study also included the other two segments of the forest-based supply chain.

Each of the three questionnaires included characteristic questions specific to the population. The average results from the characteristic section of the logging business questionnaire included logging business owners age (55), number of years they operated/managed their own business (27), tons per week harvested (872), amount invested in operation (~$800,000), number of trucks (3), number of full-time employees (6), and number of logging crews per business (1). The average characteristics from the consultant questionnaire were number of years work as a consultant (22) and the average tract size they commonly work with (73 acres). The mill questionnaire included only one characteristic question; number of years involved in buying wood for a mill (22). All populations were asked what county they considered to be the center of their operations which was used to sort respondents into the three Virginia regions.

4.2.1 Subobjective One and Two

A total of 168 logging business questionnaires were completed and returned, for a response rate of 27 percent. The results from the study found that the top two challenges logging businesses face are fuel related. The number one challenge reported by logging

businesses was fuel costs for in-woods harvesting equipment followed by fuel costs for trucks. Logging businesses reported that only 32.9% were profitable in the past year and the majority (56%) calculated profit margins either for each tract they harvest or monthly. In the Mountains, the more hardwood sawtimber harvested the more profitable businesses reported they were. Only 26.1% of businesses had an outlook that their business was economically sustainable while 38.8% of businesses reported that their business was not sustainable.

4.2.2 Subobjective Three

The survey populations included logging business owners, consulting foresters (landowner representatives) and mill owners or procurement representatives, response rates were 27.1%, 69.1%, and 39.7%, respectively. Sixty percent of logging businesses respondents are descendants of logging families while 56% of logging business owners, 44.9% of mills representatives, and 32.6% of consulting foresters wouldn't encourage their own child to pursue a career in the logging or forest industry. Results indicated that based on current conditions over a third of the logging businesses (38.8%) rated the outlook for their business as not economically sustainable. Across the other two segments including consulting foresters and mills, an even larger percentage of respondents (68.9% and 56.3% respectively) viewed logging operations as not economically sustainable. Over fifty-five percent of logging businesses reported there being too much logging capacity in Virginia, while almost sixty percent of mills (59.2%) indicated that there is just the right amount of logging capacity. Mill survey respondents indicated that their business has experienced no effect (42%) to minor effect (32%) due to a lack of logging capacity in the past year. However, mill and consultants expect, in the next five years, that their operations will experience a greater negative effect due to a lack

of logging capacity available to harvest and deliver wood. All segments of the forest supply chain indicated concern regarding the long-term outlook for economic sustainability of the entire logging industry.

4.2.3 Primary Objective

The study was conducted because no or little research exists where logging businesses have been asked to rank the challenges and issues they undergo, and little or no research exists focused on evaluating the economic sustainability of logging businesses and other segments in the forest supply chain, especially in the state of Virginia. Virginia is a great state to use for studying the logging industry due to its variety of regional characteristics. Overall logging businesses have indicated that the state industry was not great at the time the survey was conducted (summer 2023). However, on a positive note there were a lot of neutral responses, and changes in market conditions or the addition of new markets in Virginia could quickly move perspectives to have more positive outlooks. Although the survey didn't provide answers, it determined what the real challenges are, and hopefully this study will be a catalyst for change. The degree of concern portrayed throughout the study for not only logging businesses, but the industry overall (mills and landowners included) provides an opportunity for all supply chain segments to work together to find ways to improve the industry and implement a more economically sustainable future.

4.3 What Is Next

The study shows the challenges but not solutions, the hope is that it will be the catalyst bringing together different groups to work to address those challenges and identify possible

solutions. However, a proposed idea could be to come up with a fuel or cost index which would provide logging businesses with more stable market prices and a way to plan longer term. This survey is a snapshot in time providing valuable information and a starting point to evaluate logging industry economic sustainability in the future.

Based on findings from chapter two: future studies could focus on the addition of new mills and markets, increasing competition and wood consumption within Virginia. Additional potential research could focus on recruitment and retention of a younger workforce entering the logging industry. A continuation of this survey could help to determine how challenges and issues faced by logging businesses change over time with fluctuating market conditions. Continuing this survey would allow researchers the ability to compare perspectives on how logging business outlooks for the economic sustainability of their businesses change over time and what challenges affect them the most.

Based on findings from chapter three: a study focused on the relationships between forest-based supply chain segments would be beneficial to the long-term sustainability of the forest industry. Additional research focused on logging business characteristics that affect profitability would help in the understanding of logging business long-term economic sustainability. A continuation of this survey to determine how supply chain perspectives on economic sustainability change as markets and the economy fluctuate. Continuing this survey would allow researchers the ability to compare perspectives on economic sustainability and outlooks for the future of the industry.

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