THE LOGGING SECTOR IN THE LAKE STATES OF MICHIGAN, MINNESOTA, AND WISCONSIN: STATUS, ISSUES AND ECONOMIC POTENTIAL

By

Shivan Gc

A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

Forestry – Doctor of Philosophy
Environmental Science and Policy – Dual Major

2023

ABSTRACT

In the wood products supply chain, the logging industry is a critical link that connects forest resources and the management of those forests with wood-using mills. A healthy logging industry is, therefore, a prerequisite for sustainable forest management and for well-functioning forest products industries. This study used the data collected from coordinated mail surveys of logging businesses in the Lake States of Michigan, Minnesota, and Wisconsin to assess the status and capacity of the sector in 2016. It analyzed the similarities and differences between mechanized and chainsaw-based logging businesses in each state. Additionally, the procurement areas of logging businesses in Michigan were delineated using a road network dataset and indicated average one-way travel distance of logging businesses to harvest sites using ArcGIS. The areas with high versus low competition for timber resources in the loggers' wood basket were also identified. The condition of timber resources and ownership types in the wood basket of respondent logging businesses were assessed using forest inventory and analysis data 2019. Based on their level of reliance on nonindustrial private forests (NIPFs) for stumpage, the logging businesses in Michigan were categorized as NIPF-dependent and nondependent businesses and similarities and differences between the two groups were explored. Further, the study utilized impact analysis for planning (IMPLAN) software and 2017 IMPLAN data to estimate the economic contribution of the logging industry to each state and to the region's economy. IMPLAN was also used to understand the potential economic impacts of projected loss in logging businesses in each of the three states and to understand how substitution of lost logging capacity through imports would affect the economic footprint of forest products industries within that state.

Our findings highlight interesting traits of logging businesses in the region. Despite the presence of many small logging businesses, much of the volume (58%) was produced by a few large producers (13%) who seemed to have an advantage over their smaller sized counterparts. Businesses and business owners across the region were aging (average business duration, 27 years and average owner age, 54 years), and the majority were producing below their full operational capacity and achieving break-even profit levels. About a quarter of logging businesses in the region intended to exit from the market in the short-term future, and there seemed to be a lack of enticing factors attracting new workforce members into the business.

Mechanized logging businesses had a significantly higher number of owners per

business, were more likely to be family-run operations, had greater amounts of capital invested in business, and harvested five times the timber volume compared to chainsaw-based logging businesses. Compared to chainsaw-based logging businesses, mechanized logging businesses in Wisconsin were more likely to indicate that they will continue logging in the short-term future.

The findings from the service area delineation for Michigan's logging businesses revealed that 15% of the total forest acres available in the procurement areas of respondent logging businesses have relatively less competition while one percent have very high competition. Forest conditions dataset in the procurement areas indicate net annual growth to be more than double the removals, meaning that sustainability in timber resource use was not a concern at the time of the study. However, net growth to removals ratios varied considerably with ownership types suggesting that increased timber harvests from all ownership types may not be equally sustainable. NIPF dependent and nondependent logging businesses in Michigan varied in terms of average volume harvested, equipment used, and methods employed for acquiring stumpage.

The economic contribution analysis results revealed that the logging industry directly employed over 12,000 people in 2017 and generated more than $900 million in direct economic output to the three-state regional economy. Including ripple effects, the contributions were much higher. In case of lost logging capacity within a state, if the local demand for roundwood and logs produced by the logging industry is met through imports, a considerable portion of indirect and induced economic effects that could be realized within the state leak out of it.

Information about logging businesses as presented in this study are useful for developing a better understanding about this industry among policy makers, foresters, landowners, and forest products industries alike to help sustain and strengthen this industry in the future.

Keywords: Logging industry, economic contribution, network analysis, nonindustrial private forests, mechanized logging

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to Dr. Karen Potter-Witter, my major advisor, for being a role model and for inspiring me to embark on my Ph.D. journey. She has been a constant source of support, guidance, and encouragement throughout my Ph.D. program and academic career. I am also grateful to my guidance committee member Dr. Larry Leefers. He has been very approachable, helpful, and provided constructive suggestions and guidance throughout the study. Appreciation is due to my other committee members Dr. Patricia Norris, Dr. Emily Huff, and Dr. Andrew Finley for their invaluable assistance during the advising process and for their continued guidance throughout the study.

Special thanks go to Dr. Raju Pokharel for sharing with me his expertise on service area delineation and for guiding me in mapping the procurement areas of logging businesses in Michigan. Thanks to Dr. Jagdish Poudel for his help in providing IMPLAN data and assisting me in conducting economic contribution and impact analysis.

Sincere gratitude goes to Dr. Charlie Blinn and Dr. Mark Rickenbach for sharing with me the survey data collected from logging businesses in Minnesota and Wisconsin and providing constructive feedback and guidance while developing the regional study of logging businesses. I am also grateful to the logging business survey team in each state (Matt Kelly in Michigan; Stephanie Snyder, Matt Russell, and Rachel Peterson in Minnesota; Julie Ballweg, Tricia Gorby, Craig Johnson, and Melinda Vokoun in Wisconsin) for their valuable input during survey design and analysis. Thanks go to all the logging business owners who responded to our survey questionnaire.

Thanks to Michigan Forest Products Council for funding support to conduct the logging survey in Michigan. Thanks to Minnesota Forest Industries, the Minnesota Logger Education Program, Wisconsin Department of Natural Resources, and the Great lakes Timber Professionals Association for supporting logging business surveys in Minnesota and Wisconsin.

Thanks to MSU ESPP and Department of Forestry for funding support during my study.

Thanks to so many friends in the forestry department and beyond who have made my life at MSU more joyful: Naresh, Nafisa, Ichchha, Tara and many more.

Finally, I am thankful for the constant love, support, and encouragement that is provided by my family members including parents, parent-in-laws, siblings, husband, Supratik, and kids Serene and Samaira.

TABLE OF CONTENTS

CHAPTER 1. INTRODUCTION

The logging industry is a critical component of the forest products industries which contributes significantly to the Lake States' (Michigan, Minnesota, and Wisconsin) economy. The forest products industries employ over 142,000 people and generate close to $48 billion in direct economic output to the three states' economy (Leefers et al. 2020). In the wood products supply chain, the loggers act as a connecting link joining forest resources with the forest products industries. They harvest and process standing timber from various landownership types and market the harvested timber to primary forest products mills. The loggers thus help to meet society's demand for wood products and assist land managers to fulfill their forest management objectives (Rickenbach et al. 2005). Since loggers are the primary implementors of forest management prescriptions on the ground, their actions help shape the structure of forests and forest composition (Rickenbach et al. 2005). A strong logging industry is not only essential for production forestry to thrive but is equally important for maintaining healthy forest systems. Besides, in many forest-dependent rural communities, the logging industry provides an important source of income and employment; thus, the industry also serves as an engine for economic development in rural areas.

Studies conducted on logging businesses in the Lake States region and beyond (He et al. 2021, Blinn et al. 2015, Rickenbach et al. 2015, Georgen et al. 2013, Gc and Potter-Witter 2011, Allred et al. 2011) have indicated that, despite being a crucial element of the multi-billion-dollar forest products industries and playing an important role in rural economies, loggers are struggling to remain in business and operate profitably in recent times. The challenges faced by the logging industry include declining markets for wood products owing to economic recession and shifts in consumer demand for certain wood products such as printed media (Espinoza 2020). Additionally, logging businesses and loggers are grappling with rising operating costs, including fuel, parts, and equipment, as well as expenses associated with complying with environmental regulations and forest certification (He et al. 2021, Baker et al. 2014). The aging population of logging business owners, and difficulties in recruiting and retaining skilled workers further compound the hardships faced by the industry (Rickenbach et al. 2015, Georgen et al. 2013, Allred et al. 2011).

Due to the pivotal role that logging businesses play in the wood supply chain, it is in the interest of policymakers, land management organizations, procurement mills, and forest

products associations to have access to timely and up-to-date information about the status of the logging industry, know about the challenges that the industry faces, and understand its strengths and weaknesses (Blinn et al. 2015). Over the course of the past four decades, numerous logging business studies have been conducted in different parts of the U.S. to assess the status and capacity of the logging industry and to understand the trends in logging business characteristics over time. Examples include: Conrad et al. 2018, Rickenbach et al. 2015, Blinn et al. 2015, Vaughan and Mackes 2015, Leon and Benjamin 2012, and Bolding et al. 2010. Periodic surveys of logging businesses have been conducted in southern U.S. states such as Georgia since 1987 and in South Carolina since 2012 (Conrad et al. 2018, Greene et al. 2013, Baker and Greene 2008, Greene et al. 2001, Greene et al. 1988). Other states that have conducted surveys of logging businesses at different time periods include Minnesota (Blinn et al. 2015, Powers 2004, Bolstad 1980) and more recently Wisconsin (Rickenbach et al. 2015. Rickenbach et al. 2005) and Michigan (Abbas et al. 2014, Gc and Potter-Witter 2011, Rickenbach et al. 2005).

Most of the logging business studies conducted in the Lake States region, are state-oriented studies that have proven valuable in analyzing state-specific factors such as harvesting capacity, capital investment, profitability of businesses, and other business characteristics. However, due to variations in timeframes, study focus, and questionnaire design, these state-level data and analyses fall short of presenting a comprehensive picture of the logging industry across the region. Considering the frequent movement of harvested timber across state borders within the Lake States region due to their close geographic proximity (Piva and Neumann 2018), it becomes apparent that a regional study of logging businesses would provide a more holistic understanding of the logging industry. Except for the studies by Rickenbach et al. (2005), that surveyed logging businesses in Wisconsin and Michigan's Upper Peninsula, and by Abbas et al. (2014), that included loggers from Michigan and northern Wisconsin, no other study to our knowledge has examined Lake States logging businesses from a regional standpoint. Given this, the second chapter of this dissertation attempts to address the gap in regional logging business literature by using the data collected through coordinated mail surveys of logging businesses in Michigan, Minnesota, and Wisconsin conducted in spring 2017. The objectives of the chapter are two-fold: 1) To develop a baseline dataset of logging business metrics across the region to obtain a better

understanding of business attributes, owner demographics, harvest potential, equipment infrastructure, and challenges and opportunities facing the industry, and 2) To compare the capacity and structure of logging businesses among states. While the baseline dataset of business metrics can serve as a reference point against which future comparisons can be made to assess how the industry evolves over time, the comparative analysis of businesses among states can help identify the strengths and shortcomings of businesses within states. Such information can be useful for better positioning of businesses for improved efficiency and profitability in the future.

Logging business studies conducted across the country have noted significant changes in the ways that loggers and logging businesses operate over the past four decades (He et al. 2021, Conrad et al. 2018). The most prominent change is the mechanization of logging operations starting in the 1960s (Conrad et al. 2018, Greene et al. 2001). Since the 1960s, many logging businesses in the country have adopted mechanized harvesting equipment such as feller-bunchers and cut-to-length harvesters for felling timber; delimbers and slashers for topping and bucking; and cable skidders, grapple skidders, and forwarders for in-woods transportation (Conrad et al. 2018). Mechanization of logging and transportation equipment has increased both the productivity and safety of logging workers and transformed the industry from labor intensive to capital intensive businesses (Conrad et al 2018, Blinn et al. 2015, Sejdo 1997). From their conversation with loggers and equipment vendors in Wisconsin in 2005, Rickenbach and Steele (2005) noted that an initial investment of $0.4 million to $1.5 million was common for employing a modern mechanized logging system in early 2000s. More recently, Conrad et al. (2018) noted an average equipment investment cost of $1.97 million for logging businesses in Georgia and $2.23 million for those in South Carolina. With high capital invested in business, mechanized logging businesses are at a greater risk of financial crisis should market and business conditions be not as favorable (Rickenbach and Steele 2005). That is because mechanized logging businesses have the burden of making higher regular payments to cover fixed costs, irrespective of their production level. Production level of a logging business may be governed by several factors including market demand for wood products, weather conditions, mill quotas, equipment breakdowns and other reasons. Mechanized logging businesses also demand a workforce capable of operating complex machines and require larger landings and skid trails compared to their non-mechanized

counterparts (Bennett 2010).

Despite the rise in adoption of mechanized felling equipment, past studies (Rickenbach et al. 2015, Abbas et al. 2014, Leon and Benjamin 2012, Allred et al. 2011) have also noted continued reliance of several logging businesses on non-mechanized felling techniques, such as chainsaws and skidders or forwarders for harvesting timber. Flexibility to work on difficult terrain, usefulness when working with high valued timber, low capital investment required for business startup and operation, and comparative advantage when harvesting timber on smaller sized forest parcels, are some of the positive aspects of non-mechanized logging operations (Allred et al. 2011, Rickenbach and Steele 2005). Given the trend towards urbanization (Nowak and Walton 2005) and forest parcelization (Gobster and Rickenbach 2004, Mehmood and Zhang 2001), these same benefits may be helpful in the continued survival and operation of non-mechanized logging businesses in the future (Allred et al. 2011, Rickenbach and Steele 2005).

Few studies to date have analyzed the differences between mechanized and chainsaw-based logging businesses in the U.S. (Allred et al. 2011, Rickenbach and Steele 2005). The emphasis of those studies that have been done has been to understand the differences in production levels, sources of timber, and perception about forest parcelization as a potential problem for logging businesses. The third chapter of this dissertation contributes to this existing body of literature with an additional emphasis on understanding how mechanized and chainsaw-based logging businesses are operating more recently in Michigan, Minnesota, and Wisconsin and where the industry might be headed in the future given the existing trends. This chapter addresses the question: Will mechanized logging businesses in these states ultimately take over the logging business as in the U.S. South or will chainsaw-based logging businesses continue to have their niche? More specifically, using the data collected through the mail survey of logging businesses in Michigan, Minnesota, and Wisconsin in 2017, this chapter compares mechanized and non-mechanized logging businesses in terms of owner and business characteristics. Using binary logistic regression, it explores the factors that influence the short-term longevity of logging businesses in each of the three states. The aim is to identify whether mechanization status of a logging business influences business owners' intention to remain or not remain in business in the short-term future.

Besides mechanization, other important factors that affect the operations and

profitability of logging businesses are modifications in forest ownership patterns (in terms of forest ownership type and ownership size) and condition of forest resources on which the loggers rely (He et al. 2021, Allred et al. 2011). Depending upon the type of forestland ownership, the management objectives and resulting forest management prescriptions for tracts of forests may vary (Hoover and Riddle 2021, Sass et al. 2021, DeCoster 1998). For instance, forestlands owned by corporate private landowners may be managed for maximizing timber benefits, therefore leading to a larger and more frequent timber harvests. On the other hand, forestlands owned by nonindustrial private forest landowners may be managed for obtaining non-timber amenity benefits, leading to less frequent timber harvests. Similarly, forestlands owned by federal and state government agencies may have varying management objectives which ultimately guide the management prescriptions undertaken in such forests. Besides forest ownership type, the size of forest tracts available for timber harvests also affects logging operations. Past studies have noted increased timber production costs associated with decreased forest tract size due to diminished timber harvesting economies of scale (Moss and Hedderick 2012, Greene et al. 1997, Cubbage 1983, Row 1978). Forest tract size available for harvest is also likely to vary depending upon the type of forest ownership. Approximately 60% of forestlands owned by nonindustrial private owners in the country are one to nine acres in size, whereas those owned by corporate private owners are much larger than that (Butler 2012). Additionally, the condition of forest resources in loggers' procurement areas also determines the type of management prescriptions undertaken and the amount of timber products that can be generated without negatively impacting the sustainability of forest resource base.

In the recent U.S. history, a key event that has modified forest ownership patterns across the country is the vertical disintegration of forest products industries starting in the 1990s. Large-scale divesture of forestlands owned by vertically integrated forestry companies started during that period, primarily to reduce tax burden and debt load (Sass et al. 2021). This led to the shift in millions of acres of forestlands from forest industries to timber investment management organizations, real estate investment trusts, families, and others (Sass et al. 2021, Butler 2008). Besides vertical disintegration of forest products industries, ongoing factors that change forest ownership patterns include intergenerational transfer, urbanization, estate tax structures, and lifestyle preferences for forestlands.

A review of existing logging business literature reveals that not many logging business studies have analyzed the wood basket of such businesses to understand resource condition, ownership type, and competition dynamics in loggers' procurement areas. The fourth chapter of this dissertation attempts to address this gap for logging businesses in Michigan. It delineates procurement areas for 115 logging businesses in Michigan using road network datasets for the state and information collected from a mail survey of logging businesses to understand the status of forest ownership, condition of forest resources, and competition level prevalent among logging businesses in Michigan. This chapter further classifies Michigan's respondent logging businesses as NIPF dependent and nondependent businesses based upon their level of reliance on nonindustrial private forests for stumpage and analyzes similarities and differences between the two groups. This is important because NIPF owners are the major forest ownership type in Michigan, owning more than 40% of total forestlands in the state. The majority of forestlands held by NIPF owners in Michigan (60%) are small holdings (less than 100 acres) (USDA Forest Service 2021). Information about competition for resources among logging businesses and condition of resources in the wood basket can provide useful insights into existing logging businesses and help them better understand and navigate market dynamics. Additionally, this information is also useful for landowners and forest resource managers.

Survey-based logging business studies in the Lake States region and across the country emphasize that more and more logging business owners are aging in place and approaching retirement age (Conrad et al. 2018, Rickenbach et al. 2015, Leon and Benjamin 2012, Baker and Greene 2008). Logging businesses in the U.S. are predominantly family businesses (Allred 2009, Egan and Taggart 2004), and when the family business owner reaches their retirement age, the business can either be taken over by an identified successor(s), sold, or terminated (Malinen 2001). In Wisconsin, Rickenbach et al. (2015) noted that 20% of the logging businesses in the state left their business between 2003 and 2010 and another 19% indicated intentions to exit from the market in the short-term future. In the same study, the authors noted that only seven percent of new businesses had opened from 2003 to 2010 to fill the gap left by logging businesses exiting from the market. Similar findings were obtained by Blinn et al. (2015) in MN and Allred (2009) in the north central region of the United States.

To complicate matters, past logging business studies have also expressed concerns

about difficulty in attracting and retaining skilled employees in logging businesses across the country (Espinoza 2020, Conrad et al. 2018). Non-attractive wage and benefits packages, and the physically intense nature of the work have been listed as some of the factors demotivating people from joining the profession (He et al. 2021). Espinoza (2020) notes that contraction of the logging workforce coupled with difficulty in hiring and retaining employees and an ongoing shortage of truck drivers have contributed to making timber harvesting the most fragile link in the wood products supply chain. Since the forest products industry can only be as strong as its weakest link, the industry and all concerned stakeholders need to focus more attention on sustaining and strengthening the logging industry in the years to come. Given this, the fifth chapter of this dissertation uses impact analysis for planning (IMPLAN) software and 2017 IMPLAN data to highlight the economic importance of logging businesses to the economies of Michigan, Minnesota, and Wisconsin and the combined three-state region.

Quantifying the economic contribution of the logging industry to a particular region can be useful for emphasizing the importance of the industry to that region and for attracting supporting policies for sustaining and strengthening the logging industry in the future. This chapter not only estimates the economic contributions of the logging industry in the Lake States region but goes beyond that to assess what it means for the state economy to lose logging businesses without replacement. It uses hypothetical but probable scenarios to assess the impact of lost logging capacity on the state economies of Michigan, Minnesota, and Wisconsin and what it means to replace the lost capacity within each state through imports. Such information can help emphasize the importance of the logging industry within the state and highlight interconnections of the logging industry with other forest products industry sectors so that broader forest products industries can fathom how changes in logging industry dynamics can impact them.

The dissertation is organized as follows. Chapter 2 contains the first article, entitled "The logging sector in the Lake States of Michigan, Minnesota, and Wisconsin: Status, issues and opportunities". Chapter 3 contains the second article, entitled "Mechanized versus chainsaw-based logging businesses in the Lake States region: Evolution and future direction". Chapter 4 contains the third article, entitled "Assessing the wood basket and characterizing Michigan's logging businesses by their reliance on nonindustrial private forests for

stumpage". Chapter 5 contains the fourth article entitled, "Potential economic impacts of projected logging business closures and import substitution to meet local demand in the Lake States". Finally, Chapter 6 summarizes the conclusions for this dissertation.

LITERATURE CITED

Abbas, D., R. Handler, B. Hartsough, D. Dykstra, P. Lautala, and L. Hembroff. 2014. A survey analysis of forest harvesting and transportation operations in Michigan. Croatian Journal of Forest Engineering. 35(2):179–192.

Allred, S.B. 2009. Logging firm succession and retention. Forest Products Journal. 59(6):31-36.

Allred, S., C. Michler, and C. Mycroft. 2011. Midwest logging firm perspectives: Harvesting on increasingly parcelized forestlands. International Journal of Forestry Research. 2011:1-7.

Baker, S.A., and W.D. Greene. 2008. Changes in Georgia's logging workforce 1987-2007. Southern Journal of Applied Forestry. 32(2):60-68.

Baker, S.A., B. Mei, T.G. Harris, and W.D. Greene. 2014. An index for logging cost changes across the US South. Journal of Forestry. 112 (3):296-301.

Bennett, K.P. editor. 2010. Good forestry in the granite state: Recommended voluntary forest management practices for New Hampshire (second edition). University of New Hampshire Cooperative Extension, Durham, N.H. 224p.

Blinn, C.R., T.J. O'Hara, D.T. Chura, and M.B. Russell. 2015. Minnesota's logging businesses: An assessment of the health and viability of the sector. Forest Science. 61(2):381-387.

Butler, B. 2008. Forest ownership patterns are changing. National woodlands. Spring 2008. Available online at https://www.nrs.fs.usda.gov/pubs/jrnl/2008/nrs_2008_butler_001.pdf; last accessed June 15, 2023.

Butler, B.J. 2012. Forest ownership patterns. In: Laband, D.N., B.G. Lockaby, and W.C. Zipperer. Urban-rural interfaces: Linking people and nature. Madison, WI. American society of agronomy and crop science society of America. 117-125. Chapter 7.

Conrad, J.L., W.D. Greene, and P. Hiesl. 2018a. A review of changes in US logging businesses 1980s-present. Journal of Forestry. 116(3):291-303.

Conrad, J.L., W.D. Greene, and P. Hiesl. 2018b. The evolution of logging businesses in Georgia 1987-2017 and South Carolina 2012-2017. Forest Science. 64(6):671-681.

Cubbage, F.W.1983. Tract size and harvesting costs in southern pine. Journal of Forestry. 81(7):430-433.

DeCoster, L.A.1998. The boom in forest owners-A bust for forestry? Journal of Forestry. 96(5):25-28.

Egan, A., and D. Taggart. 2004. Who will log? Occupational choice and prestige in New England's north woods. Journal of Forestry. 15(6):20-25.

Espinoza, O. 2020. Trends in the U.S. forest products sector, markets, and technologies. In: Dockry, Michael J., Bengston, David N., Westphal, Lynne M., comps. Drivers of change in U.S. forests and forestry over the next 20 years. Gen. Tech. Rep. NRS-P-197. Madison, WI: U.S. Department of Agriculture, Forest Service, Northern Research Station: 26–49. https://doi. org/10.2737/NRS-GTR-P-197-paper4.

Gc, S., and K. Potter-Witter. 2011. An examination of Michigan's logging sector in the emerging bioenergy market. Forest Products Journal. 61(6):459-465.

Gobster, P.H., and M.G. Rickenbach. 2004. Private forestland parcelization and development in Wisconsin's Northwoods: perceptions of resource-oriented stakeholders. Landscape and Urban Planning. 69(2004):165-182.

Goergen, M., J. Harding, C. Owen, M. Rey, and L. Scarlett. 2013. The state and future of U.S. forestry and forest industry. Available online at the-state-and-future-of-the-u.s.-forest-industry.pdf (usendowment.org); last accessed April 28, 2023.

Greene, W.D., B.D. Jackson, and J.D. Culpepper. 2001. Georgia's logging businesses, 1987 to 1997. Forest Products Journal. 51(1):25-28.

Greene, W.D., T.G. Harris Jr, C. E. DeForest, and J. Wang. 1997. Harvesting cost implications of changes in the size of timber sales in Georgia. Southern Journal of Applied Forestry. 21(4):193-198.

He, M., M. Smidt, W. Li, and Y. Zhang. 2021. Logging industry in the United States: Employment and profitability. Forests 2021, 12, 1720. https://doi.org/10.3390/f12121720.

Hoover, K., and A.A. Riddle. 2021. U.S. Forest ownership and management: Background and issues for congress. Congressional research service report R46976. Available online at https://crsreports.congress.gov/product/pdf/R/R46976; last accessed June 16, 2023.

Leefers, L., J. Poudel, D. Neumann, and Public Sector Consultants. 2020. Forest Products Industries' Economic Contributions: Michigan. Lansing Public Sector Consultants. 44p.

Leon, B.H., and J.G. Benjamin. 2012. A survey of business attributes, harvest capacity and equipment infrastructure of logging businesses in the Northern Forest. The University of Maine School of Forest Resources. 29p.

Malinen, P. 2001. Like father, like son? Small family business succession problems in Finland. Enterprise and Innovation Management Studies. 2(3):195-204.

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

Moss, S.A., and D.B. Hedderick. 2012. An economic evaluation of a small-scale timber harvesting operation in Western Maryland, USA. Small-scale Forestry.11(2012):101–117.

Nowak, D.J., and J.T. Walton. 2005. Projected urban growth (2000-2050) and its estimated impact on the US forest resource. Journal of Forestry. 103(8):383-389.

Rickenbach, M., and T.W. Steele. 2005. Comparing mechanized and non-mechanized logging firms in Wisconsin: Implications for a dynamic ownership and policy environment. Forest Products Journal. 55(11):21-26.

Rickenbach, M., and T.W. Steele. 2006. Logging firms, nonindustrial private forests, and forest parcelization: evidence of firm specialization and its impact on sustainable timber supply. Canadian Journal of Forest Research. 36:186-194.

Rickenbach, M., M. Vokoun, and S. Saunders. 2015. Wisconsin logging sector: Status and future direction. The University of Wisconsin Extension (G4073), Madison, WI. 23p.

Rickenbach, M., T.W. Steele, and M. Schira. 2005. Status of the logging sector in Wisconsin

and Michigan's Upper Peninsula, 2003. The University of Wisconsin Extension, Madison, WI. 40p.

Row, C.1978. Economics of tract size in timber growing. Journal of Forestry.76(9):576-582.

Sass, E.M., M. Markowski-Lindsay, B.J. Butler, J. ws, A. Hartsell, E. Huff, and A. Robillard. 2021. Dynamics of large corporate forestland ownerships in the United States. Journal of Forestry. 119(4): 363-375. https://doi.org/10.1093/jofore/fvab013.

Sedjo, R.A. 1997. The forest sector: important innovations. Resources for the future. Discussion paper 97-42. Available online at http://www.rff.org/files/sharepoint/WorkImages/Download/RFF-DP-97-42.pdf; last accessed June 17, 2023.

USDA Forest Service. 2021. Family forest (10+ acres) ownership characteristics: Michigan, 2018. Res. Note NRS-281. Madison, WI: U.S. Department of Agriculture, Forest Service, Northern Research Station. 2p. https://doi.org/10.2737/NRS-RN-281.

CHAPTER 2. THE LOGGING SECTOR IN THE LAKE STATES OF MICHIGAN, MINNESOTA, AND WISCONSIN: STATUS, ISSUES AND OPPORTUNITIES

2.1 Abstract

Coordinated mail surveys of logging businesses in the Lake States of Michigan, Minnesota, and Wisconsin were conducted in spring 2017 to assess the status and capacity of the sector in 2016. Many similarities among logging businesses were noted across the region. Despite the presence of many small logging businesses, much of the volume (58%) is produced by a few large producers (13%) who seem to have an advantage over their smaller sized counterparts. Businesses and business owners are aging (average business duration, 27 years and average owner age, 54 years), and the majority are producing below their full operational capacity and achieving break-even profit levels. About one-fourth of the businesses intend to exit the market in the next five years and there are a lack of factors attracting new workforce members into business. Differences exist among states in terms of harvesting systems used, source and method of timber procurement, and transportation strategy adopted.

Keywords: Timber harvesting, logger survey, logging capacity, forest products industry

2.2 Background

Forests cover approximately 55 million acres of land area in the Lake States of Michigan, Minnesota, and Wisconsin (US Forest Service, Forest Inventory and Analysis 2019) and the forest products industry is an integral component of each state's economy. Collectively, the forest products industries directly employ over 130,000 people in these three states and generates over $46 billion in direct output to the three states economy (Minnesota's Forest Resources 2016, Leefers 2017, Wisconsin Department of Natural Resources 2018).

The logging sector is a critical component of the forest products industry that connects forest resources and the management of those forests with wood using mills, which in turn use it to manufacture various forest products. Besides having a significant economic effect within rural communities through employment and purchase of goods and services, logging businesses are also the primary implementors of forest management activities. A strong logging sector is, therefore, crucial for sustaining a vibrant forest-based economy and for maintaining a healthy forest system.

Forests in the Lake States are diverse due, in part, to continental glaciations which

produced a complex pattern of landforms (Stearns 1997). Maple/beech/birch and oak/hickory are the predominant forest-type groups in Michigan and Wisconsin, while the forests in Minnesota are dominated by aspen/birch and spruce/fir forest types (US Forest Service, Forest Inventory and Analysis 2019). Forest products markets vary across the region with pulpwood being the primary forest product harvested in Minnesota and Wisconsin while sawlogs being the major forest product harvested in Michigan. Due to concerns about soil compaction and rutting, a high percentage of timber in the region is harvested during winter (Blinn et al. 2015).

The industry, forest landowners, academics and policy makers have long realized the importance of the logging sector across the region. Over the past 40 years, the literature includes several logging businesses studies in Michigan (Rickenbach et al. 2005, Gc and Potter-Witter 2011, Abbas et al. 2014), Minnesota (Bolstad 1980, Blinn et al. 2015) and Wisconsin (Rickenbach et al. 2005, Rickenbach et al. 2015) to assess the health and viability of the sector. These studies are primarily state-oriented and have proven useful for state-level analyses of factors such as harvest capacity, capital investment, profit levels and other business strategies. However, because of the differences in timeframes, focus and questionnaire wording, those state-level data and analyses do not provide a comprehensive picture of logging businesses and the sector across the region.

The timber harvested in the Lake states region commonly moves between states because of their proximity, therefore, a regional study of logging businesses provides a more holistic picture of the industry. However, except for the study by Rickenbach et al. (2005) that surveyed logging businesses in Wisconsin and Michigan's Upper Peninsula, and by Abbas et al. (2014) that included loggers from Michigan and northern Wisconsin, no other study to our knowledge has examined Lake State's logging businesses from a regional standpoint. This study attempts to address this gap in the literature and aims to provide an overview of logging businesses across the Lake States region of Michigan, Minnesota and Wisconsin. The objectives of the study are two-fold: 1) To develop a baseline dataset of logging business metrics across the region in order to have a better understanding about business attributes, owner demographics, harvest potential, equipment infrastructure and challenges as well as opportunities facing the industry and 2) To compare the capacity and structure of logging businesses among states. While the baseline dataset of business metrics can serve as a

reference point against which future comparisons can be made to assess how the industry evolves over time, the comparative analysis of businesses among states can help identify the strengths and shortcomings of businesses within states. Such information can be useful for better positioning of businesses for improved efficiency and profitability in the future.

2.3 Methods

2.3.1 Survey design and administration

Coordinated mail surveys of logging business owners in Michigan, Minnesota, and Wisconsin were conducted in spring 2017. Survey instruments for each state were based upon past state level surveys and were developed in coordination with the researchers from Michigan, Minnesota, and Wisconsin. Though each state had its own separate survey instrument, many of the questions were worded consistently to allow for cross state comparison of the data. The data was collected on a broad suite of areas including production levels, stumpage sources, equipment mix, capital investment, operational capacity, profitability, plans for business, and factors influencing the recruitment of logging workforce. To understand the operational capacity of logging businesses in 2016, the respondents were asked to indicate if they operated at their full operational capacity, meaning that no additional volume could be produced given their equipment and labor availability as well as weather and site conditions. If the respondent indicated producing below their full operational capacity, a follow up question asked how much additional volume they could have produced, if they operated at their full capacity. The respondents were also asked to self-rate the profitability of their business in 2016 using a five-point Likert scale (ranging from 1, very poor to 5, excellent). All businesses were asked to report numbers for the 2016 calendar year.

The list of logging business owners in Michigan was compiled from the lists maintained by the Michigan Department of Natural Resources (DNR) and the Michigan Forest Products Council. It included 1,085 logging businesses, which was the sample size for the state. In Wisconsin, the list of logging business owners was compiled from the lists maintained by the Wisconsin DNR, cooperating foresters, county, national, and state forest administrators and the Forest Industry Safety and Training Alliance. It included 911 logging businesses which was the sample size for the state. In Minnesota, the list of logging businesses was obtained from the membership directory of logging business owners enrolled in the Minnesota Logger Education Program (MLEP) 2017. The total sample size for

Minnesota was 383 logging businesses. The number of logging business owners included in our study is considerably higher than the estimates of logging businesses reported by the US Bureau of Labor Statistics (2020). According to the Bureau of Labor Statistics (2020), there were 340 logging businesses in Michigan, 178 in Minnesota and 260 in Wisconsin in 2016. However, after consultation with the representatives from DNR in each state and the researchers who had conducted logging business owner surveys in each state in the past, a consensus was reached to use the larger sample size for this study. To screen out non-loggers from responding to the survey in Michigan and Wisconsin, the first question in the survey instrument asked if the respondent owned or managed an independent logging business within the state. If the response was 'yes', then only the respondent was asked to complete the survey, else he/she was requested to return the survey without completing it.

Each state followed Dillman's tailored design method (Dillman 2000) for administering the survey. A pre-survey notification letter was sent to all participants prior to full mailing of the survey questionnaire. It was then followed by a full mailing of the survey instrument along with a cover letter and a postage-paid business reply envelope. Reminder postcards with thank you notes were sent to the non-respondents which was followed by a second wave of the survey questionnaire. In Minnesota, a follow-up letter was sent to all MLEP members following the second wave of survey questionnaire to increase the response rate. Likewise, in Michigan a third wave of survey questionnaires was sent to boost the response rate. Mailings in each state were performed by universities in that state. Wisconsin included a $2 bill with the first mailing of their survey instrument as part of their design.

2.3.2 Data analysis

Once the data was collected, the non-response bias was estimated in each state by comparing the responses of the first and last 25% of respondents as suggested by Armstrong and Overton (1977). According to the authors, late responders are like non-responders and hence can be used as a proxy for non-responders (Armstrong and Overton 1977). The variables used for non-response bias test included total volume harvested, years in business, age of the owners, percentage of volume harvested from private woodlands, percentage of volume transported by company owned trucks, and the amount of capital invested in business. The businesses that indicated harvesting less than 100 cords of timber in 2016 were excluded from subsequent analysis. The conversion units adopted include one standard cord equivalent

to 500 board feet or 2.3 tons or 530 cunits.

The data on common survey questions across all three states were pooled to run composite analyses. To be more representative of the logging businesses across the region, the combined data was weighted using known timber harvest data for the three-states region. The timber harvest data was obtained from USDA Resource Update Reports 2016 (Paulson and Pugh 2016, Miles et al. 2017, and Kurtz 2017). According to the resource update reports, 42% of the total timber volume harvested in the region came from Michigan, 36% from Wisconsin and 23% from Minnesota. The responses to our survey revealed that 45% of the total reported removals in the region came from Wisconsin, 31% from Minnesota and 24% from Michigan. The weights were then estimated as a ratio of the proportion of timber volume harvested in the population to that in the sample as suggested by Groves et al. (2009). The estimated weights were 1.75 for Michigan, 0.74 for Minnesota and 0.80 for Wisconsin.

The data was analyzed using descriptive and inferential statistical techniques in IBM SPSS Statistics 25. Cross-state comparisons were made using the Analysis of Variance and the Tukey HSD test for continuous variables that were normally distributed and by the Kruskal-Wallis test followed by the Mann-Whitney U-test with Bonferroni correction for those that were not normally distributed. Additionally, Chi-square tests of independence were used to analyze categorical variables. The statistical significance for all tests was set at an alpha level of 0.05.

2.4 Results and Discussion

The overall response rate was 23% for Michigan, 39%for Minnesota and 50% for Wisconsin after considering the undeliverable addresses. It should, however, be noted that, in the case of Michigan, out of the 254 responses that were obtained initially, 134 respondents indicated that they had either retired or were no longer in the logging profession, thus reducing the effective sample size for the state. A probable reason for this is the usage of state's logging business owner database that was not up to date. Updating the loggers' database and including monetary incentives may improve survey responses in Michigan in the future. Logging business studies with comparable response rates have also been noted in other parts of the country (Luppold et al. 1998, Leon and Benjamin 2012) suggesting that it is not uncommon to get seemingly low response rates in logging business surveys.

There were 550 usable responses in total, of which 54% (295 responses) were from

Wisconsin, 25% (140 responses) from Minnesota and 21% (115 responses) from Michigan. The non-response bias tests were conducted in each state as stated earlier and the results from two sample t-tests and Mann-Whitney U tests revealed no significant difference between the early and late respondents at the 0.05 alpha level. Thus, ruling out the concern for non-response bias in the obtained dataset.

2.4.1 Industry and owner demographics

The average logging business in the region had been in operation for 27 years and most (68%) were family businesses, meaning that at least two family members played a central role in the leadership and daily workings of the business. The percentage of businesses indicating that they were family businesses increased with the increase in production size (46% for those harvesting 1,000 cords or less volume annually to 88% for those harvesting >15,000 cords annually). Many businesses (63%) have remained in operation for more than 20 years while only 9% had opened in the last five years. These findings are consistent with those obtained by past studies in the region (Blinn et al. 2015, Rickenbach et al. 2015, Gc and Potter-Witter 2011).

Sixty-three percent of the businesses were single owner operations with 28% having two owners and the remainder having three or more owners. The predominance of single owner operated logging businesses has been noted in the Lake States (Rickenbach et al. 2015 and Gc and Potter-Witter 2011) and in the Northeast region (Leon and Benjamin 2012) by past studies.

The average logging business owner in the region was found to be 54 years old and had 32 years of experience in the logging profession. Approximately half of the responding businesses had owners who were 55 years or older while only 5% had owners younger than 35 years (Figure 2.1). These statistics not only highlight the low representation of young leadership in logging businesses across the region, but also indicate that succession planning is going to be of concern in the years to come. In Wisconsin, Rickenbach et al. (2015) noted that the median age of logging business owners increased from 46 years in 2003 to 52 years in 2010, suggesting that business owners have aged in place. Our findings suggest the continuation of this trend. Other studies (Conrad et al. 2018a, Conrad et al. 2018b, Leon and Benjamin 2012) have noted aging logging business owners across the country.

A slightly higher percentage of businesses in Minnesota (76%) were family businesses

as compared to those in Michigan (69%) and Wisconsin (63%), however the difference was not statistically significant (Table 2.1). Likewise, no significant difference in the number of owners or owner's age was observed among states (Table 2.1). The logging businesses in Minnesota had been in operation for a significantly longer duration (30 years) compared to those in Michigan (25 years). Likewise, business owners in Wisconsin had significantly more experience in the logging profession (33 years) compared to business owners in Michigan (30 years) (Table 2.1).

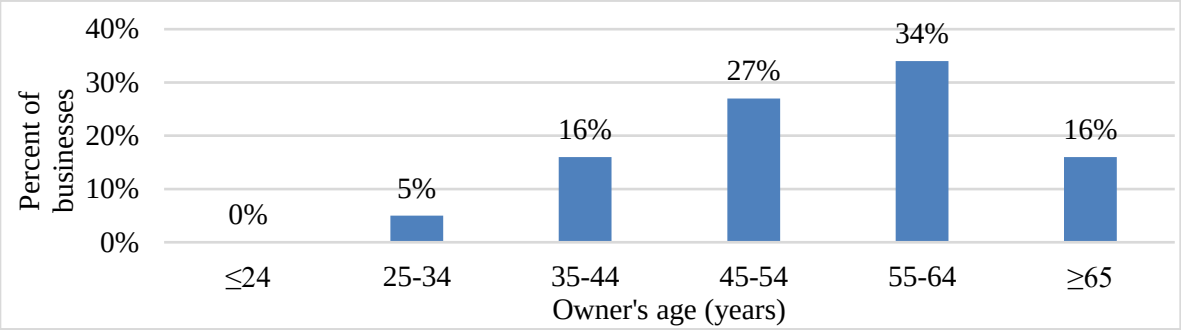


Figure 2.1 Distribution of logging businesses in the Lake States region by owner's age.

Table 2.1 Comparison of logging business owner and industry demographics across states.

Variable	**Michigan**	**Minnesota**	**Wisconsin**	**Test Statistic (p-value)**
Company is a family business (Percent saying yes)	Yes= 69%[a]	Yes= 76%[a]	Yes= 63%[a]	$\chi^2 = 5.399$ (0.067)
Years in business (Mean)	25 years[a]	30 years[b]	28 years[ab]	Kruskal-Wallis H = 10.455 (0.005)
Number of owners (Mean)	1[a]	2[a]	1[a]	Kruskal-Wallis H = 5.609 (0.061)
Age of owner(s) in years (Mean)	53 years[a]	54 years[a]	54 years[a]	F statistic in Anova = 0.521 (0.594)
Years of logging business owner(s) experience (Mean)	30 years[a]	31 years[ab]	33 years[b]	F statistic in Anova = 3.486 (0.031)

*Like superscripts (a and b) denote no significant difference between states at $\alpha = 0.05$

2.4.2 Production level and equipment used

Collectively, the respondent logging businesses reported harvesting 4.8 million cords in the region during 2016, which is approximately 65% of the total timber volume harvested during that year (Paulson and Pugh 2016, Miles et al. 2017, and Kurtz 2017). The average production per business was ~ 9,000 cords with a median production close to 4,000 cords (Table 2.2). Many businesses (55%) were small producers, i.e. they harvested 5,000 cords or less volume in 2016 (Figure 2.2) and contributed 11% of the total reported volume harvested in the region. On the contrary, 13% of the businesses harvested more than 15,000 cords and contributed 58% of the total reported volume in 2016 (Figure 2.2). It shows that despite the presence of many small logging businesses, the market is disproportionately dominated by a few large producers. A similar trend was also reported by earlier studies in Wisconsin and Minnesota (Rickenbach et al. 2015, Blinn et al. 2015). Likewise, through the periodic surveys of logging businesses in Georgia and South Carolina, Conrad et al. (2018b) noted that the long-term trend in both Southern states is towards fewer but larger businesses.

Table 2.2 Comparison of production data, felling method employed and stumpage demographics of logging businesses among states.

Variable	**Michigan**	**Minnesota**	**Wisconsin**	**Test Statistic (p-value)**
Volume harvested (cords)	10,559[a] (Mean) 5,008 (Median)	11,267[a] (Mean) 4,000 (Median)	7,389[a] (Mean) 4,000 (Median)	Kruskal-Wallis H = 1.526 (0.466)
Percent of volume harvested by different felling methods	Chainsaw- 10%[a] CTL harvester- 57%[a] Feller-buncher- 33%[a]	Chainsaw- 2%[b] CTL harvester- 24%[b] Feller-buncher- 74%[b]	Chainsaw- 15%[a] CTL harvester- 71%[a] Feller-buncher- 14%[a]	Kruskal-Wallis H = 51.849 (0.000) Kruskal-Wallis H = 47.416 (0.000) Kruskal-Wallis H = 84.412 (0.000)
Percent of volume harvested from different landownership categories	Private woodlands (45%)[a] Industrial forests (21%)[a] State forests (25%)[a] County forests (3%)[a]	Private woodlands (20%)[b] Industrial forests (15%)[a] State forests (27%)[b] County forests (24%)[b]	Private woodlands (57%)[a] Industrial forests (4%)[b] State forests (10%)[a] County forests (27%)[c]	Kruskal-Wallis H = 61.585 (0.000) Kruskal-Wallis H = 18.486 (0.000) Kruskal-Wallis H = 67.770 (0.000) Kruskal-Wallis H = 124.529 (0.000)
Percent of stumpage purchased by business	60%[a]	72%[b]	72%[b]	Kruskal-Wallis H = 8.752 (0.013)
Percent of volume transported to mills by company owned trucks	45%[a]	64%[b]	37%[a]	Kruskal-Wallis H = 26.862 (0.000)

*Like superscripts denote no significant difference between states at $\alpha = 0.05$

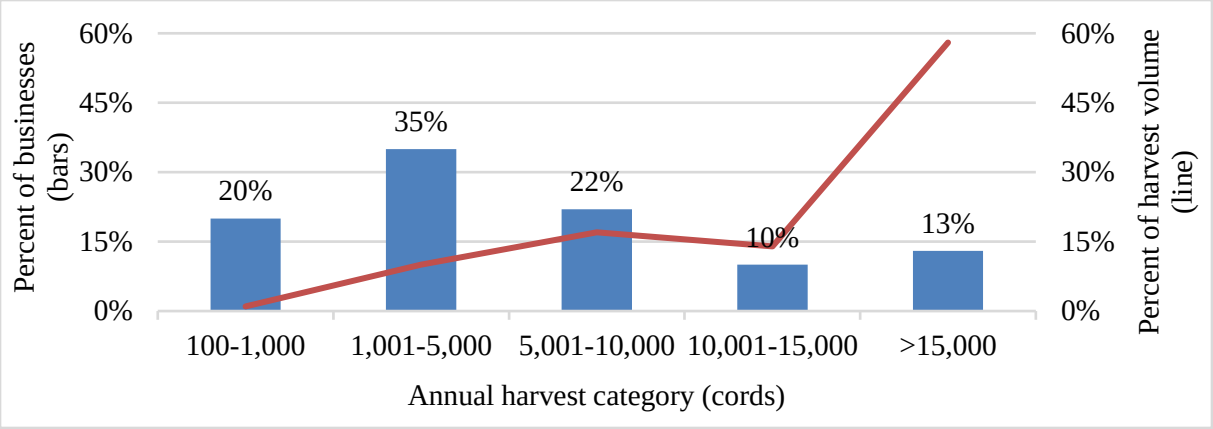


Figure 2.2 Percent of businesses (bars) and volume produced (line) by annual harvest category.

The trend of few large logging businesses generating a major share of production resembles what is being witnessed in the agricultural sector. Over the past several decades, the number of small to medium sized agricultural farms across the U.S. have declined drastically while production is increasingly being dominated by a few large farms (MacDonald et al. 2013). The literature in agricultural economics (Hall and Leveen 1978) notes that large-sized farms have an advantage over their smaller-sized counterparts owing to technical and allocative efficiency. Technical efficiency resulting from the economies of scale and allocative efficiency due to greater access to high-quality resources, better management opportunities, and greater market access and availability of premium prices for large volume producers (Hall and Leveen 1978). Similar economic factors might be responsible for favoring large logging businesses in our study. Large logging businesses, that have a big enough land base to support their harvest system, are likely to have an advantage in operation over small producers due to the economies of scale. Additionally, they may have greater access to stumpage especially from large-sized public sales, and greater access to markets as well as availability of premium prices for their products. This logic is supported to some extent by the written comments provided by small logging businesses in Michigan. Several small logging businesses in Michigan expressed concerns about unequal mill prices, especially from large paper mills, for the same cord of wood in favor of large producers in the state. Other concerns expressed by small producers include high minimum bid prices on public timber sales, and increased competition for stumpage with logging businesses backed by mills. These comments agree with the views expressed by logging business owners in

Minnesota in 2013 (Blinn et al. 2015). Minnesota logging business owners believed that large producers in the state received higher prices from mills, were more efficient in their operations, and were better able to retain their employees year-round allowing them to produce more timber (Blinn et al. 2015). Also, large logging businesses had better relationships with mills which purchased some of their stumpage, thus reducing the need of large producers to purchase and hold their own stumpage (Blinn et al. 2015). An important point to note when making comparisons between the agricultural and logging sector, is that the farmers own their farmlands, while loggers usually log lands owned by other private or public entities. Past studies have shown timber harvesting costs to increase with decreasing forest tract size (Germain et al. 2019, Regula et al. 2018). Given this, the parcelization of forest lands, particularly those owned by non-industrial private forest landowners (Butler and Leatherberry 2004), may in fact, favor small logging businesses as they may be able harvest smaller forest tracts more profitably (Rickenbach and Steele 2006).

About one-fourth of the respondents indicated harvesting timber exclusively using chainsaws, however, they accounted for only 10% of the total volume produced. The remaining businesses used some combination of mechanized felling equipment. A little more than half of the total volume produced (55%) was harvested using cut-to-length (CTL) harvesters and 36% was harvested using feller-bunchers. The logging businesses varied significantly across states in terms of the harvesting systems used (Table 2.2). In Michigan and Wisconsin, much of the volume was produced using CTL harvesters (57% and 71% respectively), while in Minnesota, most of the volume (74%) was produced using feller-bunchers (Table 2.2). Such findings are in line with past studies in the region (Abbas et al. 2014, Blinn et al. 2015, Rickenbach et al. 2015). A significantly higher percentage of the volume was produced using chainsaws in Michigan and Wisconsin (10% and 15% respectively) as compared to Minnesota (2%) (Table 2.2). Minnesota is dominated with aspen which is managed through clear-cuts and yields pulpwood but little sawtimber. Therefore, an operator is likely to maximize the rate of production since the marginal return per cord is low. Less volume production using chainsaws in Minnesota, thus, seems logical. In Wisconsin and Michigan, more species are managed under uneven aged systems. Also, the amount of sawtimber is higher. Thus, the timber in those two states generally offer more opportunities for merchandising higher value products where operators seek to maximize value by operating

slower.

The average age of the newest piece of CTL harvester within a business was 8.6 years and the feller-buncher was 13.8 years, meaning that mechanized felling equipment across the region is approaching or even exceeding the limits of its productive age. Businesses operating with aging equipment may need additional downtime for repair and maintenance in the future which could impact their production capacity and efficiency. Though information about the number of hours put on each equipment could help estimate its productivity more accurately, it was out of the scope of this study and was not considered.

Small volume producers in general were found to own relatively older mechanized felling equipment compared to their larger sized counterparts (Figure 2.3). A probable reason for it could be that small producers may only operate seasonally and therefore, may be reluctant to invest in newer equipment and associated loan payments. Since purchasing new equipment is likely to drive a business towards year-round production and may necessitate hiring/retaining of employees, it might not entice small producers. Across the region, the small producers were relatively older in age (Average age 59 years for those harvesting 1,000 cords or less volume annually and 54 years for those harvesting 1,001 to 5,000 cords) compared to large volume producers (Average age ranging from 51 to 53 years). Old small producers may be more complacent about their production level or may not have plans to expand their business, therefore, may be less interested in investing in new equipment.

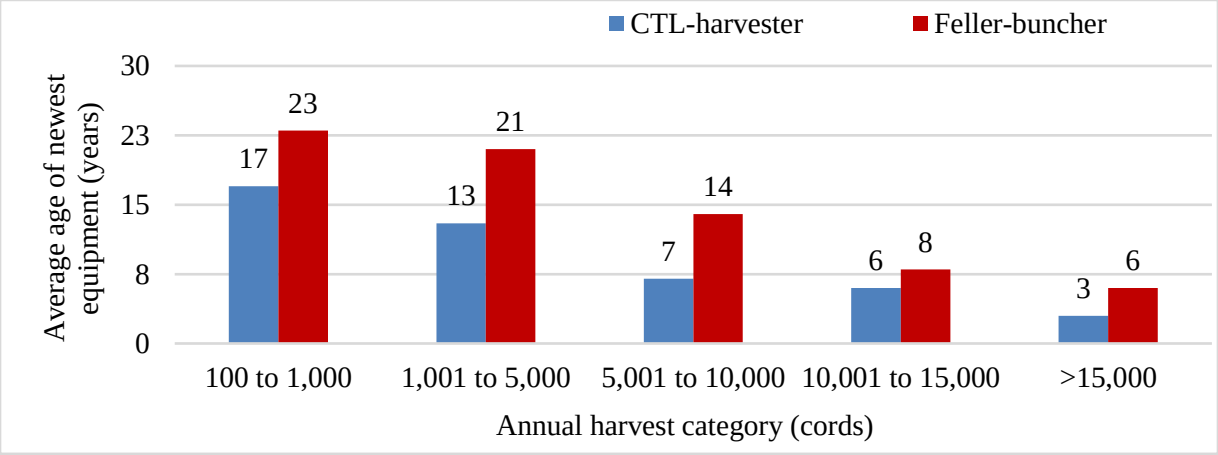


Figure 2.3 Average age in years of the newest piece of mechanized felling equipment by annual harvest category.

2.4.3 Stumpage sources

More than two-thirds of the stumpage harvested in the region was self-purchased by logging businesses with the remainder purchased by mills or other brokers. This is consistent with past studies in the region (Blinn et al. 2015, Rickenbach et al. 2015), but differs from what is observed in the U.S. South (Conrad et al. 2018a, Conrad et al. 2018b). In the South, wood dealers are the primary purchasers of timber for many logging businesses (Conrad et al. 2018b), where businesses negotiate a cut-and-haul rate with wood dealers and maintain high productivity to earn profits (Conrad et al. 2018a). Unlike that, purchasing their own stumpage, offers logging businesses greater flexibility in negotiating the price and allows them to cut out the middle entity, thus reducing transaction costs and increasing profit potential (Conrad et al. 2018a). It also offers logging businesses greater independence and control over business by allowing them to concentrate their procurement in an area and offering scheduling flexibility. However, purchasing own stumpage can also impose additional risks on businesses as it requires greater investment and skills on the part of business owners (Conrad et al. 2018a). The logging businesses in Minnesota and Wisconsin purchased a significantly higher percentage of their own stumpage compared to those in Michigan (Table 2.2). This could be because more Michigan logging businesses may be subcontracting for larger mills, thus reducing their need to purchase own stumpage.

Non-industrial private forests were the major source of stumpage for logging businesses in the region contributing 42% of the total timber volume harvested, followed by the state and county forests (37%), industrial forests (14%), national forests (6%) and others (2%) respectively. Businesses varied significantly across states in terms of their stumpage source. Compared to Minnesota, the logging businesses in Michigan and Wisconsin obtained a significantly higher percentage of their volume from non-industrial private forests (Table 2.2). In Minnesota, a significantly higher percentage of the volume harvested came from state and county forests compared to the other two states (Table 2.2). Such findings agree with past studies in the region (Blinn et al. 2015, Rickenbach et al. 2015, Abbas et al. 2014). The industrial forests contributed a significantly larger share of stumpage in both Michigan and Minnesota as compared to Wisconsin (Table 2.2). These findings are consistent with the timberland ownership patterns across states. In Michigan and Wisconsin, much of the timberland is under private ownership (64% and 71% respectively) followed by the state and

local government (23% and 20%) and the federal government (13% and 9%) respectively. In Minnesota, however, 45% of the timberland is owned by state and local government, 43% by private owners and 12% by the federal government (USDA Forest Service, Forest Inventory and Analysis 2018). According to Rickenbach et al. (2015), a logging business's decision about which lands to harvest depends to a large extent on where the business is located. Additionally, expectations as well as limitations placed on harvests by landowners, forest certification, and government regulations impact where a logging business chooses to harvest (Rickenbach et al. 2015).

Small logging businesses harvested a greater share of their volume from non-industrial private forests (NIPFs) compared to large businesses. Approximately 78% of the total volume produced by businesses harvesting 1,000 cords or less volume annually came from NIPFs as compared to 35% of that produced by businesses harvesting >15,000 cords annually from the same ownership group. Such trend was also observed in Minnesota in the past (Blinn et al. 2015). Since stumpage sales from NIPFs are likely to be smaller in size compared to public sales, high moving costs associated with operating highly mechanized equipment which is generally the characteristic of large logging businesses may hinder it from operating in smaller sized NIPF tracts. Unlike large mechanized logging businesses, small businesses with less mechanized equipment may not face such high equipment moving costs thus making them economically more efficient at harvesting smaller sized NIPF parcels. Past studies (Germain et al. 2019, Regula et al. 2018, Rickenbach et al. 2005) have noted higher harvesting costs associated with smaller forest parcels as fixed costs are spread across small harvest volumes. Also, small logging businesses may not always have the capital to bid on public sales that are usually larger in size and may not have the capacity to complete large timber harvests on public sales within the specified time frame, thus making them focus more on small NIPF tracts.

2.4.4 Stumpage delivery

Approximately 54% of the harvested volume was transported to mills using contracted trucks, with the remainder transported by company-owned trucks (Table 2.2). The percentage of volume transported using company-owned trucks increased with the size of production. The smallest producers (those harvesting 1,000 cords or less volume annually) transported 25% of their total production using company-owned trucks whereas, the largest producers

(harvesting >15,000 cords annually) transported 56% of their production using their own trucks. Since large logging businesses are likely to need trucking services on a more regular basis for clearing the landing of piled wood and delivering it to mills compared to small producers, it makes sense for large producers to have their own trucking facilities. Small producers with limited financial assets may benefit by specializing in harvesting while subcontracting for their trucking needs. Also, given the predicted nationwide shortage of truck drivers (Costello and Karickhoff 2019), large logging businesses may be able to offer better wages and benefits to truck drivers and be able to hire and retain them compared to small producers (Conrad et al 2018a). Among the states, the Minnesota logging businesses transported a significantly greater percentage of their volume using company owned trucks compared to businesses in both Michigan and Wisconsin (Table 2.2). This suggests that more logging businesses in Michigan and Wisconsin may be subcontracting for their trucking needs. In the Northeast, Leon and Benjamin (2012) noted that many logging businesses (75%) subcontracted some portion of their trucking services.

2.4.5 Investment in business, operational capacity, and profit levels

Approximately three-quarters of the respondents said that they had less than $500,000 invested in their business, while 13% had at least one million invested in business. Businesses producing more than 15,000 cords annually reported a median investment greater than one million, which agrees with the numbers reported in Wisconsin by Rickenbach et al. (2015). Much of the invested capital (68%) was tied up in harvesting and transportation equipment, with the remaining used for purchasing stumpage (28%) and for other miscellaneous purposes (4%). Greater investment in fixed costs, may increase the production capacity of logging businesses, but it may also make them more likely to undertake logging jobs that are not always profitable. This is because the cost of idling equipment may impose greater loss than undertaking the not so profitable logging jobs. However, as noted by Regula et al. (2018), to maintain their long-term economic viability, logging businesses should be cognizant of the unprofitable logging jobs they may undertake and use them only to bridge the gap between more profitable ones. Small businesses with lower fixed costs, may have a greater flexibility in choosing logging jobs that are guaranteed to be profitable.

The logging businesses in Michigan differed significantly from the other two states in terms of the amount of capital invested in their business (Table 2.3). A higher proportion of

logging businesses in Michigan (41%) had $500,000 or more capital invested in their business compared to those in Minnesota (21%) and Wisconsin (16%) respectively. When asked about the ease/difficulty in accessing capital for business (on a five-point Likert scale ranging from very easy to very hard), approximately 55% of the respondents said that it was somewhat or very easy while 22% found it to be somewhat or very hard. No significant difference in access to capital for business was noted across states (Table 2.3).

Approximately 37% of the respondents said that they operated at full operational capacity, while the remaining (63%) operated below full capacity in 2016. If these businesses operated at their full capacity, they could have produced an additional 1.3 million cords, thus indicating that logging capacity to meet additional demand is not a concern at the moment. The percentage of businesses operating at full capacity increased with the size of production (Figure 2.4). Past literature (LeBel and Stuart 1998) has shown low-capacity utilization to have a negative impact on technical efficiency of logging businesses, thus it is in the best interest of businesses to improve their capacity utilization. Theoretically, 100% capacity utilization can help minimize the cost of production for logging businesses, but it may not always be feasible due to myriad factors ranging from adverse weather conditions to mill quotas, equipment breakdowns and government regulations (Conrad et al. 2017). No significant difference in operational capacity among logging businesses was observed across states (Table 2.3).

When asked to self-rate the profitability of their logging business in 2016, the respondents on average said that they achieved a break-even or average profit level. Approximately 37% indicated their profit level to be good or excellent while 28% said it was poor or very poor. These numbers are comparable with those obtained by Rickenbach et al. (2015) in Wisconsin. The profit level of logging businesses did not vary significantly across states (Table 2.3), nor did it have a distinct pattern among small versus large logging businesses.

Table 2.3 Investment in business, operational capacity, and profit levels of logging businesses across states.

Variable	Michigan	Minnesota	Wisconsin	Test Statistic (p-value)
Access to capital for business (Median rating)	Somewhat easy[a]	Somewhat easy[a]	Somewhat easy[a]	Kruskal-Wallis H = 5.088 (0.079)
Capital invested in business (Median rating)	$100,000 to $499,999[a]	$100,000 to $499,999[b]	Less than $100,000[b]	Kruskal-Wallis H = 39.683 (0.000)
Percent of businesses that operated at full capacity (Mean)	44%[a]	35%[a]	33%[a]	$\chi^2 = 5.095$ (0.078)
Self-rated profit level (Median rating)	Average or broke even[a]	Average or broke even[a]	Average or broke even[a]	Kruskal-Wallis H = 2.703 (0.259)

*Like superscripts denote no significant difference between states at $\alpha = 0.05$

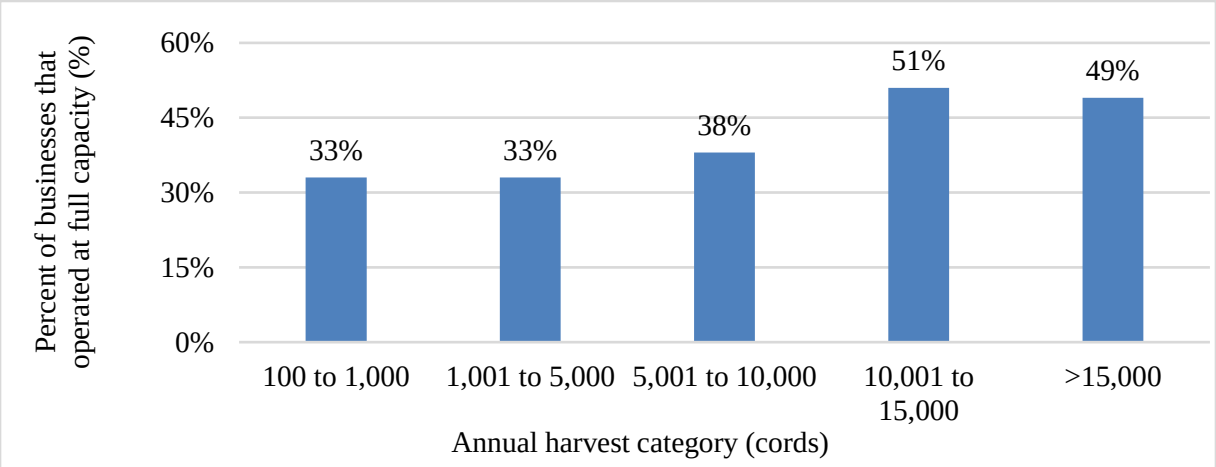


Figure 2.4 Percent of logging businesses operating at full capacity in 2026 by annual harvest category.

2.4.6 Plans for business

When asked if they will remain in business in the next five years, many of the

respondents (74%) indicated that they will continue logging, while 26% intended to exit from the market. Those indicating departures accounted for 11% of the total volume harvested in 2016 and 18% of the total capacity in the region. The later representing total volume harvested plus additional volume that could be produced if the businesses operated at their full capacity in 2016. Looking at the possibility of potential departures by annual production size, most indicated departures (41%) were concentrated in 100 to 1,000 cords category (Figure 2.5), thus suggesting that small logging businesses are more likely to exit from the market in near future compared to large businesses. Old age and retirement were the primary reasons noted by logging businesses for their intention to exit from the market. Other reasons included unstable market condition, non-profitable business environment, excessive regulation on harvest and labor issues. No significant difference in the percentage of businesses that intended to remain in business was observed across states (Table 2.3).

In response to the question that inquired about logging business owner's plan for business succession, approximately 38% said that an owner's family member would most likely take over the business at some point in the future. Approximately 58% either did not have a successor identified or said that no one would take over ownership of their business. The percentage of respondents saying that a family member would take over their business increased with the size of production. Sixty-nine percent of the largest producers (those harvesting >15,000 cords annually) said that a family member would take over ownership of their business in the future.

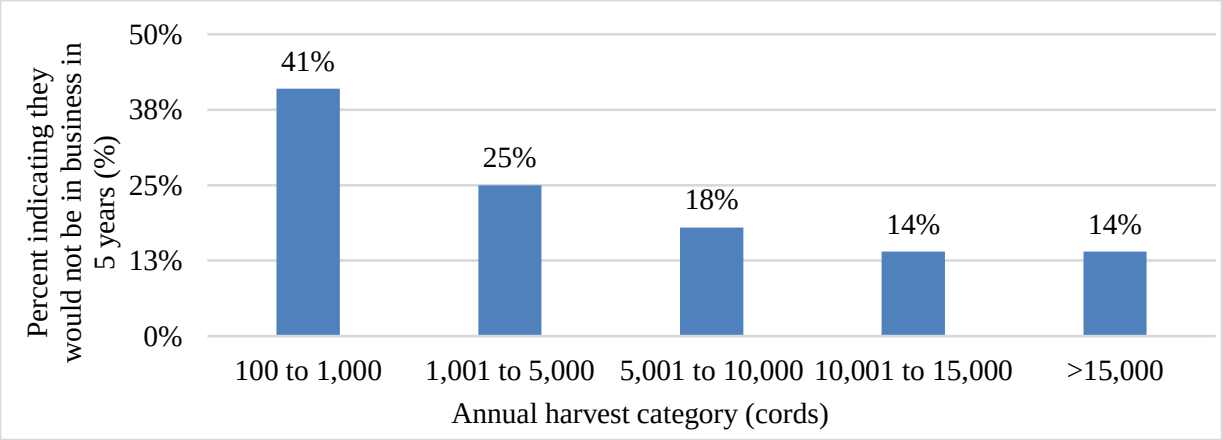


Figure 2.5 Percent of logging businesses indicating that they will not be in business in 5 years by annual harvest category.

2.4.7 Factors encouraging/discouraging people from pursuing logging career

Given the concern that is often expressed in logging business literature (Egan and Taggart 2004, Gc and Potter-Witter 2011) about recruitment of workers in the logging industry, the respondents in our surveys were asked to rate the importance of nine potential factors that may have influenced their decision to enter the profession on a five point Likert scale (ranging from 1, not at all important to 5, extremely important). To this, the three listed factors on average were rated as at least 'very important' with a mean rating above 4. These include the sense of independence that the profession has to offer, the sense of accomplishment and the enjoyment obtained from working outdoors (Figure 2.6). Such results agree with the findings from previous logger surveys conducted in other parts of the country (Leon and Benjamin 2012, Egan and Taggart 2004). The findings were consistent across states.

Additionally, the respondents were asked to rate the importance of eight listed factors that may encourage or discourage the entry of new people into logging business on a five-point Likert scale (ranging from 1, greatly discourages to 5, greatly encourages). The mean rating of all listed factors except 'work environment' was found to be below 3 which is 'neither encourages nor discourages'. This shows that none of the listed factors were identified as encouraging entry of new people into the profession. The benefits package associated with logging was rated the lowest, meaning that it somewhat to greatly discourages entry of new people into a logging business (Figure 2.7). Also, when asked if the respondents would encourage family members or close friends to become a logger, only 20% said that they would, the rest were either unsure (31%) or would not encourage their loved ones to become a logger (49%). Similar results were noted by Egan and Taggart (2004). The authors found that despite many respondents having familial ties to logging profession, most of the loggers in New England region (69%) were not in favor of encouraging their future generation to join the logging business (Egan and Taggart 2004).

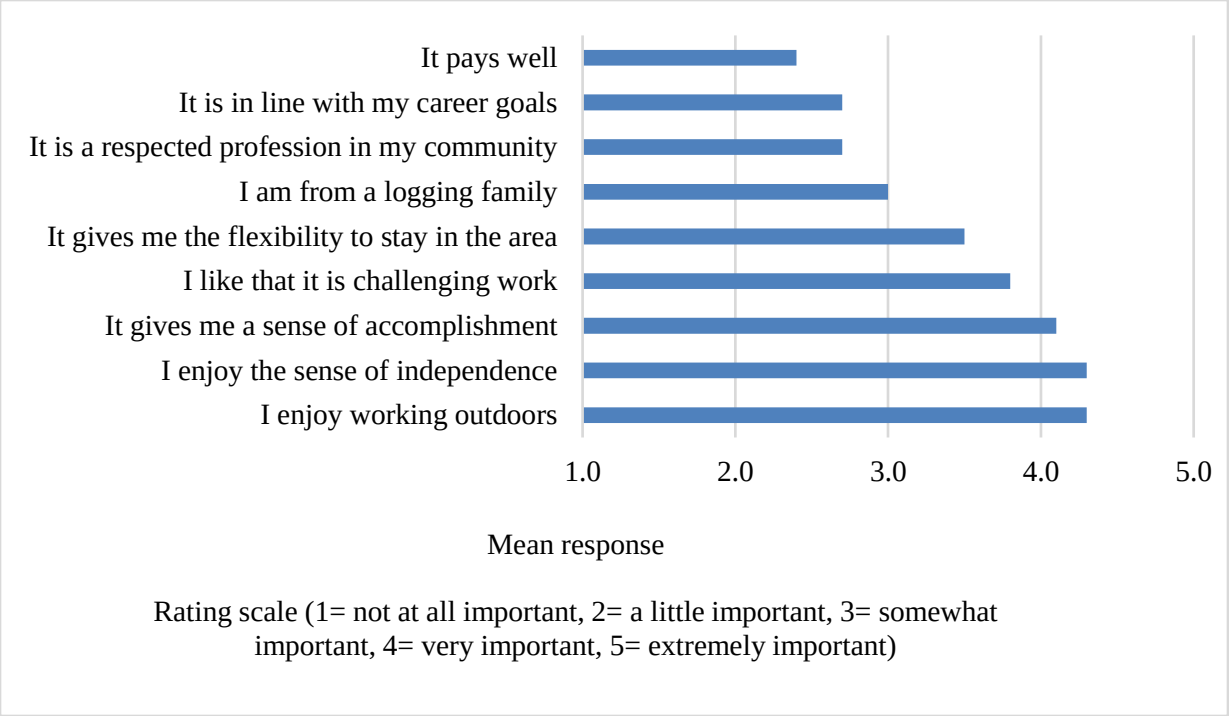


Figure 2.6 Importance of nine listed factors that influenced a logging business owner's decision to enter the logging business.

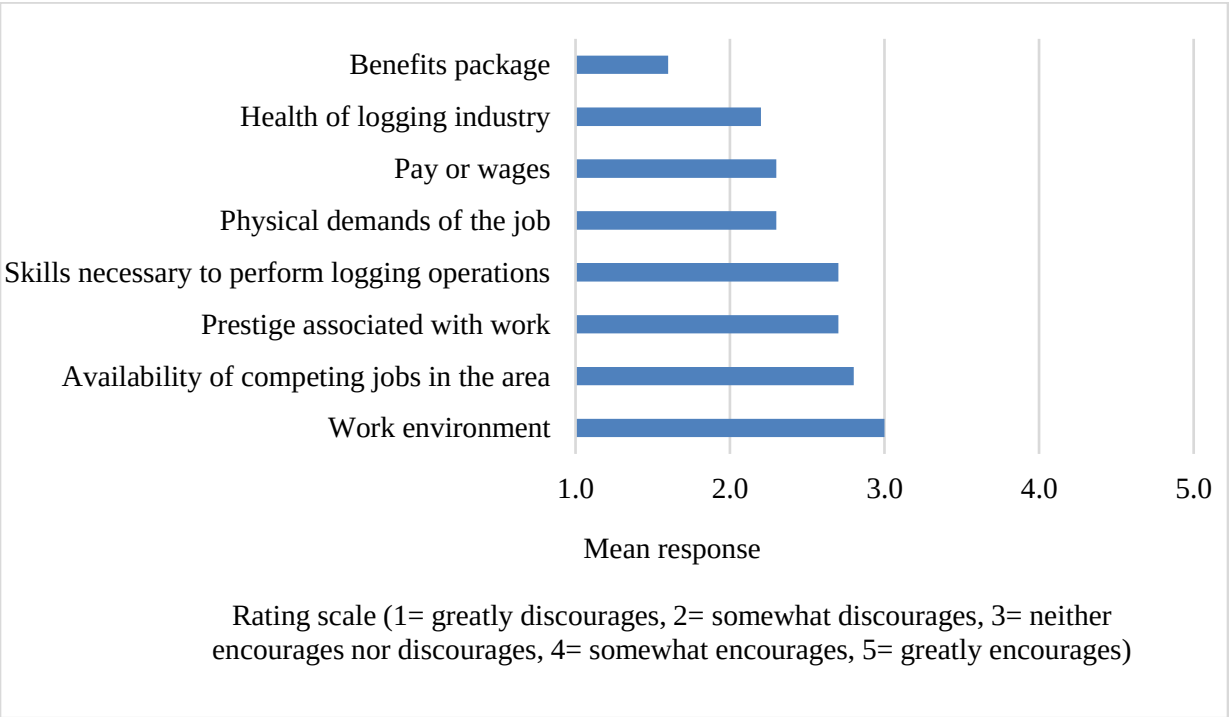


Figure 2.7 Average Likert scale rating for eight listed factors that may encourage or discourage entry of new people into logging business.

2.5 Conclusions

Our results revealed many similarities among logging businesses across the region. Some key findings are:

- The markets in the Lake States region are dominated by a few large logging businesses that generate the major share of volume harvested. Compared to small producers, large logging businesses are operated by relatively younger owners, have greater amounts of capital invested in their business and own newer equipment. A greater percentage of large logging businesses operate at full operational capacity than small producers and may be receiving preferential treatments from mills.

- Small logging businesses, particularly those harvesting 1,000 cords or less annually, are more likely to exit from the market in near future. These businesses harvest a major share of their volume (78%) from NIPFs, and their loss may have negative repercussions on forest management in small NIPFs.

- Logging business owners across the region are aging. However, not many have identified their successors, thus raising concerns about the future of logging businesses once the current owner retires. This is more so in the case of small logging business than with large producers.

- Many logging businesses operate below their full operational capacity and generate break-even profit levels. Low-capacity use can reduce the technical efficiency of logging businesses and make them less profitable. Hence, efforts to increase the capacity use of logging businesses, through investment in better equipment, long term fiber agreements with mills, or flexibility in regulatory harvesting policies where appropriate, may prove to be beneficial in the long run.

- Not many enticing factors were noted to attract new people into the logging profession. Unless wages and benefits (insurance, health care, retirement) associated with logging are as attractive as with other competing jobs in the area, it will be a challenge to recruit and retain qualified workers. One approach to improve the recruitment of logging workforce is to focus on diversifying the pool of workers. Current loggers and logging business owners are predominantly white males. In the

future, efforts could be made to attract more women and people from other racial groups into logging. It is also important to understand who is entering the workforce and what their needs and expectations are, in order to make the profession more attractive to them. Increased use of technology, Internet, and social media may be beneficial in reaching out to the new generation of logging workforce.

Although many commonalities among logging businesses were noted across the region, some variations were also observed. Logging businesses in Michigan and Wisconsin were more alike in terms of the harvesting systems used but varied from those in Minnesota. Also, businesses varied between states in their method and source of timber procurement as well as transportation strategy adopted. Timely and updated information about logging businesses is crucial for gauging the performance of the industry and understanding its trajectory in the future. Although the findings presented here are solely based upon information provided by Lake States logging business owners, they are likely to have broader implications as many of the noted characteristics resonate with logging businesses across the country.

LITERATURE CITED

Abbas, D., R. Handler, B. Hartsough, D. Dykstra, P. Lautala, and L. Hembroff. 2014. A survey analysis of forest harvesting and transportation operations in Michigan. Croatian Journal of Forest Engineering. 35(2):179–192.

Armstrong, J.S., and T.S. Overton. 1977. Estimating nonresponse bias in mail surveys. Journal of Marketing Research. 14: 396-402.

Blinn, C.R., T.J. O'Hara, D.T. Chura, and M.B. Russell. 2015. Minnesota's logging businesses: An assessment of the health and viability of the sector. Forest Science. 61(2):381-387.

Bolstad, K. 1980. A profile of Minnesota's loggers. Unpublished Plan B Paper. Department of Forest Resources, College of Forestry, St. Paul, MN.

Butler, B.J., and E.C. Leatherberry. 2004. America's family forest owners. Journal of Forestry. 102(7):4-9.

Conrad, J.L., M.M. Vokoun, S.P. Prisley, and M.C. Bolding. 2017. Barriers to logging production and efficiency in Wisconsin. International Journal of Forest Engineering. 28(1):57-65.

Conrad, J.L., W.D. Greene, and P. Hiesl. 2018a. A review of changes in US logging businesses 1980s-present. Journal of Forestry. 116(3):291-303.

Conrad, J.L., W.D. Greene, and P. Hiesl. 2018b. The evolution of logging businesses in Georgia 1987-2017 and South Carolina 2012-2017. Forest Science. 64(6):671-681.

Costello, B., and A. Karickhoff. 2019. Truck driver shortage analysis 2019. American Trucking Associations. 16p.

Dillman, D.A. 2000. Mail and internet surveys: The tailored design method. 2nd ed. John Wiley & Sons, Inc., New York. 464 pp.

Egan, A., and D. Taggart. 2004. Who will log? Occupational choice and prestige in New England's north woods. Journal of Forestry. 15(6):20-25.

Gc, S., and K. Potter-Witter. 2011. An examination of Michigan's logging sector in the emerging bioenergy market. Forest Products Journal. 61(6):459-465.

Germain, R., J. Regula, S. Bick, and L. Zhang. 2019. Factors impacting logging costs: A case study in the Northeast, US. The Forestry Chronicle. 95(1):16-23.

Groves, R.M., F.L. Fowler Jr., M.P. Couper, J.M. Lepkowski, E. Singer, and R. Tourangeau. 2009. Survey methodology. 2nd Edition. John Wiley & Sons, Inc., New Jersey. 461 pp.

Hall, B.F., and E.P. LeVeen. 1987. Farm size and economic efficiency: The case of California. American Journal of Agricultural Economics. 60(4):589-600.

Kurtz, C.M. 2017. Forests of Wisconsin, 2016. Resource update FS-108. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 4p.

LeBel, L.G., and W.B. Stuart. 1998. Technical efficiency evaluation of logging contractors using a nonparametric model. Journal of Forest Engineering. 9(2):15-24.

Leefers, L.A. 2017. Statewide report: Forest products industries' economic contributions to

Michigan's economy-2017 update. Available online at https://www.michigan.gov/documents/dnr/2016ForestProductsIndustriesContributions_535055_7.pdf; last accessed September 17, 2019.

Leon, B.H., and J.G. Benjamin. 2012. A survey of business attributes, harvest capacity and equipment infrastructure of logging businesses in the Northern Forest. The University of Maine School of Forest Resources. 29p.

Luppold, W.G., C.C. Hassler, and S. Grushecky. 1998. An examination of West Virginia's logging industry. Forest Products Journal. 48(2):60-64.

MacDonald, J.M., P. Korb, and R.A. Hoppe. 2013. Farm size and the organization of U.S. crop farming. USDA Economic Research Report. 152. 55p.

Miles, P.D., S.J. Crocker, B.F. Walters, and D. Kepler. 2017. Forests of Minnesota, 2016. Resource update FS-115. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 4p.

Minnesota's Forest Resources 2016. A report published by Minnesota Department of Natural Resources.2017. Available online at https://files.dnr.state.mn.us/forestry/um/forest-resources-report-2016.pdf; last accessed: January 24, 2019.

Paulson, C., and S.A. Pugh. 2016. Forests of Michigan, 2016. Resource update FS-113. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 4p.

Regula, J., R. Germain, S. Bick, and L. Zhang. 2018. Assessing the economic viability of loggers operating tree-length harvest systems in the Northeast. Journal of Forestry. 116(4):347-356.

Rickenbach, M., T.W. Steele, and M. Schira. 2005. Status of the logging sector in Wisconsin and Michigan's Upper Peninsula, 2003. The University of Wisconsin Extension, Madison, WI. 40p.

Rickenbach, M., and T.W. Steele. Logging firms, nonindustrial private forests, and forest parcelization: Evidence of firm specialization and its impact on sustainable timber supply. Canadian Journal of Forest Research. 36:186-194.

Rickenbach, M., M. Vokoun, and S. Saunders. 2015. Wisconsin logging sector: Status and future direction. The University of Wisconsin Extension (G4073), Madison, WI. 23p.

Stearns, F.W. 1997. History of the Lake States Forests: Natural and Human Impacts. Available online at https://www.ncrs.fs.fed.us/gla/reports/history.htm; last accessed May 6, 2019.

US Forest Service, Forest Inventory and Analysis. 2019. EVALIDator web-application Version 1.6.0.03a. Available online at http://apps.fs.fed.us/Evalidator/evalidator.jsp; last accessed January 18, 2019.

US Bureau of Labor Statistics. 2020. Quarterly census of employment and wages, 2016. Available online at https://www.bls.gov/cew/downloadable-data-files.htm; last accessed March 4, 2020.

Wisconsin Department of Natural Resources. 2018. Forest Economy Wisconsin. Available

online at http://dnr.wi.gov/topic/forestbusinesses/factsheets.html; last accessed: September 17, 2019.

CHAPTER 3. MECHANIZED VERSUS CHAINSAW-BASED LOGGING BUSINESSES IN THE LAKE STATES REGION: EVOLUTION AND FUTURE DIRECTION

3.1 Abstract

This study assessed the differences between mechanized and chainsaw-based logging businesses in the three Lake States of Michigan, Minnesota, and Wisconsin using data collected through the coordinated mail surveys of logging businesses in each state in 2017. Compared to the chainsaw-based logging businesses, mechanized logging businesses had higher numbers of owners per business, were more likely to be family-run operations, harvested more than five times the timber volume, and had greater amounts of capital invested in businesses. Mechanized and chainsaw-based logging businesses also varied in terms of the source of stumpage and average travel distance to the harvest site. Chainsaw-based logging businesses procured a greater share of their timber from nonindustrial private forests and operated in areas closer to their business locations (within 30 miles) compared to mechanized logging businesses. When looking at the factors that are likely to influence logging business owners' intentions to remain or not to remain in business in the short-term future using binary logistic regression, mechanization status of a logging business was found to be significant only in Wisconsin but not in Michigan and Minnesota. In all three states, the age of the logging business owner was found to have a significant negative association with their indicated intention to remain in business. Compared to mechanized logging businesses, fewer chainsaw-based businesses had successors identified in each state hinting that loss of such businesses may be permanent once the current owners retire or leave the business. This could have implications for conducting timber harvests and forest management prescriptions on smaller-sized forest parcels that may not be economically viable for mechanized logging businesses, given their high moving costs.

3.2 Background

Loggers and logging businesses are a critical component of the wood products supply chain. They are the entities responsible for harvesting timber from different forest ownership groups and supplying it to the wood products industries, which in turn generate products that we all use. Additionally, loggers' harvesting actions are responsible for shaping the structure and composition of forests and for maintaining forest health and productivity (Rickenbach et

al. 2015). The survival and stability of an adequate number of logging businesses is, therefore, a prerequisite for the stability and profitability of the broader forest products industry, for meeting consumer demand for wood products, and for sustainable forest management. Besides, the logging industry provides much needed employment opportunities in rural America (He et al. 2021, Leon and Benjamin 2012).

Significant changes have occurred in the ways that loggers and logging businesses operate within the United States over the past four decades. These changes are a result of the mechanization of timber harvesting, processing, and transportation equipment (He et al. 2021, Loving 1991), vertical disintegration of the forest products industry (Goergen et al. 2013), and modifications in forest ownership patterns across the country (Zhang and Pearse 2012). Additionally, increased awareness about environmental issues has led to the implementation of policies and practices that influence the source, timing, and method of timber procurement (Conrad et al. 2018). This study provides an overview of logging businesses in the Lake States region from a mechanization standpoint and attempts to understand where the industry might be headed in the future.

3.2.1 Evolution of logging businesses in the U.S with an emphasis on the Lake States region

Logging has been an integral part of the American history since early 1600s when Jamestown settlers cut down timber to build the first European settlement in the new world. Since then, logging has contributed consistently to the US economy, though much has changed in how loggers and logging businesses operate over the years. Early loggers were physically robust men employed seasonally by large lumber companies to harvest timber. They worked long hours and lived away from home in poorly maintained logging camps scattered throughout the forests (Stearns 1997). These loggers used axes and cross-cut saws for harvesting timber and animal power for hauling wood. Waterways were commonly used for transporting harvested timber to lumber mills which were often located near large rivers. Following World War II, the introduction of chainsaws for harvesting and processing timber and log trucks for transportation changed the ways that loggers operated in the woods, as well as their living arrangements, and behavior (Stearns 1997). Loggers were no longer compelled to live in isolated logging camps but could commute to work from home and family (Stearns 1997). Later, railroad lines were constructed to transport harvested logs out of the forests to sawmills and to mines which used wood as fuel for smelting copper and iron in the region

(MSU Extension 2022).

In the Lake States region, the widely prevalent logging camps of the 1800s had completely disappeared by the mid-1900s, and the pulp and paper companies that dominated the market started obtaining their timber from independent loggers (Stearns 1997). This gave rise to the era of independent logging businesses, which is the logging business structure prevalent in the region today. Further mechanization in the years that followed led to the development of feller-bunchers and cut-to-length harvesters for felling timber; delimbers and slashers for topping and bucking; and cable skidders, grapple skidders, and forwarders for in-woods transportation. These machines decreased the demand for labor, increased safety as well as productivity of logging crews, and increased the amount of capital invested in businesses (Conrad et al 2018, Blinn et al. 2015, Rickenbach and Steele 2005, Loving 1991). Mechanization thus transformed the logging industry from labor-intensive to capital-intensive operations (Rickenbach and Steele 2005).

Besides mechanization, vertical disintegration of the forest products industry and modifications in forest ownership patterns have also changed the ways in which loggers operate in the woods. Before the mid-1990s, industrial forest landowners owned 13% of all U.S. timberlands and contributed 30% of the nation's timber supply (Zhang and Pearse 2012). During this period, logging businesses obtained most of their timber from forestlands owned by large forest products companies. By 2000, however, almost all forestlands owned by large forest products companies had been divested and forestlands became an important asset class for investors (Zhang and Pearse 2012). This resulted in the shift of millions of acres of forestlands from the forest industry to timber investment management organizations, real estate investment trusts, families, and others (Butler 2008). Between 1993 and 2006, the area of private forestlands in the U.S. increased by seven percent and the number of landowners increased by 12, mainly due to the divestiture of landholdings held by vertically integrated forest products industries (Butler 2008). Currently, close to 58% of the U.S. forest and woodlands are under private ownership, with family forest owners owning a major share of it (38%), followed by corporate private owners and others (Oswalt et al. 2019). The remaining 42% is under public ownership (Oswalt et at. 2019). Of the total timber harvested in the U.S., roughly 89% comes from privately-owned forests (Oswalt et at. 2019). Hence, changes in private forest ownership patterns have direct implications for how logging businesses operate

and for their profitability. Past literature suggests that there has been a reduction in the average forest tract size owned by private forest landowners in the U.S. owing to the vertical disintegration of forest products industries, increased urbanization, and intergenerational transfer (Mehmood and Zhang 2001). Other studies have found small forest tract size to be associated with less active forest management and increased harvesting costs (Hoover and Riddle 2021, Moss and Hedderick 2012, Rickenbach et al. 2005, Romm et al. 1987, Straka et al. 1984).

Apart from the changes in forest ownership patterns, federal policies enacted to promote multiple-use benefits from forests and those emphasizing the protection of habitat for endangered species have also limited the area and volume of timber available for harvest from both public and private forests. Likewise, state policies such as those requiring the use of best management practices (BMPs) have imposed restrictions on the timing and method of timber procurement, thus increasing harvesting costs incurred by logging businesses over the years (Montgomery et al. 2005, Cubbage 2004, Ellefson and Miles 1985).

3.2.2 Commonly used timber harvesting systems in the U.S.

Based upon the type of equipment used for felling and processing timber, harvesting systems in the U.S. can broadly be categorized as chainsaw-based systems, whole tree and tree-length systems, and cut-to-length systems (Rickenbach et al. 2015). Chainsaw-based systems use chainsaws for manually felling and processing timber which is then transported to the landing by cable skidders or forwarders (Rickenbach et al. 2015). Whole tree and tree-length systems use feller-bunchers to fell and bunch trees and skidders to transport felled trees to the landing. Further processing of tree-length material then takes place at the landing. Cut-to-length systems use harvesters for felling and processing timber and forwarders for transporting it to the landing (Rickenbach et al. 2015).

Currently, timber harvesting in the U.S. (in terms of volume generated) is dominated by mechanized logging equipment such as feller-bunchers in the Southeast and Minnesota and by cut-to-length harvesters in Wisconsin and Michigan (Conrad et al. 2018). Despite the widespread adoption of mechanized logging equipment, a substantial number of logging businesses in the Northeast, the Midwest, and the Northwest still rely on conventional chainsaw-based systems for harvesting and processing timber (Rickenbach et al. 2015, Blinn et al. 2015, Abbas et al. 2014, Leon and Benjamin 2012, Allred et al. 2011, Allen et al. 2008).

Rickenbach et al. (2015) noted that 32% of logging businesses in Wisconsin used chainsaws for harvesting timber in 2010, which was a decline from 36% in 2003. Likewise, in Minnesota 50% of logging businesses harvested some of their timber using chainsaws in 2011 (Blinn et al. 2015), though the total timber volume felled using chainsaws has declined consistently in Minnesota (Blinn et al. 2015). In Vermont, New York, Maine, and New Hampshire, 71%, 68%, 53% and 33% of the logging businesses, respectively, harvested timber using chainsaws in 2011 and 2012 (Leon and Benjamin 2012). In all these states, the total timber volume harvested by chainsaws was much smaller compared to that harvested using mechanized felling equipment (Leon and Benjamin 2012).

High productivity, reduced labor requirements, and better safety features are some of the major advantages of using mechanized logging equipment. However, such systems are more capital-intensive, demand a workforce capable of operating complex machines, and require larger landings and skid trails compared to chainsaw-based systems (Bennett 2010). Chainsaw-based logging systems, though less productive than mechanized systems, offer greater flexibility to work on difficult terrain, are useful when working with high valued timber and require low capital investment for business startup and operation (Bennett 2010). Chainsaw-based logging systems also provide a comparative advantage when harvesting timber on smaller-sized forest parcels (Allred et al. 2011, Rickenbach and Steele 2006). Past studies (Rickenbach et al. 2015, Blinn et al. 2015) have also noted the difference in source of timber for mechanized and chainsaw-based logging systems with the latter relying more on private forests and the former depending more on public forests, thus suggesting firm specialization to some extent (Rickenbach et al. 2015, Blinn et al. 2015). Given the changing trend of forestland ownership from few landowners owning large tracts of forestlands to many landowners owning smaller-sized forest parcels, firm specialization, as noted above, can be instrumental in the continued existence of small chainsaw-based logging businesses in the future.

Few studies to date have analyzed the differences between mechanized and chainsaw-based logging businesses in the U.S. (Allred et al. 2011, Rickenbach and Steele 2005). The emphasis of those studies that have been done has been to understand the differences in production levels, sources of timber, and perception about forest parcelization as a potential problem for logging businesses. This study contributes to this existing body of literature with

an additional emphasis on understanding how mechanized and chainsaw-based logging businesses are operating at present and where the industry might be headed in the future based on current conditions and trends. Will mechanized logging businesses in the Lake States region ultimately take over the logging business as in the U.S. South or will chainsaw-based logging businesses continue to have their niche?

The goal of this study is to develop a better understanding about the structure and status of mechanized versus chainsaw-based logging businesses in the three Lake States of Michigan, Minnesota, and Wisconsin and to understand the outlook for both mechanized and chainsaw-based logging businesses in the study area. The specific research questions that the study aims to address are:

- Do mechanized and chainsaw-based logging businesses in the study area vary notably in terms of their owner characteristics and business strategies adopted?
- Is one group outperforming another in terms of operational capacity and profit levels obtained?
- Are mechanized and chainsaw-based logging businesses equally likely to remain in business in the future or does mechanization status of a logging business influence a business owner's intention to continue logging in the future?

3.3 Methods

3.3.1 Survey design and data collection

Data for the study was collected through coordinated mail surveys of logging business owners in Michigan, Minnesota, and Wisconsin conducted in spring 2017. Three separate survey instruments were developed based upon past state-level surveys conducted in each state in coordination with researchers from all three states. Though separate survey instruments were developed for each state, most questions were worded consistently to allow for cross-state comparison of the data; these are the ones used for this study. Formal pretesting of the survey instrument was not done; however, feedback from logging industry representatives and the Department of Natural Resources in each state was sought to improve the wording of the survey instruments. Data was collected over a broad suite of areas including owner demographics, equipment mix, production levels, operational capacity, stumpage sources, capital investment, perceived profitability, and plans for business.

The mailing list of logging business owners in Michigan was compiled from the lists maintained by the Michigan Department of Natural Resources (DNR) and the Michigan Forest Products Council. It included 1,085 logging businesses which made the sample size for Michigan. In Wisconsin, the list of logging business owners was compiled from the lists maintained by Wisconsin DNR, cooperating foresters, county, national, and state forest administrators, and the Forest Industry Safety and Training Alliance. It included 911 logging businesses, which was the sample size for Wisconsin. In Minnesota, the list of logging businesses was composed of the membership directory of logging business owners enrolled in the Minnesota Logger Education Program (MLEP) in 2017. It included 383 logging businesses, which was the sample size for Minnesota.

The mail survey in each state was conducted following Dillman's tailored design method (Dillman 2000). It involved sending out a pre-survey notification letter to all participants prior to mailing the full survey. This was followed by a mailing of the survey questionnaire along with a cover letter and a postage-paid business reply envelope. Reminder postcards with "thank you" notes were then sent to non-respondents, which was followed by a second wave of the survey questionnaire. In the case of Michigan, three waves of survey questionnaires were sent to increase the response rate. In Minnesota, a follow-up letter was sent to all MLEP members following the second wave of the survey questionnaire, and in Wisconsin, a U.S.$2 bill was included with the first mailing of the survey instrument to boost the response rate. Mailings in each state were conducted by universities in the respective states.

To assess the differences in perceived profit levels, the respondent logging businesses were asked to indicate their self-rated profit level on a five-point Likert scale ranging from 1 (very poor) to 5 (excellent). To provide insight into operational capacity, the respondent businesses were asked to indicate if they operated at full capacity in 2016, meaning that no additional volume could be produced, given their equipment and labor availability as well as weather and site conditions. All businesses were asked to provide their responses for calendar year 2016.

3.3.2 Data preparation and analysis

Upon receipt of the completed surveys, nonresponse bias was estimated by comparing the responses of the first and last 25% of the respondents in each state as suggested by

Armstrong and Overton (1977). The variables used for nonresponse bias tests included total timber volume harvested in 2016, number of years that logging businesses had been in operation, age of the owners, percentage of volume harvested from private woodlands, percentage of volume transported by company-owned trucks, and the amount of capital invested in logging businesses. The businesses that indicated harvesting less than 100 cords of timber in 2016 were excluded from subsequent analysis. The conversion units adopted include one standard cord equivalent to 500 board feet.

For analysis, the respondent logging businesses were categorized as mechanized operations if they adopted some form of mechanized harvest system such as feller-bunchers and cut-to-length harvesters, or more diversified tools including chainsaws. Those using only chainsaws for harvesting timber and skidders or forwarders for in-woods transportation were categorized as chainsaw-based harvest operations. Our data analysis proceeded in two parts. First, we did a comparative analysis of mechanized versus chainsaw-based logging businesses in all three states in terms of their owner and business characteristics as well as business strategies adopted. Welch's t-tests were used to compare the responses of mechanized versus chainsaw-based logging businesses for continuous variables that were normally distributed, and Mann-Whitney U-tests were used for variables that were not normally distributed. In addition, Chi-square tests of independence were used to analyze categorical variables. Statistical significance for all analyses was set at $\alpha = 0.05$.

Next, to understand if the mechanization status of a logging business was a significant predictor of a business owner's intention to remain in business in the future, a binary logistic regression model was estimated for each state. The dependent variable for the model was the respondent business owner's indicated intention to remain or not to remain in business five years from the date of the survey. The independent variables included mechanization status, self-rated profit levels, operational capacity, age of the owners, and whether the business was a family run operation or not. Mathematically, the model can be expressed as

Prob $(R_i) = f(M_i, P_i, O_i, A_i, F_i)$

where,

R_i is a binomial (0,1) variable reflecting business owner *i's* intention to remain or not to remain in business in five years (1 if the business owner intended to remain in business, 0 otherwise).

M_i is a binomial dummy variable indicating business *i's* mechanization status (1 if the business is a mechanized logging operation, 0 otherwise);
P_i is the self-indicated profit level of business i (ordinal variable ranging from 1 to 5, 1 indicating very poor profit level and 5 indicating excellent profit level);
O_i is a binomial dummy variable indicating if business i operated at its full operational capacity (1 if the business operated at full capacity and 0 otherwise);
F_i is a binomial dummy variable representing whether the logging business *i* is a family-run operation or not (1 if the business is a family business, 0 otherwise);
A_i is the respondent business owner *i*'s age in years.
Given their economic viability, the logging businesses with high profit levels and those that indicated they operate at full operational capacity may be more likely to remain in business in the future. Past logging business studies (Conrad et al. 2018, Rickenbach and Steele 2005) have noted that mechanized logging businesses are more productive than chainsaw-based logging operations and have higher amounts of capital invested in their businesses. With high capital investment at stake in their businesses, mechanized logging businesses may be less likely to exit from the market in the future. Likewise, logging businesses with multiple family members engaged in the business may continue logging as it provides a source of income for multiple family members. Logging business owners that are older may, on the other hand, be physically less capable of continuing logging businesses and may view retirement as an option. Hence, older business owners were expected to be more likely to indicate that they will exit from the market in the future. All statistical tests were conducted using IBM SPSS Statistics 27.

3.3.3 Model estimation

Since the response variable in this study was binary in nature, binomial logistic regression was applied for estimating the model parameters. Logistic regression is based upon the cumulative logistic probability function and estimates the probability of an action given a set input variables. In binary logistic regression, the probabilities for each outcome are specified as:

$$P(Y_i = 1) = P_i = \frac{e^{X_i\beta}}{1 + e^{X_i\beta}}$$

$$P(Y_i = 0) = 1 - P_i = \frac{1}{1 + e^{X_i\beta}}$$

The likelihood function for the model is (Greene 1993)

$$L = \prod_{i=1}^{n} P_i^{y_i} \left[1 - P_i\right]^{1-y_i)}$$

where, P_i is the probability that a logging business owner *i* indicates that he/she will remain in business in the short-term future, X_i represents the independent variables, and β denotes model coefficients. Maximum likelihood estimation procedures are employed to estimate the value for model parameters.

3.4 Results and Discussion

The overall response rate was 23% for Michigan, 39% for Minnesota and 50% for Wisconsin. In Michigan, however, out of the 254 responses that were obtained initially, 134 respondents indicated that they had either retired or were no longer in the logging profession, thus reducing the effective sample size for the state. A probable reason for this is the use of the State's logging business owner database that was not up to date. Keeping an updated record of the logging business owner database in Michigan and using such information in future surveys may help to boost the response rate in the state for future surveys. Though the effective response rate for Michigan was low, the responses obtained still provide important information about logging businesses in the state. Notably, there have been other logging business studies with comparable response rates in the past (Leon and Benjamin 2012, Milauskas and Wang 2006). A total of 550 usable responses were obtained from the logging businesses in all three states. Out of this, 504 respondents (82 in MI, 133 in MN, and 289 in WI) answered questions about the harvesting systems used in 2016 and are included in this study. As stated earlier, nonresponse bias tests were conducted for each state, and the results indicated no significant difference between the early and late respondents at 0.05 alpha level, thus ruling out the concern for nonresponse bias in the obtained dataset.

Out of the total respondents in Michigan that answered the question about the harvesting systems used, 33% said that they harvested timber using chainsaws while the remaining used some form of mechanized felling equipment. Likewise, 30% of the logging businesses in WI and 17% in MN harvested timber using chainsaws in 2016 while the remaining businesses used mechanized felling equipment for harvesting timber. Feller-

bunchers were the most commonly used mechanized felling equipment in MN (with 85% of mechanized logging businesses harvesting timber using this method) while cut-to length harvesters were more common in Michigan and Wisconsin. These results are consistent with earlier surveys conducted in the Lake States region (Blinn et al. 2015, and Rickenbach et al. 2015, Abbas et al. 2014). Eighty-five percent of the mechanized logging businesses in Michigan and 88% in Wisconsin harvested timber using cut-to-length harvesters in 2016. The section below provides results from the comparative analyses of mechanized versus chainsaw-based logging businesses in each of the three states followed by results obtained from the binary logistic regression models estimating the factors influencing respondent logging business owners' intention to remain or not to remain in business in the short-term future.

3.4.1 Comparison of logging business owners and industry characteristics of mechanized versus chainsaw-based logging businesses.

On average, the respondent logging businesses in all three states have remained in business for more than 20 years with no significant difference observed in the years of operation between mechanized versus chainsaw-based logging businesses in any of the states (Table 3.1). The trend of aging logging businesses has been reported by past state level surveys across the region (Blinn et al. 2015, and Rickenbach et al. 2015, Abbas et al. 2014), and our findings suggest the continuation of this trend. Many respondent businesses (52% in MN, 63% in MI, and 65% in WI) were single-owner operations, with the remainder having two or more owners. This is consistent with the findings of Rickenbach and Steele (2005). Through the survey of logging businesses in Upper Michigan and Northern Wisconsin, the authors noted that 61% of the logging businesses in the study area were single owner-operator enterprises with no employees (Rickenbach and Steele 2005). When comparing the number of owners per logging business, mechanized businesses in all three states were found to have a higher number of owners per business compared to chainsaw-based businesses with the difference being statically significant in MN and WI (Table 3.1). Since mechanization requires greater amounts of capital to be invested for business startup and operation, it seems logical for such businesses to have more than one owner as it provides an opportunity for combining investments among owners.

Most of the respondent logging businesses (69% in MI, 76% in MN, and 63% in WI) identified themselves as family businesses, meaning that at least two family members played a

central role in the leadership and daily workings of the business. This was expected, as several previous studies have noted logging businesses to be family-run operations, and familial ties to logging have been noted as influential factor in occupational choice of many loggers across the country (Taggart and Egan 2011, Allred 2009, Egan and Taggart 2004, Keefer et al. 2003). Chi-squared tests of independence revealed a statistically significant association between a logging business being a family run operation and its mechanization status (Table 3.1). Compared to chainsaw-based logging businesses, a higher number of mechanized logging businesses in all the states identified themselves as family businesses (Table 3.1).

The average logging business owner in Michigan was found to be 53 years old; the average age in Minnesota and Wisconsin was 54 years old. The owners of mechanized logging businesses in general were younger as compared to those of chainsaw-based businesses, with the difference being statistically significant in Minnesota and Wisconsin (Table 3.1). Seventy-one percent of the chainsaw-based logging business owners in Minnesota, 42% in Michigan, and 38% in Wisconsin were 60 years or older. Though it seems logical for older business owners to be more experienced in their trade and have higher amounts of capital built up over the years that could be invested in their business, they may also be more complacent about their production levels and may not have plans for expanding the business. On the contrary, younger business owners may be technologically savvy and may look for ways of expanding their business, thereby investing in mechanized logging equipment.

Table 3.1 Logging business owner and industry characteristics of mechanized versus chainsaw-based logging businesses in Michigan, Minnesota, and Wisconsin.

Variable	State	Mechanized Logging Businesses	Chainsaw-based Businesses	Test statistic (*P*-value)
Years in business (mean)	MI	24 years[a]	25 years[a]	t-value = -0.312 (0.756)
	MN	30 years[a]	32 years[a]	t-value = -0.542 (0.589)
	WI	29 years[a]	26 years[a]	t-value = 1.221 (0.223)
Company is a family business (percent saying yes)	MI	84%[a]	42%[b]	χ^2 =14.462 (0.000)
	MN	80%[a]	52%[b]	χ^2 = 7.346 (0.007)
	WI	73%[a]	42%[b]	χ^2 = 23.701 (0.000)
Number of owners (mean)	MI	1.58[a]	1.31[a]	U= 800.500 (0.172)
	MN	1.72[a]	1.24[b]	U = 1503.000 (0.011)
	WI	1.58[a]	1.20[b]	U = 10536.000 (0.000)
Age of owner(s) (mean)	MI	52 Years[a]	56 years[a]	t-value = -1.494 (0.139)
	MN	52 years[a]	63 years[b]	t-value = -4.092 (0.000)
	WI	53 years[a]	56 years[b]	t-value = -2.162 (0.032)

Like superscripts denote no significant difference between mechanized versus chainsaw-based logging businesses at α= 0.05.
U= Mann Whitney U

3.4.2 Amount of capital invested in business, production levels, and business strategy adopted by mechanized versus chainsaw-based logging businesses.

When asked to indicate the amount of capital invested in their logging business, most businesses in all three states (60% in MI, 79% in MN and 84% in WI) said that they had $500,000 or less capital invested in business. Twenty-two percent of the logging businesses in MI, ten percent in MN, and seven percent in WI had more than one million invested in business. Much of the capital was invested in harvesting equipment, with the remainder used for acquiring stumpage, over the road hauling equipment, and off-road transportation equipment. As expected, mechanized logging businesses in all three states had significantly

higher amounts of capital invested in their business (median investment of $500,000 to $999,999 for MI and $100,000 to $499,999 for MN and WI) compared to chain-saw based businesses (median investment: less than $100,000) (Table 3.2). A past study in Wisconsin (Rickenbach and Steele 2005) noted that it is common for modern mechanized logging systems in the state to require an initial investment of $400,000 or more and monthly financial payments of $5,000 or more. With high capital investment at stake in their business, mechanized logging businesses need to be extra savvy to ensure their economic viability. To pay the large debt load associated with investing in mechanized logging equipment, logging businesses need large cash flows, high machine utilization rates, and a steady supply of stumpage (Rickenbach and Steele 2005). Compared to chainsaw-based logging businesses, the cost of idling equipment is likely to be higher for mechanized operations. Hence, mechanized logging businesses are more susceptible to financial failure if market conditions are not favorable (Rickenbach and Steele 2005).

Of the total timber volume harvested by the respondent businesses in 2016, mechanized logging businesses in each state contributed a major share (98% in MN, 90% in MI and 85% in WI) with the remainder harvested by chainsaw-based logging businesses. The average timber production per business was significantly higher (five times or more) for mechanized logging businesses as compared to chainsaw-based operations in each state with the difference being much more pronounced in Minnesota than in Michigan and Wisconsin (Table 3.2). This is expected, since mechanization of the logging industry is driven by economies of scale that favor more productive and efficient harvest systems (Rickenbach and Steele 2006). Through their survey of logging contractors in Wisconsin in 2004, Rickenbach and Steele (2005) noted that mechanized logging businesses produced on average more than three times the annual volume compared to chainsaw-based businesses in the state. Our findings suggest that this gap has widened even more in recent years.

More than 60% of the stumpage harvested in all three states was self-purchased by logging businesses, with the remainder purchased by others such as mills. This finding is consistent with that obtained by past logging business studies in the region (Blinn et al. 2015, Rickenbach et al. 2015). When comparing the percentage of stumpage that was self-purchased, no significant difference was observed between mechanized and chainsaw-based logging businesses in any of the states (Table 3.2). Purchasing their own stumpage offers

logging businesses greater independence and control over their business as well as the flexibility to negotiate prices. It also reduces transaction costs by cutting out middle entities such as wood brokers and increases businesses' profit potential (Conrad et al. 2018). It is, therefore, understandable that many logging businesses in the study area opted to purchase their own stumpage rather than harvesting timber purchased by others, irrespective of their mechanization status.

Non-industrial private forests were the major source of stumpage for logging businesses in Michigan and Wisconsin, followed by state and industrial forests in Michigan, and county, state, and industrial forests in Wisconsin. In Minnesota, state and county forests were the major source of timber for logging businesses in the state followed by non-industrial private forests, industrial private forests, and national forests respectively. This is consistent with the timberland ownership patterns across the states. In WI and MI, much of the timberland (71% and 64% respectively) is owned by private forest landowners, while in MN, most timberland (45%) is owned by state and local governments (US Forest Service, Forest Inventory and Analysis 2019).

Chainsaw-based logging businesses obtained a significantly higher percentage of their harvest volume from nonindustrial private forests as compared to mechanized logging businesses in both Michigan and Wisconsin (Table 3.2). Though the difference was not statistically significant in Minnesota, a considerably higher percentage of harvest for chainsaw-based logging businesses came from nonindustrial private forests than for mechanized logging businesses (Table 3.2). Mechanized logging businesses in all the states obtained a significantly higher percentage of their stumpage from industrial, county, and state forests as compared to their chainsaw-based counterparts (Table 3.2). These findings are consistent with those obtained by Rickenbach and Steele (2005). The authors noted that chainsaw-based logging businesses in Wisconsin obtained a significantly higher proportion of their timber from non-industrial private forests while mechanized businesses obtained higher proportions of their stumpage from county and state forests (Rickenbach and Steele 2005).

The logging businesses in our survey were also asked to indicate the number of sales they harvested in different acreage categories in 2016 (0-5 acres, 6-10 acres, 11-20 acres, 21-40 acres, 41-80 acres, 81-160 acres, and 161 acres or more). The most frequently harvested acreage category for both mechanized and chainsaw-based logging businesses in Michigan

was 41 to 80 acres. In Wisconsin, it was 21 to 40 acres for both mechanized and chainsaw-based logging businesses, while in Minnesota, the most frequently harvested acreage category for mechanized logging businesses was 21 to 40 acres and for chainsaw-based businesses was 6 to 10 acres. Since harvesting with mechanized logging equipment requires building larger landings and skid trails compared to chainsaw-based systems (Bennett 2010), we expected to observe some variation in the harvest size conducted by mechanized and chainsaw-based logging businesses in the study area. However, this was not the case for Michigan and Wisconsin.

Twenty-four percent of the mechanized logging businesses in Michigan, 35% in Wisconsin, and 42% in Minnesota indicated that they harvested timber on 10 acres or smaller forest parcels in 2016, meaning that these businesses had at least one of their timber harvests on 10 acres or smaller forest parcels. Owing to diminished timber harvesting economies of scale, past studies have noted increased timber production costs with decreased forest tract size (Moss and Hedderick 2012, Greene et al. 1997, Cubbage 1983, Row 1978). Therefore, it was notable that a substantial number of mechanized logging businesses in the study area harvested timber on 10 acres or smaller forest parcels. Rickenbach et al. (2005) found that for timber sale to be profitable in Wisconsin, it may need to be 20 acres or greater in size. In Michigan, Abbas et al. (2014) noted that logging businesses in 2012-2013 were willing to bid on timber sales if it were 22 acres or larger in size. However, Conrad (2014) found that properly equipped Wisconsin loggers were capable of profitably harvesting smaller sized forest parcels. In our study, we did not specifically ask the respondents if timber harvests on smaller forest parcels were profitable or not; hence we cannot infer with certainty if such harvests were profitable or were a mere necessity for mechanized logging businesses to keep their equipment running instead of idling the equipment.

The average one-way travel distance in miles from the primary business location to the harvest site was found to be 30 miles or less for chainsaw-based logging businesses. For mechanized logging businesses this distance was significantly higher at between 31 to 60 miles (Table 3.2). Chainsaw-based logging businesses in Michigan transported a significantly higher percentage of their harvested timber volume (90%) using contracted trucking services compared to mechanized logging businesses which transported 66% of their volume using contracted trucks in the state (Table 3.2). In Minnesota and Wisconsin, chainsaw-based

logging businesses also transported a higher percentage of their harvested volume using contracted trucks compared to mechanized logging businesses in the respective states, though the difference was not statistically significant (Table 3.2).

Table 3.2 Comparison of capital investment, production level, and operational strategy adopted by mechanized versus chainsaw-based logging businesses in Michigan, Minnesota, and Wisconsin.

Variable	**State**	**Mechanized Logging Businesses**	**Chainsaw-based Businesses**	**Test statistic (*P*-value)**
Capital invested in business (median rating)	MI	$500,000 to $999,999[a]	Less than $100,000[b]	U =1214.50 (0.000)
	MN	$100,000 to $499,999[a]	Less than $100,000[b]	U =1794.00 (0.000)
	WI	$100,000 to $499,999[a]	Less than $100,000[b]	U =12471.50 (0.000)
Mean volume harvested (cords)	MI	12,544[a]	2,358[b]	U =1153.00 (0.000)
	MN	13,682[a]	665[b]	U =2056.50 (0.000)
	WI	9,667[a]	2,209[b]	U =14350.00 (0.000)
Percent of volume harvested from different forest ownership categories	MI	Private woodlands (44%)[a] Industrial Forests (25%)[a] State Forests (22%)[a] County Forests (2%)[a]	Private woodlands (81%)[b] Industrial Forests (8%)[b] State Forests (7%)[b] County Forests (2%)[a]	U=365.50 (0.000) U=908.00 (0.005) U=861.00 (0.034) U=689.00 (1.000)
	MN	Private woodlands (29%)[a] Industrial Forests (13%)[a] State Forests (25%)[a] County Forests (29%)[a]	Private woodlands (45%)[a] Industrial Forests (0%)[b] State Forests (31%)[a] County Forests (20%)[b]	U=1049.50 (0.587) U=1449.00 (0.007) U=1205.50 (0.639) U=1475.00 (0.025)
	WI	Private woodlands (60%)[a] Industrial Forests (4%)[a] State Forests (8%)[a] County Forests (21%)[a]	Private woodlands (79%)[b] Industrial Forests (2%)[b] State Forests (3%)[b] County Forests (12%)[b]	U=5970.50 (0.000) U=9323.00 (0.038) U=10024.50 (0.002) U=10691.00 (0.000)
Percent of stumpage that was self-purchased by logging businesses	MI	55%[a]	69%[a]	U=524.40 (0.184)
	MN	71%[a]	74%[a]	U=1012.50 (0.333)
	WI	74%[a]	69%[a]	U=8859.00 (0.718)

Table 3.2 (cont'd)

Average one-way travel distance in miles from primary business location to harvest site (median value)	MI	31 to 60 miles[a]	30 miles or less[b]	U=918.00 (0.008)
	MN	31 to 60 miles[a]	30 miles or less[b]	U=1431.00 (0.036)
	WI	31 to 60 miles[a]	30 miles or less[b]	U=11584.00 (0.000)
Average percent of harvest volume transported to mills using contracted trucking	MI	66%[a]	90%[b]	U=528.50 (0.028)
	MN	50%[a]	64%[a]	U= 814.50 (0.256)
	WI	65%[a]	83%[b]	U= 6301.00 (0.001)

Like superscripts denote no significant difference between mechanized versus chainsaw-based logging businesses at $\alpha = 0.05$.
U= Mann Whitney U

3.4.3 Comparison of operational capacity and self-perceived profit levels of mechanized and chainsaw-based logging businesses

The logging businesses in our survey were asked to indicate if they operated at full operational capacity in 2016, meaning that no additional volume could be produced given their equipment and employee configuration as well as weather and site conditions. To this, 44% of the respondents in MI, 35% in Minnesota, and 33% in Wisconsin said that they operated at full capacity, while the remaining operated below their full operational capacity. A slightly higher percentage of chainsaw-based logging businesses said that they operated at full operational capacity compared to mechanized businesses; however, the difference was not statistically significant (Table 3.3). Low-capacity utilization can have negative impacts on the technical efficiency of logging businesses (LeBel and Stuart 1998); however, it may not be avoided completely given unpredictable weather conditions, limited mill quotas, equipment breakdowns, and other factors.

Logging businesses were also asked to self-report their profit levels for 2016 on a scale ranging from 1 to 5 (1 being very poor and 5 being excellent). To this, the respondents in all three states on average said that they achieved break-even profit levels. The median profit level for mechanized logging businesses in all three states was found to be average (median value, 3)

while that for chainsaw-based businesses was found to be good (median value, 4). Statistically the differences in self-reported profit levels of mechanized and chainsaw-based logging businesses were significant only in Wisconsin (Table 3.3). As chainsaw-based logging businesses have less capital invested in business, they are likely to have lower debt loads and operating costs compared to mechanized businesses. Hence, they have greater chances of obtaining profits even when their productivity is low compared to mechanized logging businesses. Mechanized logging businesses operating on smaller forest parcels, on the other hand, may have high equipment moving costs with less output, and hence may have lower chances of obtaining profits on such harvests.

Table 3.3 Comparison of operational capacity and self-rated profit levels of mechanized and chainsaw-based logging businesses in Michigan, Minnesota, and Wisconsin.

Variable	**State**	**Mechanized Logging Businesses**	**Chainsaw-based Logging Businesses**	**Test statistic (*P*-value)**
Percent of businesses that operated at full capacity in 2016 (mean)	MI	43%[a]	54%[a]	$\chi^2 = 0.894$ (0.344)
	MN	35%[a]	36%[a]	$\chi^2 = 0.026$ (0.873)
	WI	30%[a]	41%[a]	$\chi^2 = 3.418$ (0.065)
Self-rated profit level (median rating)	MI	Average[a]	Good[a]	U= 572.000 (0.100)
	MN	Average[a]	Good[a]	U= 926.000 (0.333)
	WI	Average[a]	Good[b]	U= 6588.000 (0.001)

Like superscripts denote no significant difference between mechanized versus chainsaw-based logging businesses at $\alpha = 0.05$.
U= Mann Whitney U

3.4.4 Short-term longevity of mechanized and chainsaw-based logging businesses and their plans for business succession

When asked to indicate if the respondent logging businesses intended to remain in business five years from the date of the survey, about three-quarters of the respondents in all three states said that they would continue logging while the rest intended to exit from the market. A greater number of mechanized logging businesses in all three states (83% in MI, 80% in WI, and 78% in MN) intended to remain in business as compared to chainsaw-based logging businesses (70% in MI, 62% in WI, and 55% in MN). The respondent logging businesses were also asked about their plans for business succession. To this, 53% of mechanized logging

businesses in Michigan, 51% in Minnesota, and 41% in Wisconsin said that a family member would most likely take over the ownership of their business in the future. This number was considerably lower for chainsaw-based logging businesses in all three states (22% for MI, 9% for MN, and 23% for WI). Approximately a quarter of the mechanized logging businesses and 50% or more of chainsaw-based businesses in all three states said that no one was going to take over the ownership of their business in the future, suggesting potential loss of such businesses after the current owner retires.

3.4.5 Models for estimating the factors influencing logging business owners' intention to remain or not to remain in business in the short-term future.

Three binary logistic regression models were estimated, one for each state, to understand if the mechanization status of a logging business was a significant predictor of a business owner's intention to remain or not to remain in business in the short-term future. As mentioned earlier, the dependent variable was the respondent business owner's indicated intention to remain or not to remain in business five year from the date of the survey, and the independent variables included mechanization status, self-rated profit levels, operational capacity, age of the owners, and whether the business was a family run operation or not. Descriptive statistics of the variables used in the models are presented in Table 3.4. The likelihood of remaining in business in the short-term future models were significant in all three states at 0.05 alpha level ($\chi^2 = 20.655$ and $p = 0.001$ for Michigan; $\chi^2 = 23.107$ and $p = 0.000$ for Minnesota; and $\chi^2 = 44.238$ and $p = 0.000$ for Wisconsin). The Hosmer and Lemeshow goodness-of-fit tests were not significant in any of the models, suggesting adequate model fit for all the models. Adjusted r^2 was 0.376 for Michigan model, 0.263 for Minnesota model and 0.230 for Wisconsin model. Results from Michigan, Minnesota, and Wisconsin models are presented in Tables 3.5,3.6, and 3.7 respectively.

In the Michigan model, only the variable representing logging business owner's age was significant. As expected, it was negatively related to the respondent's indication of remaining in business in the short-term future. Thus, with increasing age, the respondent logging business owner's probability of remaining in business decreased in Michigan. The odds of a logging business owner indicating that he/she will remain in business decreased by 0.873 times per year increase in average age of the business owner. Mechanization status of the logging business was not significantly related to business owner's intention of remaining

in business, nor were the profit levels associated with business, full use of operational capacity, or whether the business was a family-run operation or not.

In the Minnesota model, two variables, one representing owner's age and the other representing profit levels obtained from logging business, were significant. As in Michigan, age was negatively associated with the respondent business owner's intention of remaining in business in the future (odds ratio = 0.931), while profitability of business was positively associated with it. The higher the profit levels obtained from their logging business, the more likely were the business owners to indicate that they will continue logging (odds ratio = 1.844). Again, mechanization status of the logging business was not significant in predicting the business owner's intention of remaining in logging business, nor was the fact that their business was a family run operation, or that it operated at full operational capacity.

In Wisconsin, the variables representing logging business owner's age and their mechanization status were significant. As before, age was negatively associated with logging business owner's intention of remaining in business in the short-term future (odds ratio = 0.916) while mechanization status was positively related to it (odds ratio = 2.304). Mechanized logging businesses in Wisconsin were more likely to say that they will continue logging in the future compared to chainsaw-based businesses. Profit levels obtained by the logging business, whether the business operated at its full operational capacity or not, and if the business was a family run business or not had no statistical significance on business owner's intention of remaining in business in the short-term future.

The only variable that was consistently significant in all three models was the logging business owner's age, thus older business owners in all three states are more likely to consider retirement from logging in the short-term future. This poses a question about the fate of logging businesses once the aging business owner retires. As mentioned earlier, our findings reveal that, compared to chainsaw-based logging businesses, family members of mechanized logging businesses are more likely to take over the ownership of their business once the existing owner retires. Many of the chainsaw-based businesses may, however, cease to exist in the absence of successors. Some form of support, perhaps in the form of aiding current logging businesses with their successional planning decisions or offering training programs for getting the next generation of business owners ready for taking over the business, is needed for the sustainability of the logging sector in the future.

Table 3.4 Descriptive statistics of the variables used in logistic regression models.

Variable	Description	Mean	Standard Deviation
M_j	Mechanization status (Binomial dummy variable, 1= mechanized logging business, 0 otherwise)	0.67 (MI) 0.83 (MN) 0.70 (WI)	
P_j	Self-indicated profit level (Ordinal variable ranging from 1 to 5, 1= very poor, 5 = excellent)	3.02 (MI) 3.08 (MN) 3.06 (WI)	
O_j	Operational capacity of logging business (Binomial dummy variable, 1= operate at full capacity, 0 otherwise)	0.46 (MI) 0.35 (MN) 0.33 (WI)	
F_j	Family business (Binomial dummy variable, 1 if the business is a family business, 0 otherwise)	0.69 (MI) 0.76 (MN) 0.63 (WI)	
A_j	Age of the logging business owner in years	52.98 (MI) 53.63 (MN) 54.27 (WI)	10.85 (MI) 11.73 (MN) 10.29 (WI)

Table 3.5 Binary logit estimates of factors influencing logging business owners' intention to remain in business in the short-term future in Michigan.

Variable	Coefficient estimate	SE	P value	Odds ratio
Constant	9.403	2.839	.001	
M_j	.034	.833	.967	1.035
P_j	-.321	.366	.381	0.726
O_j	1.171	.774	.130	3.224
F_j	.182	.935	.845	1.200
A_j	-.136	.040	.001	0.873*

*Significant at an alpha level of 0.05

Table 3.6 Binary logit estimates of factors influencing logging business owners' intention to remain in business in the short-term future in Minnesota.

Variable	Coefficient estimate	SE	P value	Odds ratio
Constant	2.462	1.894	.194	
M_j	.529	.624	.397	1.698
P_j	.612	.243	.012	1.144*
O_j	.460	.529	.384	0.562
F_j	.224	.547	.683	1.251
A_j	-.072	.026	.006	0.931*

*Significant at an alpha level of 0.05

Table 3.7 Binary logit estimates of factors influencing logging business owners' intention to remain in business in the short-term future in Wisconsin.

Variable	Coefficient estimate	SE	P value	Odds ratio
Constant	4.471	1.190	.000	
M_j	.834	.345	.016	2.304*
P_j	.234	.159	.141	1.263
O_j	.134	.336	.690	1.143
F_j	.420	.327	.199	1.522
A_j	-.088	.018	.000	0.916*

*Significant at an alpha level of 0.05

3.5 Summary and Conclusions

This study used data obtained from mail surveys of logging business owners in Michigan, Minnesota, and Wisconsin to understand the differences between mechanized and chainsaw-based logging businesses in the study area and to identify the factors that are likely to influence business owners' intentions to remain or not to remain in business in the short-term future. Many of the businesses in all three states were well-established operations that had been in the logging business for a long time and had aging business owners. This is consistent with the findings of past logging business studies in the region (Blinn et al. 2015, Rickenbach et al. 2015, Abbas et al. 2014). The majority of businesses used some form of mechanized felling equipment such as feller-bunchers or cut-to-length harvesters for felling timber and were identified as mechanized logging businesses in this study. The remainder used chainsaws for felling timber and skidders or forwarders for hauling timber to the landing and were noted as chainsaw-based businesses.

Some variation in owner and business characteristics was noted between mechanized and chainsaw-based logging businesses in the study area. Compared to chainsaw-based logging businesses, mechanized businesses had a higher number of owners per business, were more likely to be family-run operations, and had owners that were relatively younger in age. Mechanized logging businesses had significantly higher amounts of capital invested in their business and were much more productive compared to chainsaw-based businesses. Most of the timber volume harvested in the study area (85% or more) was generated by mechanized logging businesses with only a small share contributed by chainsaw-based businesses. This is consistent with the findings of previous logging business studies in the Lake States region and across much of the northeastern U.S. states (Blinn et al. 2015, Rickenbach et al. 2015, Leon and Benjamin 2012). Specific to the Lake States, the percentage of total timber harvests contributed by the mechanized felling systems seems to be increasing in recent years (Blinn et al. 2015, Rickenbach et al. 2015).

Many logging businesses in the study area, irrespective of their mechanization status, purchased their own stumpage rather than harvesting stumpage purchased by others such as mills. Compared to mechanized logging businesses, chainsaw-based businesses obtained a higher percentage their stumpage from private woodlands while mechanized logging businesses obtained a higher percentage of their stumpage from industrial, state, and county

forests. Chainsaw-based logging businesses procured timber from forestlands that were located closer to their primary business location (within 30 miles) and transported a larger share of their harvested volume using contracted trucking services compared to mechanized logging businesses. No statistically significant difference was noted in the operational capacity of chainsaw-based or mechanized logging businesses in the study area; however, perceived profit levels were slightly better for chainsaw-based businesses compared to mechanized logging businesses with the difference being statistically significant in Wisconsin.

The results from binary logistic regression models estimating a business owner's intention to remain or not to remain in business in the near-term future revealed that the probability of a business owner continuing in logging decreased with increasing age. Mechanized logging businesses in Wisconsin were statistically more likely to say that they will continue logging in the short-term future compared to chainsaw-based businesses. However, this was not the case for Michigan and Minnesota. The higher the profit levels obtained by logging businesses in Minnesota, the more likely they were to remain in business in the short-term future. Age of the logging business owner was consistently found to be an important influencing factor in their decision to continue logging in the future. With many business owners approaching their retirement age, there remains a concern about who will take over the businesses once the current owners retire. Our results reveal that a greater number of mechanized logging businesses in the study area have thought about their successional plan and intend to transfer their business to someone within the family compared to chainsaw-based operations.

Many chainsaw-based logging businesses, though operating at good profit levels during the time of our survey, are likely to cease operating in the future in the absence of a successor identified to take over the ownership of their business. Chainsaw-based logging businesses in the study area appear to have a niche and were found to be operating at decent profit levels during the time of our survey. Their numbers and timber harvest volumes, however, are likely to shrink further in the future. Since chainsaw-based logging businesses are found to concentrate their harvest on private woodlands, which are known to be smaller in size compared to industrial and public forests, an important concern that arises with the projected loss of such businesses is who will harvest timber from smaller-sized private woodlands in the future. Our results, however, reveal that a considerable number of

mechanized logging businesses in the study area already harvest timber in forest parcels of 10 acres or less. Hence, mechanized logging businesses will likely fill the gap left by departing chainsaw-based businesses in the future, though it remains to be seen whether such harvests are profitable and worth the effort for mechanized logging businesses.

LITERATURE CITED

Abbas, D., R. Handler, B. Hartsough, D. Dykstra, P. Lautala, and L. Hembroff. 2014. A survey analysis of forest harvesting and transportation operations in Michigan. Croatian Journal of Forest Engineering. 35(2):179–192.

Allred, S.B. 2009. Logging firm succession and retention. Forest Products Journal. 59(6):31-36.

Allred, S., C. Michler, and C. Mycroft. 2011. Midwest logging firm perspectives: Harvesting on increasingly parcelized forestlands. International Journal of Forestry Research. 2011:1-7.

Armstrong, J.S., and T.S. Overton. 1977. Estimating nonresponse bias in mail surveys. Journal of Marketing Research. 14: 396-402.

Bennett, K.P. editor. 2010. Good forestry in the granite state: Recommended voluntary forest management practices for New Hampshire (second edition). University of New Hampshire Cooperative Extension, Durham, N.H. 224p.

Blinn, C.R., T.J. O'Hara, D.T. Chura, and M.B. Russell. 2015. Minnesota's logging businesses: An assessment of the health and viability of the sector. Forest Science. 61(2):381-387.

Butler, B. 2008. Forest ownership patterns are changing. National woodlands. Spring 2008. Available online at nrs_2008_butler_001.pdf (usda.gov); last accessed April 25, 2023.

Conrad, J.L. 2014. Adapting to a changing landscape: How Wisconsin loggers persist in an era of parcelization. Forest Products Journal. 64(7/8):273-280.

Conrad, J.L., W.D. Greene, and P. Hiesl. 2018. A review of changes in US logging businesses 1980s-present. Journal of Forestry. 116(3):291-303.

Cubbage, F.W.1983. Tract size and harvesting costs in southern pine. Journal of Forestry. 81(7):430-433.

Cubbage, F.W. 2004. Costs of forestry best management practices in the South: A review. Water, air and soil pollution: Focus. 4(1):131-142.

Dillman, D.A. 2000. Mail and internet surveys: The tailored design method. 2nd ed. Wiley, New York. 464p.

Ellefson, P.V., and P.D. Miles. 1985. Protecting water quality in the Midwest: Impact on timber harvesting costs. Northern Journal of Applied Forestry. 2(6):57-61.

Egan, A., and D. Taggart. 2004. Who will log? Occupational choice and prestige in New England's north woods. Journal of Forestry. 15(6):20-25.

Greene, W.H.1993. Econometric analysis. 2nd ed. New Jersey: Prentice-Hall International, Inc. 791p.

Goergen, M., J. Harding, C. Owen, M. Rey, and L. Scarlett. 2013. The state and future of U.S. forestry and forest industry. Available online at the-state-and-future-of-the-u.s.-forest-industry.pdf (usendowment.org); last accessed April 28, 2022.

He, M., M. Smidt, W. Li, and Y. Zhang. 2021. Logging industry in the United States:

Employment and Profitability. Forests 2021, 12, 1720. https://doi.org/10.3390/f12121720.

Keefer, M.J., J.C. Finley, A.E. Luloff, and M.E. McDill. 2003. Understanding loggers' perceptions. Journal of Sustainable Forestry. 17(3):81-102.

LeBel, L.G., and W.B. Stuart. 1998. Technical efficiency evaluation of logging contractors using a nonparametric model. Journal of Forests Engineering. 9(2):15-24.

Leon, B.H., and J.G. Benjamin. 2012. A survey of business attributes, harvest capacity and equipment infrastructure of logging businesses in the Northern Forest. The University of Maine School of Forest Resources. 29p.

Loving, E. 1991. Components of logging costs. Ms. Thesis, Virginia Polytechnic Institute and State University, Blacksburg, VA. 205p.

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

Michigan State University Extension. 2022. Forest basics-Michigan forest history. Available online at https://mff.forest.mtu.edu/PDF/1-TreeBasics/3-History.pdf; last accessed April 24, 2023.

Milauskas, S.J., and J. Wang. 2006. West Virginia logger characteristics. Forest Products Journal. 56(2):19-24.

Montgomery, R.A., M.H. Pelkki, and S.R. Mehmood. 2005. Use and cost of best management practices (BMPs) and BMP-related sustainable forestry initiative guidelines to Arkansas timber producers. Forest Products Journal. 55(9):67-73.

Oswalt, S.N., W.B. Smith, P.D. Miles, and S.A. Pugh. 2019. Forest resources of the United States, 2017. A technical document supporting the Forest Service 2020 RPA assessment. US Forest Service General Technical Report WO-97. 223p.

Rickenbach, M., and T.W. Steele. 2005. Comparing mechanized and non-mechanized logging firms in Wisconsin: Implications for a dynamic ownership and policy environment. Forest Products Journal. 55(11):21-26.

Rickenbach, M., T.W. Steele, and M. Schira. 2005. Status of the logging sector in Wisconsin and Michigan's Upper Peninsula, 2003. The University of Wisconsin Extension, Madison, WI. 40p.

Rickenbach, M., and T.W. Steele. 2006. Logging firms, nonindustrial private forests, and forest parcelization: evidence of firm specialization and its impact on sustainable timber supply. Canadian Journal of Forest Research. 36:186-194.

Rickenbach, M., M. Vokoun, and S. Saunders. 2015. Wisconsin logging sector: Status and future direction. The University of Wisconsin Extension (G4073), Madison, WI. 23p.

Room, J., R. Tuazon, and C. Washburn. 1987. Relating forestry investment to the characteristics of nonindustrial private forestland owners in northern California. Forest Science. 33(1):197-209.

Row, C.1978. Economics of tract size in timber growing. Journal of Forestry. 76(9):576-582.

Stearns, F.W. 1997. History of the Lake States forests: Natural and human impacts. Available online at Stearns2.PDF (fs.fed.us); last accessed November 15, 2021.

Straka, T.J., H.W. Wisdom, and J.E. Moak. 1984. Size of forest holding and investment behavior of nonindustrial private owners. Journal of Forestry. 82(8):495-496.

Taggart, D., and A. Egan. 2011. Logging across borders and cultures: An example in Northern Maine. Forest Products Journal. 61(7):561-569.

US Forest Service, Forest Inventory and Analysis. 2017. EVALIDator web-application Version 1.6.0.03a. Available online at http://apps.fs.fed.us/Evalidator/evalidator.jsp; last accessed 7/18/2022.

Zhang, D., and P.H. Pearse. 2012. Forest economics. UBC Press. Vancouver, BC. 390p.

CHAPTER 4. ASSESSING THE WOOD BASKET AND CHARACTERIZING MICHIGAN'S LOGGING BUSINESSES BY THEIR RELIANCE ON NONINDUSTRIAL PRIVATE FORESTS FOR STUMPAGE

4.1 Abstract

This study delineates the procurement areas for individual logging businesses to create a combined wood-basket for 115 logging businesses in Michigan using a road transportation network dataset and information collected from a mail survey of logging businesses. Forest ownership and forest condition datasets are used to understand the status of timber resources and the reliance of logging businesses on different forest-ownership types for stumpage. Information about competition hotspots and status of timber resources can be useful for logging businesses when navigating market dynamics and is important for sustainable management of forest resources, too. Based upon their level of reliance on nonindustrial private forests (NIPFs) for stumpage, the logging businesses are classified as NIPF-dependent and nondependent businesses, and similarities and differences between the two groups are explored. This is important as NIPF ownership is the major forest-ownership type in Michigan.

Relatively less competition for timber resources was noted in 15% of total forest acres present in the wood-basket (five or fewer businesses competing in the same area) while high competition was noted in one percent of it (more than 20 businesses competing in the same area). The net annual growth-to-removals ratio in the wood-basket ranged from 5.0 to 1.2 depending upon forest ownership types, suggesting that increased harvests from all ownership types in the future may not be equally sustainable. NIPF-dependent and nondependent businesses varied in terms of volume-harvested, equipment-used, and methods employed for acquiring stumpage, but had similar self-indicated profit levels.

Keywords: Procurement area, logging contractors, NIPF dependency

4.2 Introduction

Forests cover more than half of Michigan's land area (54%), and the forest products industry is an important part of the state's economy supporting over 91,000 total jobs and contributing more than $20 billion in total output in Michigan (Leefers et al. 2020). Logging businesses are a key component of the forest products industry supply chain and connect forest resources with wood processing facilities (mills). They are also the primary

implementors of forest management prescriptions, and their actions in the forests help shape forest structure and composition for present and for future use (Allred et al. 2011). There are more than 800 logging and trucking businesses, about 300 primary manufacturers, and over 1,000 secondary manufacturers in Michigan (Michigan DNR 2023).

The change in market demand for forest products as well as modifications in ownership patterns (in terms of ownership size and ownership type) for forests on which the loggers rely can have an impact on how they operate, where they operate, and the profit levels that loggers obtain from their logging business (He et al. 2021, Allred et al. 2011, Sinclair et al. 1985). Forest management objectives vary for different forest ownership types and influence the amount of timber that can be harvested from the forests. Besides ownership, the condition of forest resources in the loggers' procurement areas also determines the kind of management prescriptions undertaken and the products generated. Hence, ownership and timber resource conditions both influence productivity and profit potential for logging businesses. The information about condition of timber resources and ownership in the loggers' procurement areas is important for understanding the viability of the logging industry at present and for predicting their future potential. Besides, this information is crucial for sustainable management of forest resources.

Forest conditions, ownership, and loggers' operating systems are evolving with time. Since the 1980s, there has been a considerable increase in forest acreage with large diameter trees (trees greater than 10 inches) in Michigan while the forest with medium and small diameter trees has declined (Pugh 2018). Mature forests offer different management opportunities to harvest timber, manage old growth attributes, or improve structural diversity (Michigan SAF 2022). Such forests also offer an opportunity for regeneration of young forest stands following harvest (Michigan SAF 2022). Forest ownership has changed over time due to the vertical disintegration of the forest products industry and parcelization of forest lands. Between 2005 and 2006 more than one million acres of corporate private forestlands changed ownership from vertically integrated forest products industries to timber investment management organizations (TIMO) and real estate investment trusts (REIT) in the Upper Peninsula region of Michigan (Froese et al. 2007). Approximately 8.7 million acres of timberland in Michigan were owned by 334,658 nonindustrial private forest (NIPF) landowners in 1994 (Leatherberry et al. 1998). By 2022, the number of NIPF landowners in

the state increased to 498,000 (Stampfly and Lueckel 2023) with an almost static forestland acreage. This trend has led to parcelization of NIPF lands within the state; it is expected to continue in the future. Some of the common reasons for forest parcelization include intergenerational transfer of ownerships, property and estate taxes, real estate markets, urbanization, and demand for recreation (Solomon 2012). At present, approximately 61% of the total forest area in Michigan (20.2 million acres) is under private ownership, 70% of which is under NIPF ownership (USDA Forest Service 2020).

Past studies have noted increased timber production costs associated with decreased forest tract size because of diminished timber harvesting economies of scale (Moss and Hedderick 2012, Greene et al. 1997, Cubbage 1983, Row 1978). Similarly, change in forest ownership type along with the tract size can alter management focus for a tract of forest (Hoover and Riddle 2021, DeCoster 1998), hence impacting the amount of timber that can be harvested from that forest. On the other hand, changes in how logging businesses operate, in terms of the equipment used, can have implications for where they choose to operate. For instance, studies in the Lake States have noted the difference in the source of timber for mechanized vs chainsaw-based logging businesses with the former focusing more on public forests and the latter focusing more on private forests, particularly those owned by NIPFs (Rickenbach et al. 2015, Blinn et al. 2015).

Besides changes in forest conditions and forest ownership patterns across the state, a noticeable change has also occurred in the way that logging businesses operate. Compared to logging businesses a few decades ago, many businesses today use mechanized harvesting equipment, such as cut-to-length harvesters and feller-bunchers for harvesting timber (Conrad et al. 2018, Rickenbach et al. 2015, Abbas et al. 2014). Mechanization of logging equipment has transformed the logging industry from labor-intensive to capital-intensive operations (Rickenbach and Steele 2005). With the reduction in the average forest tract size owned by private forest landowners (particularly NIPF forest owners) and an increase in the mechanization of harvesting equipment, there remains a question about the economic feasibility of conducting timber harvests on smaller-sized forest parcels. Harvesting costs on smaller-sized forest parcels increase when using mechanized felling equipment because of high moving and setup costs as well as high hourly fixed costs (Moss and Hedderick 2012, Greene et al. 1997). Rickenbach and others (2005) noted that for a timber sale to be profitable

in Wisconsin, the harvest tract size may need to be 20 acres or greater. Similarly, the logging businesses in Michigan indicated that the minimum forest tract size that they are willing to bid on is 22 acres (Abbas et al. 2014). However, others have noted that properly equipped loggers can profitably harvest smaller-sized forest parcels (Conrad 2014) and that the quality of timber present in a forest stand is a more important determinant of a logger's decision of whether to conduct a timber harvest on a smaller-sized forest parcel (Moss and Hedderick 2012, Kittredge et al. 1996).

Given the trends of forest parcelization and mechanization of logging businesses, Allred et al. (2011) conducted a mail survey of logging businesses in the north central region of the U.S. to understand how such trends impacted logging business and to explore the relationship between the profitability of a logging business and ownership type as well as forest tract size. The authors did not note a consistent view among logging businesses regarding the impact of urbanization and parcelization on their logging businesses. Some logging businesses viewed urbanization and parcelization as significant issues facing their business, while others did not. In general, the profitability of a logging business was found to increase with increasing size of timber sale. For smaller-sized timber sales, the profitability of a logging business decreased with increasing reliance on public forests for stumpage, meaning that smaller-sized timber sales were more profitable on private forestlands (Allred et al. 2011). Additionally, non-mechanized logging businesses in the study region were noted to be significantly better able to conduct timber sales profitably on small-(20 acres or less) and medium-sized forest tracts (21 to 80 acres) compared to mechanized logging businesses (Allred et al. 2011). Rickenbach and Steele (2006) looked at the wood basket of logging businesses in northern Wisconsin and Michigan's Upper Peninsula to understand whether there were structural differences between businesses that were more dependent on one ownership type for stumpage versus multiple types of ownership. The authors noted that logging businesses that relied heavily on NIPFs for stumpage took fewer jobs, cut on smaller acreages, and cut less timber-but were more likely to do that profitably than the businesses that obtained stumpage from tracts under different types of ownership structure (Rickenbach and Steele 2006).

Most studies that assess the wood basket and harvest conditions of logging businesses in the Lake States region and beyond (Conrad et al. 2018, Barrett et al. 2017, Rickenbach et

al. 2015, Blinn et al. 2015, Allred et al. 2011, Rickenbach and Steele 2006) rely on data collected either through mail surveys of logging businesses or in-person interviews with logging business owners. Rickenbach and Steele (2006) asked logging business owners in northern Wisconsin and Michigan's Upper Peninsula to indicate the counties they operated in and used forest ownership information in those counties to identify the wood basket of respondent logging businesses. The authors did not consider transportation logistics when delineating the wood basket of logging businesses in their study. More recently, studies have used GIS software and road network datasets to delineate the procurement area of forest products industries. For instance, Pokharel and Latta (2020) and Pokharel et al. (2022) outlined the procurement areas of timber milling facilities in the U.S. using the travel time derived from road network datasets and associated road speed information using GIS. The authors then used service area information of timber milling facilities to identify areas with high versus low merchantability of forest resources and competition among facilities for timber procurement. Using available road network and associated speed limit information allows users to estimate service areas more realistically than just using aerial distance or road distance as per the authors (Pokharel and Latta 2020).

Using the available road transportation network dataset for the state of Michigan and indicated average travel distances of logging business to the harvest sites, our study aims to delineate the wood basket for 115 logging businesses in Michigan. The wood baskets for individual logging businesses are then merged to generate the combined wood basket for all logging businesses and areas with high versus low competition for timber resources identified. The information about competition for timber resources among logging businesses and condition of resources in the wood basket can provide useful insights into existing logging businesses and help them better understand and navigate market dynamics. Such information can also be useful for those considering new investments in logging businesses and can be crucial for forest stewards to sustainably manage resources for present and for future use.

Our study also aims to assess whether there are any structural differences between logging businesses that rely heavily on NIPFs for stumpage (which is the major forest ownership type in Michigan) versus those that rely on more diversified ownership types for timber. This information can be useful for understanding how changes in logging businesses may impact forest management operations in different ownership types and vice versa.

The objectives of the study are:

- To assess the wood basket of Michigan's logging businesses, including the status of timber resources and reliance of logging businesses on different forest ownership types for stumpage.
- To identify the areas with high versus low competition for timber resources in the wood basket of loggers.
- To explore the similarities and differences between logging businesses that are heavily reliant on nonindustrial private forests for stumpage versus those that rely on more diversified ownership types for stumpage.

4.3 Study Area

Michigan has approximately 20.2 million acres of forestland, the majority of which (61%) is under private ownership (USDA Forest Service 2020). Approximately 20% of the forestland is owned by state and local government and 15% by federal government (USDA Forest Service 2020). Over 70% of forest area under private ownership in Michigan is under NIPF ownership (USDA Forest Service 2020), making this group an important source of timber in the state. The average ownership size of NIPFs in Michigan is 27 acres. Forestland as well as forest ownership types are not distributed evenly across the state (Michigan SAF 2022). Most of Michigan's forests are in the northern two-thirds of the state (Figure 4.1). The Upper Peninsula region accounts for 29% of the state's land area but holds 45% of the state's forests. The Southern Lower Peninsula is the largest region with 14.8 million acres, but accounts for only 18% of the state's forests, and the Northern Lower Peninsula has 37% of Michigan's forests (USDA Forest Service 2018). Hardwood forests are the most common forest types found in Michigan, accounting for close to 75% of the state's forests; the remainder are upland and swamp conifers. The two major forest type groups in Michigan are maple-beech-birch (also referred to as the northern hardwoods) and aspen-birch (Pugh 2018).

4.4 Materials and Methods

4.4.1 Data

Logging business characteristics and other related information within the state was collected through a mail survey of logging business owners in Michigan administered in 2017 following Dillman's tailored design method (Dillman 2000). The mailing list of logging

business owners in Michigan was compiled using data maintained by the Michigan Department of Natural Resources (DNR) and the Michigan Forest Products Council. The survey was sent to 1,085 logging businesses and information was obtained on the location of logging businesses (business address), owner and/or manager characteristics, equipment mix, average travel distance to harvest sites, percentage of total volume harvested from different ownerships, types of products harvested, perceived profitability, and whether the business operated at its full operational capacity in 2016.

Logging businesses were asked to indicate their average travel distance to harvest sites on a scale ranging from 1 to 6 (1 meaning 30 miles or less, 2 = 31 to 60 miles, 3 = 61 to 90 miles, 4 = 91 to 120 miles, 5 = 121 to 150 miles and 6 = more than 150 miles). To assess the difference in perceived profit levels, the respondent logging businesses were asked to indicate their self-rated profit level on a five-point Likert scale ranging from 1 (very poor) to 5 (excellent). To understand their operational capacity, the respondent businesses were asked to indicate if they operated at full capacity, meaning that no additional volume could be produced, given their equipment and labor availability as well as weather and site conditions. All businesses were asked to report their self-assessment for 2016 calendar year. Detailed information about the logging survey methods and the data collected can be found in Gc et al. (2020).

To identify the wood basket or wood procurement area for a logging business, the road transportation network dataset for Michigan was obtained from the Michigan GIS open data available from the Michigan Department of Transportation (2022), and the forest ownership types geospatial data was obtained from Sass et al. (2020) (Figure 4.1). A working relationship was established with personnel at USDA Forest Service, Northern Research Station (J.J. Holgerson in April/May 2022) to obtain information about timber volume, growth, and removals data in the wood basket. Though timber volume, growth and removals data collected by the U.S. Forest Service is publicly available through the FIA Datamart (USDA Forest Inventory and Analysis DataMart 2023), it does not breakdown the data for private forestlands into corporate and nonindustrial private ownership categories. Therefore, to obtain the detailed information on different types of private owners using actual FIA plot data, the working relationship with Forest Service personnel was made. We provided the contacted personnel at Forest Service with the geospatial data which was then overlaid with

the actual FIA plot data to estimate timber statistics within the wood basket of logging businesses in Michigan. We also obtained the location and capacity information of primary wood processing facilities in Michigan from Michigan DNR (Michigan DNR 2018).

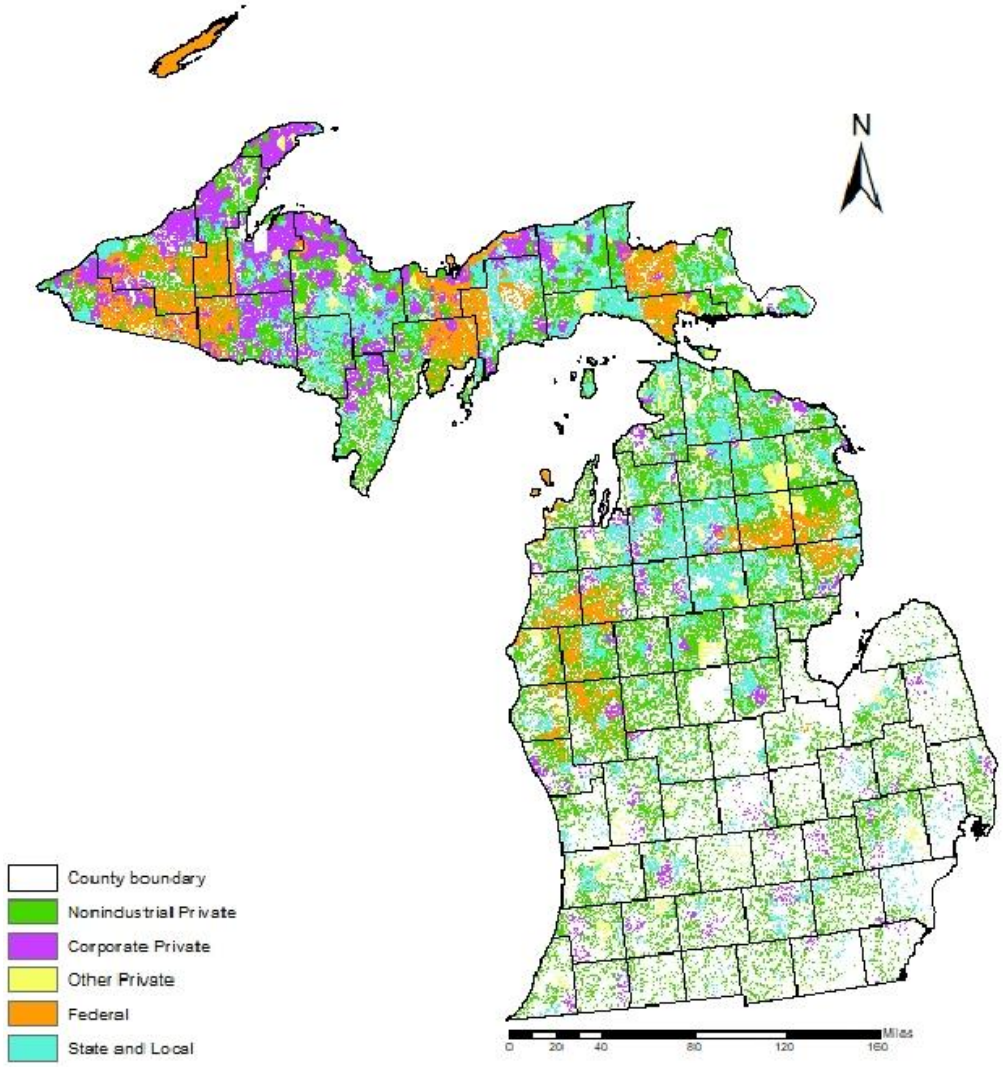


Figure 4.1 Michigan's forests by ownership type (Data source: Sass et al. 2020).

4.4.2 Identifying the wood basket of logging businesses.

Out of the total surveys mailed to logging businesses in Michigan, 115 logging businesses provided information about their business location and average one-way travel distance to the harvest sites. The locations of these respondent logging businesses were geocoded, and the information about their average travel distances to harvest sites and road

network data for Michigan were used in the 'Network Analyst' extension in ArcGIS to generate service area delineations for each logging business (Pokharel and Latta, 2020, Pokharel et. al. 2022, ESRI 2021). The average travel distance to harvest site reported by the respondent logging businesses in the survey was used to map wood procurement zones for each logging business. If a logging business indicated its average travel distance to harvest sites was 30 miles or less, then the wood procurement zone for that business were generated using 30 miles. Similarly, if the logging business indicated their average travel distance to harvest sites was 31-60, 61-90, 91-120, 121-150 miles, we used 60, 90, 120, and 150 miles, respectively, to draw the wood procurement area polygons for individual businesses. Then the wood procurement zones were merged for all logging businesses to represent the wood basket for the logging industry in Michigan (Figure 4.2).

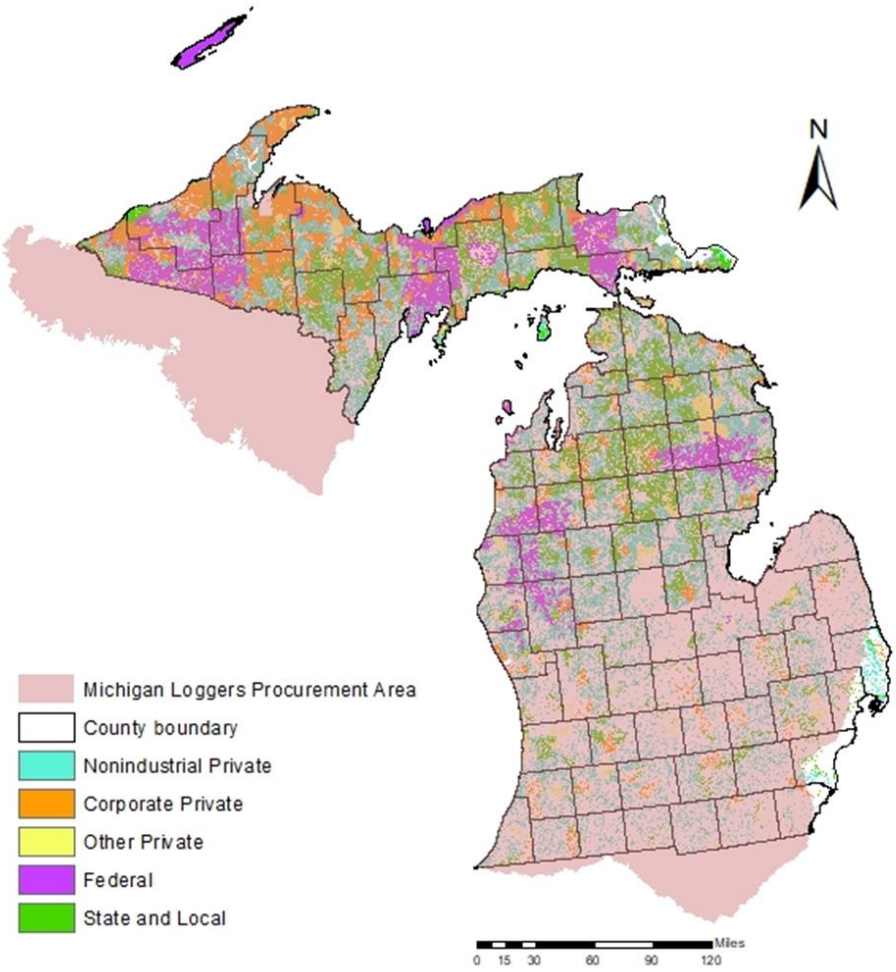


Figure 4.2 Wood basket of Michigan's logging businesses with forest ownerships in the background.

Overlapping areas were identified to generate a competition "hotspot" map for all respondent logging businesses in Michigan (Figure 4.3). There was at least one logging business operating at any location in the wood basket and at most 24 logging businesses operating in the most competitive areas in the wood basket. To simplify and to generalize the competition categories and convert them into acceptable geographic ranges for the U.S. Forest Service (USFS) to estimate the timber volume and other variables, we created five competition indices. The competition index indicates the number of respondent logging businesses competing for forest resources at a given location. Competition index 1 (CI-1) represents a zone of competition among logging businesses where at least 1 and at the most 5 logging businesses compete for timber resources. CI-2 is a zone where 6 to 10 logging businesses operate. CI-3 represents a zone where 11 to 15 logging businesses operate. CI-4 represents the hotspots of competition where 16 to 20 logging businesses operate, and CI-5 represents competition hotspots where more than 20 logging businesses compete for forest resources.

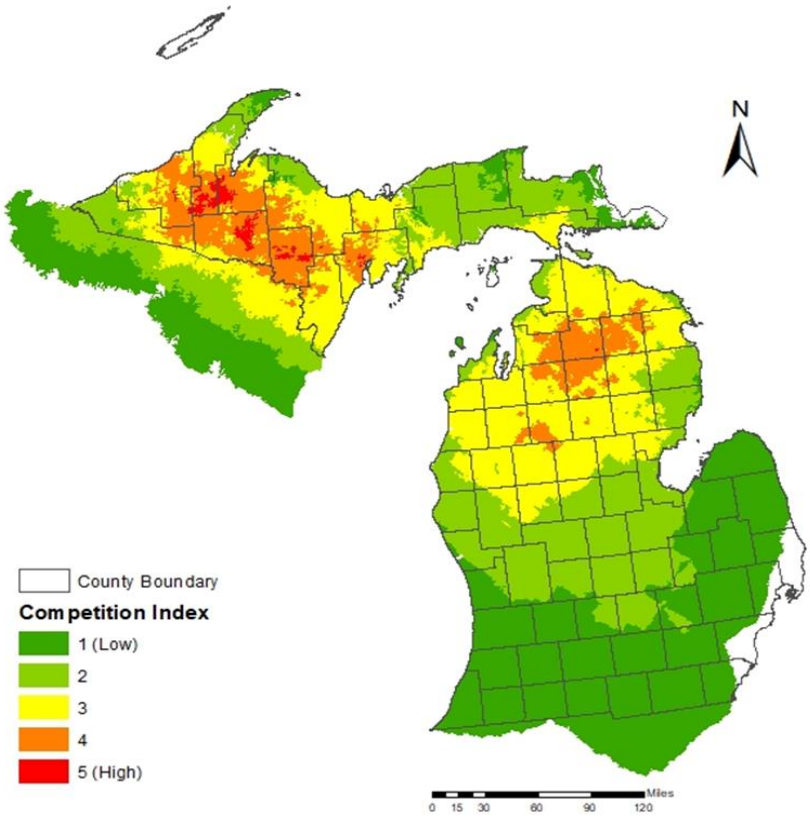


Figure 4.3 Wood basket of Michigan's logging businesses showing areas with high versus low competition for resources.

4.4.3 Estimation of wood products in wood basket.

The wood basket and the competition hotspot maps were then sent to the USFS, along with the R-script needed to run rFIA (Stanke et al. 2020) on the 2019 FIA data to estimate wood volume, growth, removals, and mortality in the wood basket and competition hotspots. FIA completed the analyses based on confidential FIA plot data. This allowed us to estimate the volume, growth, removals, and mortality for subcategories of private landowners using accurate locations for FIA plots.

4.4.4 Categorizing logging businesses based upon their level of dependence on NIPFs for stumpage.

Based upon their level of reliance on NIPFs for stumpage, the respondent logging businesses were categorized as NIPF dependent and nondependent businesses. For this, the method proposed by Rickenbach and Steele (2006) was adopted. In their 2006 study of logging businesses in northern Wisconsin and Michigan's Upper Peninsula, Rickenbach and Steele estimated a harvest concentration ratio (HCR) for logging businesses to identify their level of reliance on different forest ownership types for timber supply. HCR in their study was estimated by dividing the percentage of a logging business's production harvested from a particular forest ownership category by the presence of that forest ownership category in the logging business's wood basket (Equation 1).

$$H_{j,i} = Q_{j,i}/B_{j,i} \quad (1)$$

where $H_{j,i}$ is the HCR of logging business ***j*** for the ***ith*** forest ownership category, $Q_{j,i}$ is the percentage of total indicated production of business ***j*** from the ***ith*** ownership category, $B_{j,i}$ is the percentage of the ***ith*** ownership category present in the wood basket of business ***j,*** and ***i*** is NIPF, public, and industrial-corporate forest ownership types (Rickenbach and Steele 2006). A logging business that harvests from an ownership category in equal proportion to the presence of that ownership category in its wood basket has an HCR of 1. For instance, an HCR of 1 for NIPF ownership means that the percentage of total production from NIPF ownership is equal to the percentage of NIPF ownership present in the respondent's wood basket. HCR greater than 1 indicates that the percentage of total production from NIPF ownership exceeds the percentage of NIPF ownership present in the wood basket and HCR less than 1 shows the percentage of production from NIPF ownership to be less than the

presence of this ownership in the wood basket. HCR can thus, be used to identify logging businesses that specialize in the harvests of NIPFs (Rickenbach and Steele 2006). To further assess the dependence of logging businesses on NIPF ownership, Rickenbach and Steele (2006) outlined two criteria, first a logging business's HCR for NIPF ownership should be greater than that for all other ownership categories. Second, a logging business's HCR for NIPF ownership should be greater than the median NIPF HCR in the study area. The similar approach was adopted to classify logging businesses as NIPF dependent and nondependent businesses in our study. We estimated HCRs for respondent logging businesses for different ownership categories (NIPFs, public, and industrial-corporate private). The percentages of total indicated production of a particular logging business from different ownership categories was obtained from the mail survey of logging businesses. The percentage of different ownerships present in the wood basket of a logging business was obtained by overlaying the individual wood basket polygons with the forest ownership data layer and querying the area under each ownership category using the 'Spatial Analyst' tools in ArcGIS. Like Rickenbach and Steele's (2006) study, we used forestland area under different ownership categories as a proxy for the availability of stumpage from different ownership categories in the wood basket. Though timberland area would have given a better representation of available stumpage compared to forestlands, we used the latter due to its availability as a raster dataset.

After categorizing the logging businesses as NIPF dependent and nondependent, we conducted comparative analyses to assess the similarities and differences between the two groups in terms of owner and business characteristics, products harvested, and self-indicated profit levels obtained using t-tests, Mann-Whitney U tests, and Pearson's chi-square tests of independence depending upon data distribution. The significance of all statistical tests was set at an alpha of 0.05.

4.5 Results

4.5.1 Wood basket and competition hotspots of logging businesses

The total forest area in the combined wood basket of 115 logging businesses (Figure 4.2) was found to be over 22 million acres, including forestlands from the adjoining state of Wisconsin. Within Michigan, close to 18 million acres of forestlands made up the wood basket of respondent logging businesses. About 63% of the forest acres in the loggers' wood basket were owned by private forest landowners (68% of which were owned by NIPF

owners), 23% by the state and local government, and 14% by federal government. The annual net growth (growth minus mortality) of merchantable bole volume of growing stock trees in the wood basket was 715 million cubic feet. Annual removals were close to 310 million cubic feet, and mortality was approximately 322 million cubic feet (USFS FIA 2019). Net growth was more than double the removals (2.3), meaning that sustainability in resource use in loggers' wood basket was not a concern in Michigan at the time of the study. Average annual net growth, removals, and mortality in loggers' wood basket varies by forest ownership categories (Figure 4.4). The annual net growth to removals ratio (GRR) in nonindustrial private forests in the wood basket was 2.5, indicating that growth in these forests were two and a half times more than the removals (Figure 4.4). The GRR for corporate private forestlands was 1.2 whereas it was 5.0 for other private ownerships. Other private ownership includes forestlands under unincorporated organizations such as nonprofit organizations.

Our findings reveal that corporate private ownerships in the wood basket were removing almost at the level of growth while other private landowners were removing or harvesting only about one fifth of the total growth. GRR was 4.3 in federally owned forestlands and 2.4 in the state and locally owned forestlands. Apart from the corporate private ownership, mortality was higher than removals in all other ownership types in the wood basket. These figures highlight the intensity of forest management in forestlands owned by different forest ownerships. Out of all forest ownership types, corporate private forest landowners seemed to manage their forests more intensively compared to others. Past studies of NIPF landowners in Michigan and elsewhere across the country (Butler et al. 2021, Huff et al. 2019, Kuipers et al. 2013) note nonmonetary amenity benefits such as privacy, scenery, maintenance of wildlife habitat, and biodiversity conservation to be the important reasons for forest ownership for these landowners. Nonetheless, a little over 40% of NIPF owners across the country have conducted timber harvests on their property in the past (Huff et al. 2019). It is, therefore, not a surprise to see growth in excess of removals in NIPFs. High growth to removals ratios in federally owned forestlands and those under the other private ownership category highlight laissez faire management strategy adopted by these ownerships. Contrary to this, corporate private forest owners manage their forests to optimize financial returns from it (Hoover and Riddle 2021), and removals from these forests are almost at the levels of growth in the wood basket.

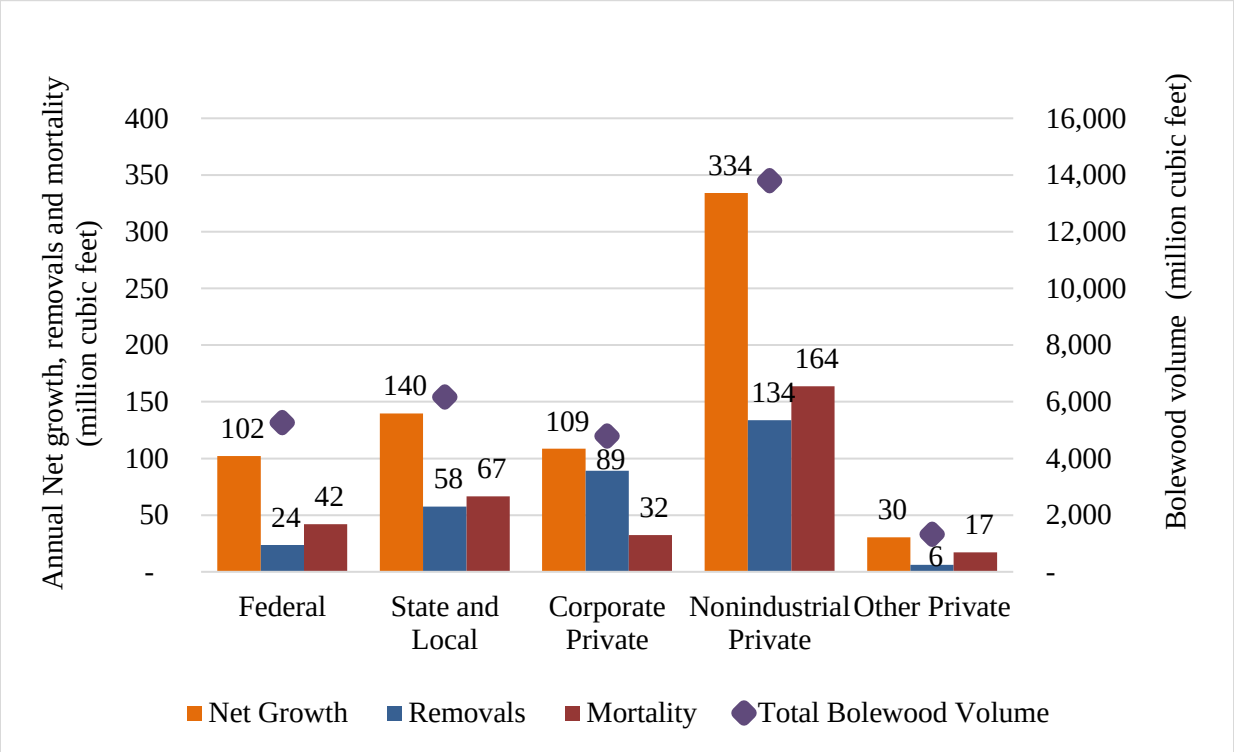


Figure 4.4 Annual net growth, removals, and mortality of merchantable bole volume of growing stock trees along with the total bole wood volume in the wood basket of Michigan's logging businesses by ownership.

Approximately 15% of the total forestlands in the wood basket (~2.63 million acres) of all respondent logging businesses were in the lowest competition zone with CI-1. One percent of forestlands (0.25 million acres) were identified in the competition hotspot with CI-5, where more than 20 logging businesses competed for timber resources. Twenty-nine percent of the forestlands (5.21 million acres) were in CI-2, 39% (7.03 million acres) were in CI-3, and 16% of forestlands (2.86 million acres) were in CI-4. For each competition index, the total forest area by forest ownership type, bole volume, and average annual net growth to removals ratios were estimated (Table 4.1).

Regionally, higher levels of competition were noted in the Western Upper Peninsula (WUP) and the upper portion of the Northern Lower Peninsula (NLP) regions of the state. This makes sense because many large and medium sized sawmills as well as pulp mills, energy mills and pellet producing facilities in Michigan are situated in these geographic regions (Figure 4.5) (Michigan DNR 2018). In 2018, primary mills located in the WUP of

Michigan processed approximately 226.5 million board feet of timber, those located in the Eastern Upper Peninsula (EUP) processed 56.8 million board feet, mills in the NLP processed 533.3 million board feet, and those in the Southern Lower Peninsula region of the state processed 162.4 million board feet of timber (Michigan DNR 2018). The Western Upper Peninsula and the Northern Lower Peninsula regions also harbor disproportionately high amounts of forestlands in the state (Pugh 2018).

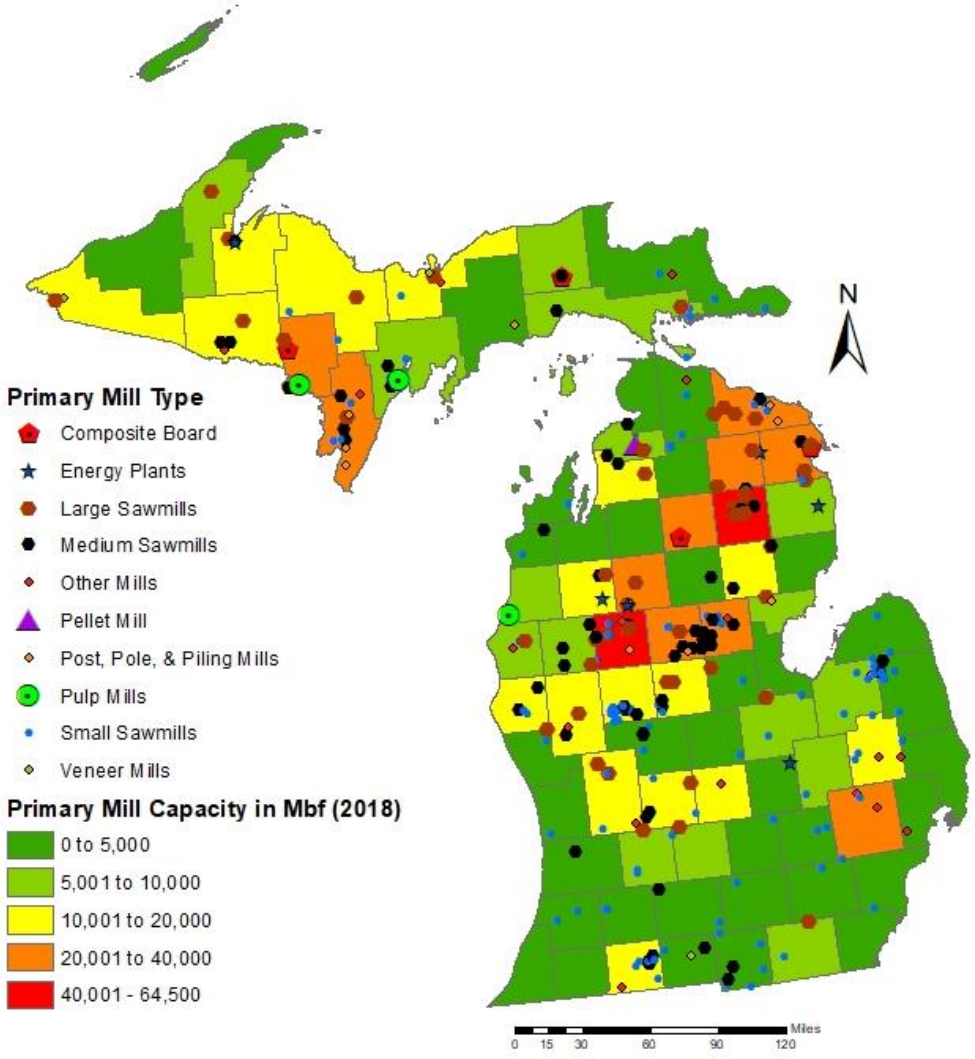


Figure 4.5 Map depicting the location of primary mills in Michigan and mill capacity expressed in thousand board feet (MBF) (Source: Michigan DNR 2023; Neumann and Haskill 2020).

Table 4.1 Forest area, ownership, bole volume, and net growth to removals ratio in the wood basket of Michigan's logging businesses disaggregated by competition indices.

Competition Index	Ownership	Area (Million acres)	Bole wood volume (Million cubic feet)	Net annual growth/removals
CI-1	Federal	0.02	28	
	State and Local	0.43	659	3.1
	Corporate Private	0.34	617	1.6
	Nonindustrial Private	1.70	3,352	4.3
	Other Private	0.14	306	25.0
	Total	**2.63**	**4,962**	**3.7**
CI-2	Federal	0.91	1,901	5.1
	State and Local	1.09	1,621	2.2
	Corporate Private	0.80	1,362	1.8
	Nonindustrial Private	2.23	4,013	2.2
	Other Private	0.18	305	2.5
	Total	**5.21**	**9,202**	**2.4**
CI-3	Federal	1.05	2,284	4.1
	State and Local	1.83	2,807	2.2
	Corporate Private	1.01	1,755	1.0
	Nonindustrial Private	2.86	4,781	1.9
	Other Private	0.28	535	4.0
	Total	**7.03**	**12,162**	**1.9**
CI-4	Federal	0.41	853	3.0
	State and Local	0.73	1,047	3.0
	Corporate Private	0.70	1,008	1.0
	Nonindustrial Private	0.91	1,504	2.8
	Other Private	0.11	189	
	Total	**2.86**	**4,600**	**2.1**
CI-5	Federal	0.09	205	16.7
	State and Local	0.03	46	
	Corporate Private	0.04	57	2.9
	Nonindustrial Private	0.10	150	5.8
	Other Private	0.00	-	
	Total	**0.25**	**458**	**7.7**

The annual net growth to removals ratio for merchantable bole volume of growing stock trees in forestlands with CI-1 was 3.7, CI-2 was 2.4, CI-3 was 1.9, CI-4 was 2.1 and CI-5 was 7.7. The considerably higher net growth to removals ratio in the highest competition category (CI-5) is most likely the result of a high percentage of federally owned forestlands (36%) present in this competition category. When looking at the levels of competition in forests owned by different forest ownership categories in the wood basket (Figure 4.6), a relatively greater percentage of forestlands under NIPF ownership had less competition for resources (22% of the area owned by NIPFs had a competition index of 1) compared to other ownership categories. One percent of total forestlands under federal ownership, 10% under state and local government ownership, and 12% under corporate private ownership had a competition index of 1 or were in the lowest competition zone. This means that compared to other forest ownership categories in the wood basket, a greater percentage of NIPF owners have limited opportunities for selling timber or conducting forest management prescriptions on their property as there are a limited number of logging businesses operating in these areas. Landowners located in the low competition zones will likely get less information on sales and prices from logging businesses compared to those located in high competition zones. For logging businesses, lower competition may mean that they have better bargaining opportunities with landowners and mills to increase their profits.

Approximately 25% of corporate private forestlands had a competition index of 4 or 5, meaning that these forestlands are in the hotspots of competition, which are higher than that for any other forest ownership category. Twenty-one percent of federally owned forestlands, 19% of state and local government owned forestlands, 15% of forestlands owned by other private ownerships, and 13% of NIPFs had a competition index of 4 or 5 (Figure 4.6). These higher competition areas are where forest landowners likely have better opportunities for negotiating with logging businesses when conducting timber harvests or other forest management prescriptions as there are fifteen or more logging businesses operating in these areas.

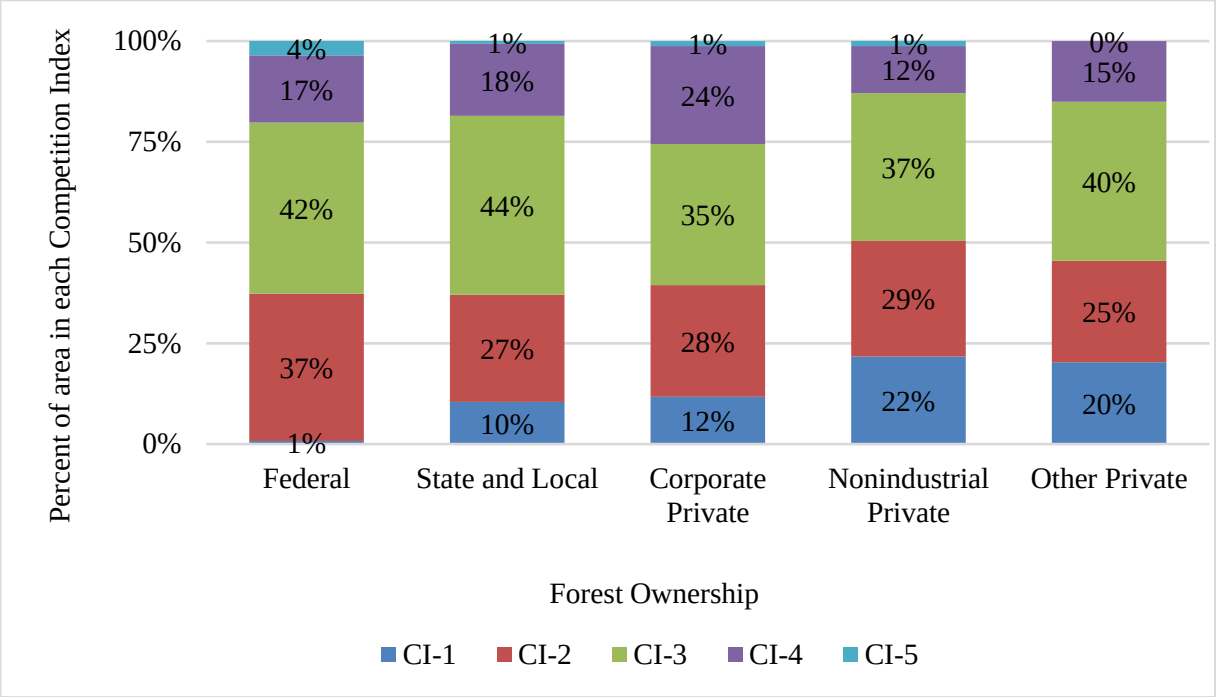


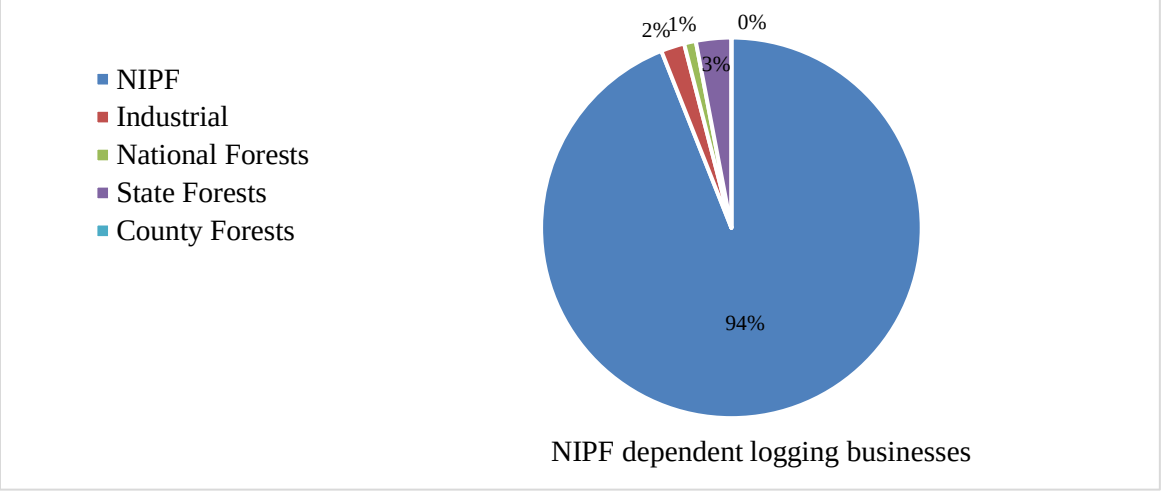
Figure 4.6 Percent of forestlands with different competition levels for Michigan's logging businesses disaggregated by ownership categories.

4.5.2 Comparative statistics for NIPF-dependent and nondependent logging businesses.

The median HCR for NIPF ownership was 1.4 with a range of 0 to 13. Fifty-six logging businesses had an HCR for NIPF ownership greater than 1.4, and more than that for any other ownership category, and hence were identified as NIPF dependent. Fifty-nine logging businesses had an HCR <= 1.4 and were identified as nondependent logging businesses. NIPF-dependent logging businesses obtained an average of 94% of their stumpage from NIPFs, while nondependent logging businesses obtained only 27% of their total production on average from NIPFs (Figure 4.7). Nondependent logging businesses exhibited reliance on more diversified ownership types for stumpage. Approximately 38% of the stumpage for nondependent logging businesses came from publicly owned forests, 34% from industrial private ownerships, and 27% from NIPFs (Figure 4.7).

Comparative analysis of owner and business characteristics for NIPF-dependent and nondependent logging businesses were then conducted (Table 4.2). A significant difference in average volume harvested was noted between NIPF-dependent and nondependent logging businesses (p=0.000) with NIPF-dependent businesses harvesting much less volume per business compared to nondependent logging businesses. On average, NIPF-dependent logging

businesses harvested 6,284 cords per business (median volume: 1,993 cords per business) while nondependent logging businesses harvested 15,163 cords per business (median volume: 10,000 cords per business). For nondependent logging businesses, just over half of the total timber volume harvested in 2016 was self-purchased by logging businesses while the remaining was purchased by mills or other brokers (Table 4.2). Compared to nondependent logging businesses, a significantly higher percentage of the timber harvested by NIPF-dependent logging businesses was self-purchased (p=0.012). Purchasing stumpage requires a logging business to invest a considerable amount of their finances in acquiring stumpage that could be invested otherwise, but it also offers greater flexibility in choosing where to harvest and negotiating the price with mills.



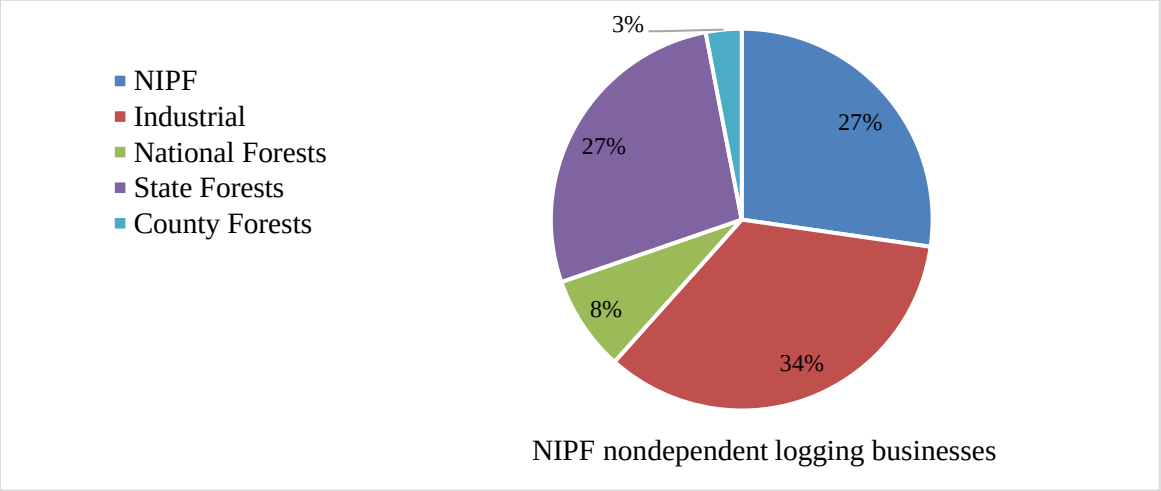


Figure 4.7 Source of stumpage for NIPF-dependent versus nondependent logging businesses in Michigan.

Compared to NIPF-dependent logging businesses, a significantly higher percentage of nondependent logging businesses used mechanized felling equipment such as cut-to-length harvesters, feller-bunchers, or a combination for harvesting stumpage (p=0.0340). Approximately 55% of NIPF-dependent logging businesses used mechanized felling equipment for harvesting timber compared to 77% of nondependent logging businesses who used such equipment (Table 4.2).

The location of businesses (Upper vs Lower Peninsula), years of operations, age of business owners, and years of experience in the logging business were not significantly different between NIPF-dependent and nondependent logging businesses. A slightly higher percentage of logging businesses located in the Lower Peninsula region of the state (64%) were identified as NIPF dependent compared to those in the Upper Peninsula of Michigan (46%). This seems logical since forests in the Upper Peninsula are dominated by federal, state, and corporate private ownerships (Figure 4.1). Both NIPF-dependent and nondependent logging businesses in Michigan have been in operation for an average of 25 years and are mostly family-owned businesses (over 65% of logging businesses in each category) with owners in their mid-50s (average age) who have 30 plus years of experience on average in the logging profession.

Table 4.2 Comparative analysis of owner and business characteristics for NIPF-dependent and nondependent logging businesses in Michigan.

Variables	**NIPF-Dependent Businesses**	**Nondependent Businesses**	**Test Statistics (p-value)**
Businesses located in the Upper Peninsula region of MI	46%	64%	Pearson Chi-square = 3.763 (*p*=0.052)
Median years in operation	27 years	23 years	Mann-Whitney U = 1624.00 (*p*=1.000)
Median volume harvested in 2016 (cords)	1,993	10,000	Mann-Whitney U = 688.00 (*p*=0.000)*
Businesses using mechanized felling equipment	55%	77%	Pearson Chi-square = 4.472 (*p*=0.034)*
Stumpage (mean %) that was self -purchased by logging business	70%	51%	Mann-Whitney U = 1840.50 (*p*=0.012)*
Mean age of the owners	54 years	53 years	T statistic = 0.680 (*p*=0.498)
Mean years of experience in logging business	31 years	30 years	T statistic = 0.467 (*p*=0.642)
Median travel distance to harvest site	30-60 miles	30-60 miles	Independent samples median test statistic = 1.064 Chi square= 0.567(0.452)
Median self-indicated profit levels	Average or Breakeven	Average or Breakeven	Independent samples median test statistic = 0.004 Chi square= 0.019(0.891)

*Significant at alpha level of 0.05.

The average one-way travel distance to harvest sites for both NIPF-dependent and nondependent logging businesses was found to be 30-60 miles; however, a considerably higher percentage of NIPF-dependent logging businesses (46%) said that they travelled fewer than 30 miles from their business location for harvesting stumpage as compared to

nondependent logging businesses (25%). When looking at the data provided by respondent logging businesses on number of harvests conducted in different forest acreage categories (0–5 acres, 6–10 acres, 11–20 acres, 21–40 acres, 41–80 acres, 81–160 acres, and more than 161 acres) in 2016, the most frequently harvested forest acreage category for NIPF-dependent logging businesses was smaller than that for nondependent logging businesses. For NIPF-dependent logging businesses, the most frequently harvested forest acreage category was 21–40 acres (for 61% of NIPF dependent logging businesses) followed by 11–20 acres (for 46% of NIPF dependent logging businesses). For nondependent logging businesses, the most frequently harvested forest acreage category was 81–160 acres (for 53% of nondependent logging businesses) followed by 41–80 acres (for 49% of nondependent logging businesses). No difference in the products or species harvested was noted between NIPF-dependent and nondependent logging businesses. Hardwood pulp was the major wood product category harvested by all respondent logging businesses, followed by hardwood sawtimber, irrespective of their dependence or non-dependence on NIPFs for stumpage. Aspen comprised about a quarter of the total volume harvested by all logging businesses, other hardwoods made up about 50% of the volume harvested and pine and other softwood species made up the remaining volume harvested.

The respondent logging businesses were asked to indicate their overall profit levels from logging jobs in 2016 using a five-point Likert scale ranging from 1 (very poor) to 5 (excellent). Overall, 41% of the NIPF-dependent and 35% of nondependent logging businesses said that they broke even or had an average profit level in 2016 (Figure 4.8). Thirty-two percent of both NIPF-dependent and nondependent logging businesses indicated their profits to be good or excellent, and the rest (27% of NIPF dependent and 33% of nondependent logging businesses) said that it was poor or very poor (Figure 4.8). No significant difference in self-indicated profit levels was observed between NIPF-dependent and nondependent logging businesses (Table 4.2). When looking at the ratings of self-indicated profit levels by average travel distance to harvest site, a noticeable pattern was observed where the percentage of logging businesses who said their profit levels were good or excellent declined with increasing average travel distance to the harvest site. Thirty-eight percent of the respondents whose average travel distance to harvest site was less than 30 miles said that their profit levels were good or excellent. A similar response was expressed by 27%

whose average distance to harvest site was 31–60 miles and 17% whose average travel distance to harvest site was 61–90 miles. None of the respondents indicated average travel distance to harvest site to be 91 to 120 miles or more than 150 miles and only one said that it was greater than 120 miles. For this respondent, the average profit level reported was good. The trend of declining profit levels with increasing travel distance to harvest site seems reasonable as equipment moving and transportation costs both increase with the increase in travel distance, thus reducing profit potential for logging businesses.

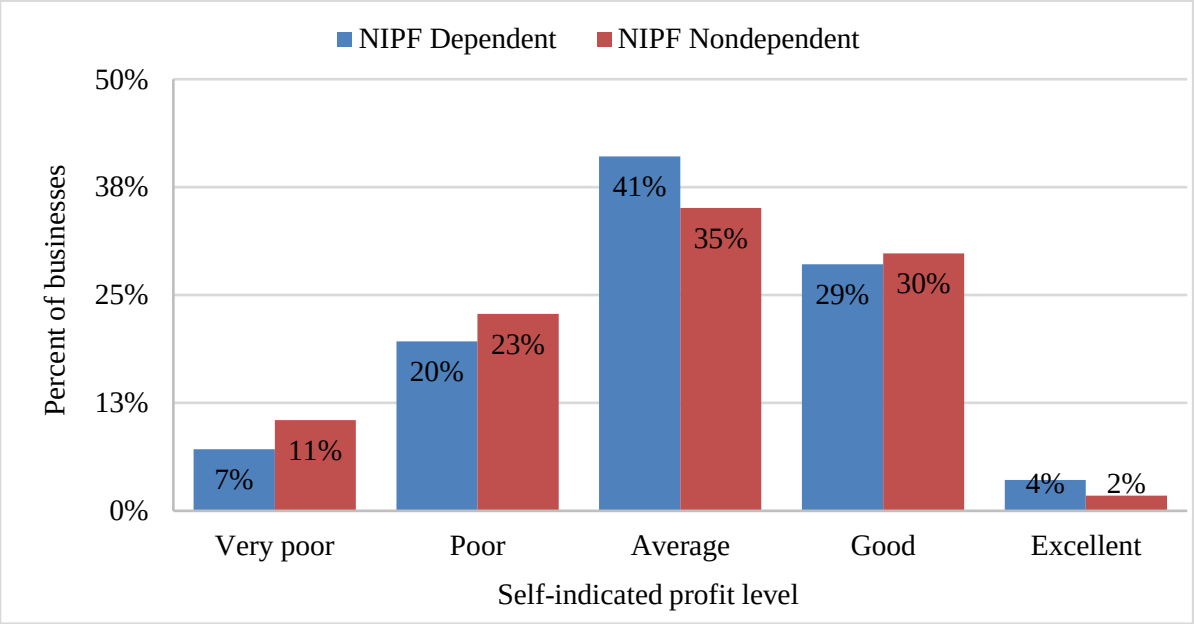


Figure 4.8 Self-indicated profit levels of NIPF-dependent versus nondependent logging businesses in Michigan.

4.5.3 Future of Logging Business in Michigan

The respondent logging businesses were asked to rank the top five major issues facing the future of logging businesses in Michigan. The top four concerns identified by both NIPF-dependent and nondependent logging businesses were identical and included mill prices, operating costs, insurance costs, and stumpage prices. The fifth most important issue facing the future of logging businesses for NIPF-dependent logging businesses was the availability of private stumpage for sale, while for nondependent logging businesses it was the replacement of aging logging equipment. Since a significantly higher percentage of nondependent businesses use mechanized felling equipment for harvesting timber compared

to NIPF-dependent logging businesses, greater concern about replacing aging equipment seems logical for this group. When asked if they would continue logging in the next five years, 73% of NIPF-dependent and 77% of nondependent logging business respondents indicated that they would continue logging in the future, with the remainder intending to exit from the market during that time. No significant difference in the percentage indicating plans to remain in business was noted between NIPF-dependent and nondependent logging businesses.

4.6 Discussion and Conclusions

Using the location information and indicated average one-way travel distance to the harvest site, this study mapped the procurement area of logging businesses in Michigan to have a better understanding about the condition of timber resources, ownership types, and competition prevalent among logging businesses within the state. It further classified logging businesses as NIPF-dependent and nondependent based on their level of reliance on NIPFs for stumpage and explored the differences and similarities between the two groups. Since NIPF ownership is the most prominent forest ownership type in Michigan (~9.6 million acres), characterizing businesses that are heavily dependent on NIPFs for stumpage can help inform how changes in such businesses may impact management of forest resources owned by NIPF owners and vice versa.

Approximately 18 million acres of forestlands within the state were identified as the procurement area of 115 logging businesses. The growth to removals ratio, a measure of sustainable wood supply, in the procurement area was found to be 2.3, indicating that there is a potential for increased harvest without negatively impacting forest resources within the state. The net growth to removals ratios, however, varied considerably depending upon forest ownership type, suggesting that increased timber harvests from all ownership types in the future may not be equally sustainable. For instance, timber removals from corporate private forestlands in the wood basket were almost at the levels of growth at the time of this study. This means that, if the demand for wood products increases in the future, a logical approach to maintain sustainable timber supply without negatively impacting the forest resource base would be to harvest more timber from ownership types other than corporate private ownership. Also, besides the corporate private ownership, annual mortality was noted to be higher than removals in all other ownership types. This is a matter of concern from forests'

health perspective and demands further investigation and action.

The procurement area maps of Michigan's logging businesses extended beyond the state boundaries, indicating some reliance on neighboring states (particularly Wisconsin) for stumpage. Due to its geographical proximity and rich forest resource base, Wisconsin is one of the major suppliers of industrial roundwood for Michigan (Piva and Neumann 2018). Within the state, the competition for resources was noted to be the highest in the Western Upper Peninsula and the Northern Lower Peninsula regions. These are the areas that have high concentrations of forestlands and large primary forest products manufacturing facilities by capacities within the state. The Upper Peninsula region has 45% of Michigan's forests, while the Northern Lower Peninsula has 37% (Pugh 2018). The Western Upper Peninsula and the Northern Lower Peninsula regions of Michigan are home to many large sawmills, pulp mills, veneer mills, oriented strand board manufacturers and pellet mills (Michigan DNR 2018). Collectively the primary mills located in these two geographic sub-regions of the state contributed over 77% of the total timber processed by all primary mills in the state in 2018 (Michigan DNR 2018). These regions, therefore, offer ample business opportunities for logging businesses.

The logging businesses located and operating in high competition areas, however, need to be more efficient in business operation and networking to have an advantage over their competitors. Past studies have identified forest stand characteristics, such as stem size, stand density, and species composition; technological investment (mechanization of logging equipment), and operator skills as influencing the productivity of logging businesses (Parajuli et al. 2020, Mac Donagh et al. 2019, Karha et al. 2004). Hence, logging businesses located in high competition areas could benefit by investing in better equipment and hiring and maintaining trained operators. Also developing better relationships with large mills in the region could help logging businesses in securing long-term timber contracts and aid in purchasing stumpage for business operation. Sustained work opportunity can help reduce anxiety in a logging business, help them hire and maintain a productive logging crew, and open other avenues for improving business efficiency.

Relatively low competition for resources was observed for logging businesses located and operating in the Southern Lower Peninsula region of the state. It is not a surprise as this region has the smallest forest area (18%) (Pugh 2018) and is home to Michigan's larger cities

and metro areas such as Detroit, Grand Rapids, and Lansing. Nonetheless, there are several primary mills located in the Southern Lower Peninsula which contributed approximately 17% of the total timber products processed by all primary milling facilities in the state in 2018 (Michigan DNR 2018). Fewer logging businesses competing for the same resource means that landowners in this region have limited access to information about timber sales/prices. Logging businesses on the other hand have better bargaining opportunities with landowners for stumpage and delivered price with mills. New logging businesses with limited resources could probably do better in areas with less competition compared to those with high levels of competition within the state.

Findings revealed that, unlike NIPF-dependent logging businesses, nondependent logging businesses acquire stumpage from all types of ownership. Therefore, factors that affect timber availability from NIPFs in the future such as parcelization of forestlands may not be as big of a concern for nondependent logging businesses as it is for NIPF-dependent logging businesses. NIPF-dependent logging businesses in our study harvested significantly less volume per business, purchased a higher percentage of their own stumpage rather than buying it from brokers or mills, and operated more frequently on smaller sized forest parcels. A significant association was observed between a business being nondependent on NIPFs and them using mechanized felling equipment for harvesting timber. But no difference was observed in the products or species harvested, nor in self-indicated profit levels obtained. These findings suggest that NIPF-dependent logging businesses in Michigan have structured themselves appropriately and have adapted to operate comfortably in their wood baskets. The most frequently harvested forest acreage category for NIPF-dependent logging businesses was found to be 21–40 acres, followed by 11–20 acres. Given the national trend of forest parcelization and the foreseeable subdivision of privately owned forestlands as pressure from urbanization increases (Hatcher et al. 2013), it seems essential to continue having this group of loggers operating on smaller sized forest parcels. For highly mechanized large logging businesses, it may not make economic sense to operate on smaller sized forest parcels due to reduced timber harvesting economies of scale and high equipment moving costs and high hourly fixed costs as shown by past studies on logging businesses (Moss and Hedderick 2012, Cubbage 1983, Row 1978).

About 73% of NIPF-dependent logging businesses and 77% nondependent businesses

in Michigan reported that they would continue logging in the short-term future. The remaining 27% of NIPF-dependent and 23% of nondependent logging businesses indicated to exit from the market in the near term. Since nondependent logging businesses are relatively larger operations with more mechanized equipment, the owners may not dissolve the business upon retirement but transfer it to a family member or others. However, the loss of smaller sized NIPF-dependent logging businesses with fewer financial assets tied to the business may be permanent. If the indicated departures of NIPF-dependent logging businesses do happen without replacement, it could pose a challenge for landowners to find logging businesses to conduct forest management operations on smaller sized forest parcels. To ensure continued existence of logging businesses that are capable of efficiently conducting forest management operations on smaller sized forest parcels, efforts need to be made by the forest products industry and concerned forestry stakeholders to strengthen such businesses. It could be through timely information about techniques for boosting the productivity of such operations or helping with business management and networking skills.

The findings obtained from this study in terms of resource condition, ownership status, and competition among logging businesses in Michigan can be beneficial for existing logging businesses as they navigate their business operation decisions and can be useful for those considering joining the profession in the future. Knowledge about where the competition for resources is high versus low and the condition of resources within the state can help guide newcomers to position their businesses to avoid business failure. Additionally, information about regions of the state with a higher or lower density of logging businesses operating can help landowners identify areas that have high market potential for selling stumpage versus those where finding people to conduct logging may be difficult. Knowledge about the condition of resources in high competition areas can help concerned stakeholders make decisions that will maintain the sustainability of the resource base. Additionally, information about the status of the value chain (logging businesses) can be beneficial for the forest products industry and government agencies alike.

Notable limitations of the study arise from data collected from a limited number of logging businesses located within Michigan. In the future, similar analysis could be conducted using a broader sample size and larger geographic area (for instance the Lake States region of Michigan, Minnesota, and Wisconsin) to provide a more holistic picture of logging

businesses, their resource conditions, reliance on different ownership types for stumpage, and competition levels. Timber harvested in the Lake States region commonly moves across state lines due to proximity; hence, a regional study of procurement areas could provide a more holistic picture. To identify different forest ownership types, present in the procurement areas of logging businesses, we used a forest ownership map of Michigan. Since forestlands also include areas that are restricted from timber harvest, a better approach would have been to use only timberland area instead of forest land area for mapping the procurement area. Additionally, we used FIA data to estimate resource condition and growth to removal ratios in the wood basket, and this data is subject to sampling error. Nonetheless, mapping the procurement areas of logging businesses and identifying competition hotspots can be a useful tool for understanding the status of the industry in areas big and small. Also, as NIPF ownership is the major forest ownership type across much of the United States, except the Pacific Northwest, our findings are likely to have broader implication beyond Michigan.

LITERATURE CITED

Abbas, D., R. Handler, B. Hartsough, D. Dykstra, P. Lautala, and L. Hembroff. 2014. A survey analysis of forest harvesting and transportation operations in Michigan. Croatian Journal of Engineering. 35(2):179-192.

Allred, S., C. Michler, and C. Mycroft. 2011. Midwest logging firm perspectives: Harvesting on increasingly parcelized forestlands. International Journal of Forestry Research. 2011:1-7.

Baker, S.A., B. Mei, T.G. Harris, and W.D. Greene. 2014. An index for logging cost changes across the US South. Journal of Forestry. 112 (3):296-301

Barrett, S.M., M.C. Bolding, and J.F. Munsell. 2017. Characteristics of logging businesses across Virginia's diverse physiographic regions. Forests. 2017. 8(12):468. https://doi.org/10.3390/f8120468

Blinn, C.R., T.J. O'Hara, D.T. Chura, and M.B. Russell. 2015. Minnesota's logging businesses: An assessment of the health and viability of the sector. Forest Science. 61(2):381-387.

Butler, B.J., S.M. Butler, J. Caputo, J. Dias, A. Robillard, and E.M. Sass. 2021. Family forest ownerships of the United States, 2018: Results from the USDA Forest Service, National woodland owner survey. USDA Forest Service. General Technical Report NRS-199. 52p.

Conrad, J.L. 2014. Adapting to a changing landscape: How Wisconsin loggers persist in an era of parcelization. Forest Products Journal. 64(7/8):273-280.

Conrad, J.L., W.D. Greene, and P. Hiesl. 2018. A review of changes in US logging businesses 1980s-present. Journal of Forestry. 116(3):291-303.

Cubbage, F.W.1983. Tract size and harvesting costs in southern pine. Journal of Forestry. 81(7):430-433.

DeCoster, L.A.1998. The boom in forest owners-A bust for forestry? Journal of Forestry. 96(5):25-28.

Dillman, D.A. 2000. Mail and internet surveys: The tailored design method. 2nd ed. Wiley, NewYork. 464p.

Espinoza, O. 2020. Trends in the U.S. forest products sector, markets, and technologies. In: Dockry, Michael J., Bengston, David N., Westphal, Lynne M., comps. Drivers of change in U.S. forests and forestry over the next 20 years. Gen. Tech. Rep. NRS-P-197. Madison, WI: U.S. Department of Agriculture, Forest Service, Northern Research Station: 26–49. https://doi. org/10.2737/NRS-GTR-P-197-paper4.

Froese, R., M. Hyslop, C. Miller, B. Garmon, H. McDiarmid Jr., A. Shaw, L. Leefers, M. Lorenzo, S Brown, and M Shy. 2007. Large-tract forestland ownership change: land use, conservation, and prosperity in Michigan's Upper Peninsula. Ann Arbor, MI. National Wildlife Federation. 54p.

Gc, S., and K. Potter-Witter. 2011. An examination of Michigan's logging sector in the emerging bioenergy market. Forest Products Journal. 61(6):459-465.

Gc, S., K. Potter-Witter, C.R. Blinn, and M. Rickenbach. 2020. Journal of Forestry.

118(5):501-514.

Goergen, M., J. Harding, C. Owen, M. Rey, and L. Scarlett. 2013. The state and future of U.S. forestry and forest industry. Available online at the-state-and-future-of-the-u.s.-forest-industry.pdf (usendowment.org); last accessed July 8, 2023.

Greene, W.D., T.G. Harris Jr, C. E. DeForest, and J. Wang. 1997. Harvesting cost implications of changes in the size of timber sales in Georgia. Southern Journal of Applied Forestry. 21(4):193-198.

Hatcher, J.E., T.J. Straka, and J.L. Greene. 2013. The size of forest holding/Parcelization problem in forestry: A literature review. Resources 2(2):39-57. https://doi.org/10.3390/resources2020039.

He, M., M. Smidt, W. Li, and Y. Zhang. 2021. Logging industry in the United States: Employment and profitability. Forests. 2021, 12, 1720. https://doi.org/10.3390/f12121720.

Huff, E. S., K. Floress, S. A. Snyder, Z. Ma, and S. Butler. 2019. Where farm and forest meet: Comparing national woodland owner survey respondents with and without farmland. Land Use Policy. 87 (June 2018):104007.

Hoover, K., and A.A. Riddle. 2021. U.S. Forest ownership and management: Background and issues for congress. Congressional research service report R46976. Available online at https://crsreports.congress.gov/; last accessed February 27, 2023.

Kärhä, K., E. Rönkkö, and S.I. Gumse. 2004. Productivity and cutting costs of thinning harvesters. International Journal of Forest Engineering. 15(2):43–56.

Kittredge, D.B. Jr., M.J. Mauri, and E.J. McGuire.1996. Decreasing woodlot size and the future of timber sales in Massachusetts: When is an operation too small? Northern Journal of Applied Forestry.13(2):96-101.

Kuipers, B.T., S. Gc, and K. Potter-Witter. 2013. Identifying appropriate communication means for reaching nonindustrial private forest landowners. Journal of Forestry. 111(1):34-41.

Leatherberry, E.C., N.P. Kingsley, and T.W. Birch. 1998. Private timberland owners of Michigan, 1994. USDA Forest. Service. Resource. Bulletin. NC-191. 81 p.

Leefers, L., J. Poudel, D. Neumann, and public sector consultants. 2020. Forest Products Industries' Economic Contributions: Michigan. Lansing Public Sector Consultants. 44p.

Mac Donagh, P., J. Roll, G. Hahn, and F. Cubbage. 2019a. Timber harvesting production, costs, innovation, and capacity in the Southern Cone and the U.S. South. Timber Buildings and Sustainability. IntechOpen. doi:10.5772/intechopen.85412.

Mac Donagh, P., S.J. Elias Velazco, G.F. Botta, T. Schlinchter, and F. Cubbage. 2019b. Logging contractor's growth in the Southern cone: An analysis of contractor business strategies, innovation, and mechanization. Forests. 10(1) 69. https://doi.org/10.3390/f10010069.

Michigan Department of Natural Resources. 2023. Forest products industry. Michigan's forests provide renewable products and skilled jobs. Available online at Forest products industry (michigan.gov); last accessed April 14, 2023.

Michigan Department of Transportation. 2022. All roads. Available online at All Roads (v17a) | MDOT Open Data - Home (arcgis.com); last accessed July 6, 2022.

Michigan Society of American Foresters. 2022. Available online at Forest Management in Michigan (michigansaf.org). Last accessed 6/22/2022. Available online at Forest Management in Michigan (michigansaf.org); last accessed April 9, 2023.

Moss, S.A., and D.B. Hedderick. 2012. An economic evaluation of a small-scale timber harvesting operation in Western Maryland, USA. Small-scale Forestry.11(2012):101–117.

Neumann, D., and B. Haskill. 2020. Michigan primary mill survey 2018. Available online at https://www.michigan.gov/-/media/Project/Websites/dnr/Documents/FRD/industry/economics/Mill_Survey_2018.pdf?rev=f4ca04085dad40b285821ecc14a0cbd8; last accessed June 12, 2023.

Parajuli, M., P. Hiesl, M. Smidt, and D. Mitchell. 2020. Factors influencing productivity and cost in the whole tree harvesting system. Clemson (SC): Clemson Cooperative Extension, Land-Grant Press by Clemson Extension. LGP 1079. Available online at https://clemson.app.box.com/s/7uszmtkcfs3zbbl73zef3sk1sqv46txc; last accessed March 19, 2023.

Piva, R. J., and D.D. Neumann. 2018. Michigan Timber Industry, 2014. Resource Update FS-RU-169. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 6 p. https:// doi.org/10.2737/FS-RU-169.

Pokharel, R., and G.S. Latta. 2020. A network analysis to identify forest merchantability limitations across the United States. Forest Policy and Economics. 116. https://doi.org/10.1016/j.forpol.2020.102181

Pokharel, R., G. Latta, and C. Washington. 2022. Identifying economically feasible priority landscape areas in Idaho for funding assistance programs. Journal of Forestry. 121(2):145-156.

Pokharel, R., J. Poudel, R. Dahal, and S. GC. 2023. Forest biomass feedstock availability and economic contribution of biopower facilities in the Lake States region. Journal of Forestry, fvad023, https://doi.org/10.1093/jofore/fvad023.

Powell, M. 2021. Timber prices and inventories plummet in the Lake States. Forest2Market. Available online at Timber Prices & Inventories Plummet in the Lake States (forest2market.com); last accessed April 27, 2022.

Pugh, S. A. 2018. Forests of Michigan, 2017. Resource Update FS-153. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 4p. https://doi.org/10.2737/FS-RU-153.

Rickenbach, M., and T.W. Steele. 2005. Comparing mechanized and non-mechanized logging firms in Wisconsin: Implications for a dynamic ownership and policy environment. Forest Products Journal. 55(11):21-26.

Rickenbach, M., T.W. Steele, and M. Schira. 2005. Status of the logging sector in Wisconsin and Michigan's Upper Peninsula, 2003. The University of Wisconsin Extension, Madison, WI. 40p.

Rickenbach, M., and T.W. Steele. 2006. Logging firms, nonindustrial private forests, and

forest parcelization: evidence of firm specialization and its impact on sustainable timber supply. Canadian Journal of Forest Research. 36:186-194.

Rickenbach, M., M. Vokoun, and S. Saunders. 2015. Wisconsin logging sector: Status and future direction. The University of Wisconsin Extension (G4073), Madison, WI. 23p.

Riddle, A.A. 2021. Covid-19 and the U.S. timber industry. Congressional research service report R46636. Available online at https://crsreports.congress.gov/product/pdf/R/R46636; last accessed July 18, 2023.

Row, C. 1978. Economics of tract size in timber growing. Journal of Forestry.76(9):576-582.

Sass, E. M., B.J. Butler, M.A. Markowski-Lindsay. 2020. Forest ownership in the conterminous United States circa 2017: distribution of eight ownership types - geospatial dataset. Fort Collins, CO: Forest Service Research Data Archive. https://doi.org/10.2737/RDS-2020-0044.

Solomon, D. 2012. Does zoning contribute to forest parcelization? Available online at Does zoning contribute to forest parcelization? – Part 1 - MSU Extension; last accessed July 17, 2023.

Stampfly J., and B. Lueckel. 2023. State and private forestry factsheet Michigan 2022. Available online at https://apps.fs.usda.gov/nicportal/temppdf/sfs/naweb/mi_std.pdf; last accessed April 14, 2023.

Stanke, H., A.O. Finley, A.S. Weed, B.F. Walters, and G.M. Domke. 2020. rFIA: An R package for estimation of forest attributes with the US Forest Inventory and Analysis database. Environmental Modelling and Software. 127 (2020) 104664. https://www.fs.usda.gov/nrs/pubs/jrnl/2020/nrs_2020_stanke_001.pdf.

Sinclair, S.A., C.C. Hassler, K. Bolstad, and E. Kallio. 1985. Characteristics of independent loggers: productivity, employees, profitability. Forest Products Journal. 35(5):19-24.

USDA Forest Service. 2020. Forests of Michigan, 2019. Resource Update FS-235. Madison, WI: U.S. Department of Agriculture, Forest Service. 2p. https://doi.org/10.2737/FS-RU-235

USDA Forest Service. Forest inventory and analysis data. 2019. Obtained through working relationship established with J. J. Holgerson, USDA Forest Service, Northern Research Station. April/May, 2022.

CHAPTER 5. POTENTIAL ECONOMIC IMPACTS OF PROJECTED LOGGING BUSINESS CLOSURES AND IMPORT SUBSTITUTION TO MEET LOCAL DEMAND IN THE LAKE STATES

5.1 Abstract

The logging industry, a critical component of the wood products supply chain, is one of the most vulnerable links of the forest products supply chain. Notable challenges faced by the logging industry include declining market demands for certain wood products, increasing operational and maintenance costs, shrinking gaps between prices paid for logging services and logging costs, an aging logging workforce, and difficulty in recruiting and retaining a skilled workforce for business operations. All of these factors have led to a decline in the number of logging businesses and the logging workforce in the Lake States region and beyond. The trend is expected to continue in the short-term future. Given this, our study uses impact analysis for planning, IMPLAN, software and 2017 IMPLAN data to assess the baseline economic contributions of the logging industry to Michigan, Minnesota, Wisconsin, and the three-state economy. It further constructs hypothetical but probable scenarios to understand how projected closures of logging businesses in each state may affect the economy of that state and what it means to meet local demand through import substitution. The findings reveal that the logging industry directly employed over 12,000 people in 2017 and generated more than $900 million in direct economic output to the Lake States economy. Including ripple effects, the contributions were much higher. In the case of lost logging capacity within a state, if the local demand for roundwood and logs generated by the logging industry is met through imports, a considerable portion of the indirect and induced economic effects which could be realized within the state leak out of that state. It is, therefore, in the economic interest of a state to utilize local timber resource in a sustainable manner by using local human resources, as much as possible.

5.2 Background

With forests covering a major share of the land area in Michigan (54%), Wisconsin (49%) and Minnesota (35%), it is no surprise that the forest products industries play an important role in the three-state economy (US Forest Service, Forest Inventory and Analysis 2022). The forest products industries employ over 142,000 workers and generate $48 billion in direct economic output to the three-state economy (Leefers et al. 2020). The logging

industry is an integral component of the forest products industries that connects forest resources with wood using mills, which in turn generate products demanded by end users. Besides being an essential link in the wood products supply chain, the choices that logging businesses and loggers make are responsible for maintaining forest's health and productivity for present and future use. The logging industry is also an important source of employment in rural areas which often lack many employment opportunities. Strong and competent logging businesses are therefore essential for well-functioning forest products industries, for strengthening rural economies, and for sustainable forest management.

Despite playing an important role in rural economies and being an integral component of the multi-billion dollars forest products industries, logging businesses in the U.S. in general and in the Midwest more specifically are facing significant challenges to fulfill their roles in recent times (Blinn et al. 2015, Rickenbach et al. 2015, Georgen et al. 2013, Gc and Potter-Witter 2011, Allred et al. 2011). The challenges they face include declining markets for certain wood products (Espinoza 2020), increased operating costs (fuel, parts, equipment) and costs of complying with environmental regulations and forest certification, decreased profit margins, and difficulty recruiting and retaining a skilled workforce for business operations (Rickenbach et al. 2015, Georgen et al. 2013, Allred et al. 2011, Gc and Potter-Witter 2011). Baker et al. (2014) developed a percentage breakdown of key factors driving logging costs in the U.S. South and found labor, fuel, and depreciation to be the three most important cost components for logging businesses in the region. In the same study, the authors noted a shrinking gap between prices paid for logging services and logging costs between 2006 and 2013 in the U.S. South, thus indicating a reduction in the potential profit obtained by logging businesses. Likewise, logging business studies in other parts of the country (Regula et al. 2018, Blinn et al. 2015) have also noted declining profit margins for logging businesses owing to various reasons. Covid-related market disruptions have further impacted the industry that was already struggling through modifications in demand for wood products, issues related to worker health, and transportation logistics. In the Lake States region, the prices paid for harvested timber delivered to mills in April 2021 were reported to be at their lowest point in over eight years (Powell 2021).

Aging logging business owners and difficulty in attracting and retaining qualified employees are some of the major concerns expressed by logging businesses across the country

(Espinoza 2020, Gc et al. 2020). Contraction of the logging workforce coupled with difficulty in hiring and retaining employees and an ongoing shortage of truck drivers have all contributed to make timber harvesting the most fragile link in the wood products supply chain (Espinoza 2020). Since forest products industries can only be as strong as their weakest link, the industries and all concerned stakeholders need to focus more attention on sustaining and strengthening the logging industry in the years to come. Given this, quantifying the economic contribution of the logging industry to a particular region can be useful for emphasizing the importance of the industry to that region and for attracting supporting policies for sustaining and strengthening the logging industry in the future. It also provides a baseline for future comparisons. By understanding the inter-industry linkages of the existing logging industry with other related industries in a region, one can understand how changes in the logging industry can have ripple effects on other forest products industries in that area.

In the past two decades, many economic contribution studies of agriculture and forest-related industries have been conducted in the U.S. at state, regional, and national levels (examples include: Jolley et al. 2020, Leefers et al. 2020, Tilley and Munn 2007, Munn and Henderson 2003, Aruna et al. 1997). Most of these studies were conducted by state or federal governmental agencies to emphasize the importance of an existing industry on local economies; some were carried out by academic institutions and others by private entities (Joshi et al. 2017). The economic contribution of logging businesses has often been included as a part of the broader forest products industries contribution analysis with only a handful of the studies (Bailey et al. 2020, Jolley et al. 2020, Lee 2014) discussing the contribution of logging businesses in detail and exploring the linkages between the logging industry and other related forest products industries. Besides studies of economic contribution, several economic impact studies have estimated the economic effect of introducing new forest-based industries (such as pellet mills or other bioenergy facilities) in an area (e.g., Henderson et al. 2017, Joshi et al. 2012) or the loss of an existing industry (e.g., pulp and paper mills) from an area (e.g., Brandies and Guo 2016). However, none to our knowledge have assessed the economic impact of changes in logging businesses and logging employment on local economies and other related industries.

In their review article exploring the change in the U.S. logging industry from the 1980s to 2017, Conrad et al. (2018) noted a decline of close to 5,000 logging businesses and

more than 35,000 logging workers from 1990 to 2016. The number of logging establishments in the U.S. from 2001 to 2020 has declined significantly (U.S. Bureau of Labor Statistics, 2022) (Figure 5.1). Mechanization of logging businesses coupled with decreased demand for printed media, decline in housing markets due to an economic recession, and loss in market share of certain domestic wood products such as furniture being replaced by low-cost imports have all contributed to this decline (He et al. 2021, Espinoza 2020).

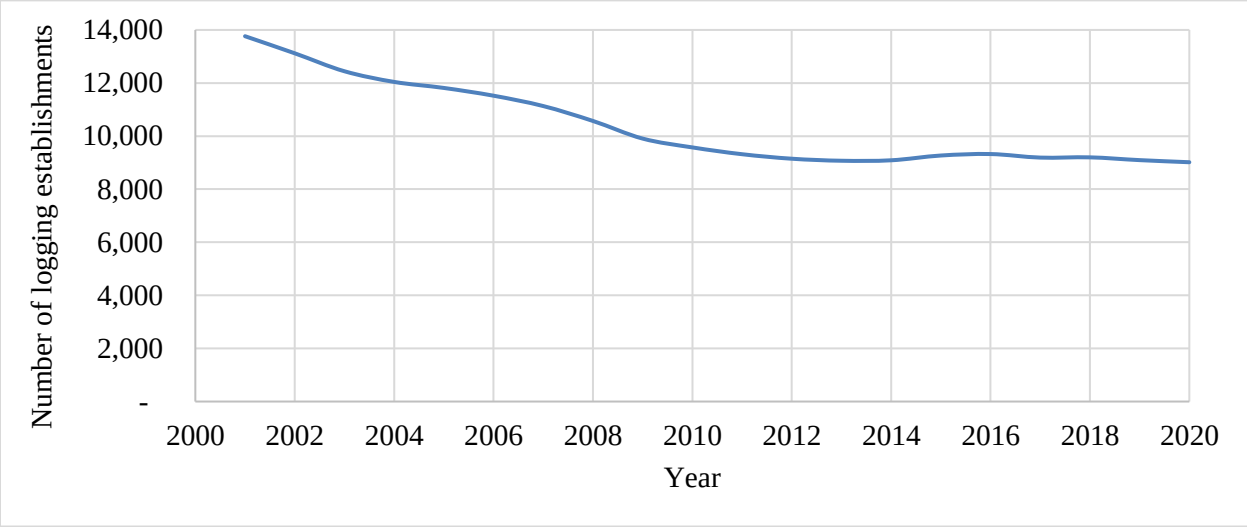


Figure 5.1 Change in logging establishments in the U.S. from 2000 to 2020 (Source: U.S Bureau of Labor Statistics 2022).

Survey-based studies of logging businesses across the country have highlighted aging logging business owners who are on the brink of retirement and a paucity of young leadership taking over the logging business (Conrad et al. 2018, Rickenbach et al. 2015, Leon and Benjamin 2012, Baker and Greene 2008). Logging businesses in the U.S. are predominantly family businesses (Allred 2009, Egan and Taggart 2004), and when the family business owner reaches their retirement age, the business can either be taken over by an identified successor(s), sold, or terminated (Malinen 2001). In Wisconsin, Rickenbach et al. (2015) noted that 20% of the logging businesses in the state were terminated between 2003 and 2010, and another 19% indicated intentions to exit from the market in the short-term future. Similar findings were obtained by Blinn et al. (2015) in Minnesota and Allred (2009) in the north central region of the United States. More recently, a coordinated mail survey of logging business owners in Michigan, Minnesota, and Wisconsin was conducted in 2017 to assess the

status of the Lake States logging industry in 2016 (Gc et al. 2020). The findings from this survey noted that 26% of logging business owners in the three-state region intended to exit from the market by 2022 (Gc et al. 2020). Given the aging cohort of logging business owners across the country and projected loss in logging businesses in the years to come, it makes sense to assess how such changes in logging businesses may affect related industries and local economies. The goal of this study is, therefore, to estimate the economic contribution of the logging industry to each state and to the regional economy of Michigan, Minnesota, and Wisconsin and to develop a better understanding about the potential impacts of projected business closures in the study area. The specific research questions for the study are:

- What is the economic contribution (direct, indirect, and induced) of the logging industry to individual states (Michigan, Minnesota, and Wisconsin) and to the three-state regional economy?
- How is the logging industry linked with other forest products industries in the study area, and how might forecasted closures of logging businesses affect local economies and related forest products industries in that area?
- In case of lost logging capacity within a state, how might replacing the lost capacity by substituting imports affect the overall contributions made by forest products industries in that state and across the three-state region?

In short, how important economically is the logging industry? If part of the industry stops production as expected, what are the economic impacts? And what role might import substitution play in replacing the lost capacity?

5.3 Materials and Methods

5.3.1 Data

To estimate the economic contribution of logging businesses to individual states and the three-state regional economy, impact analysis for planning (IMPLAN) software (Version 3.1.1001.12) and 2017 IMPLAN data were used. IMPLAN is a widely used computer software package that allows users to estimate local input-output models based on the interdependence among various producing and consuming sectors in the economy (Mulkey and Hodges 2000). Economic data for IMPLAN is compiled from various government agencies including the U.S. Department of Commerce, the U.S. Census Bureau, the U.S. Bureau of Labor Statistics, and the U.S. Bureau of Economic Analysis as well as other federal

and state government agencies (Mulkey and Hodges 2000). The 2017 IMPLAN dataset uses 536 distinct producing sectors or industries to represent the national economy based upon the North American Industrial Classification System (NAICS), and the commercial logging industry is represented by IMPLAN sector 16.

Forecasted closures of logging businesses and the resulting loss in logging capacity were based on the data obtained from a mail survey of logging businesses in the Lake states region of Michigan, Minnesota, and Wisconsin (Gc et al. 2020). Additionally, a review of past logging business literature in the region (Rickenbach et al. 2015) also aided in reaching a consensus about projected loss of logging businesses in the region.

5.3.2 Analysis

This study uses economic contribution analysis to estimate the economic contribution of the logging industry in Michigan, Minnesota, and Wisconsin's economies and economic impact analysis to understand how projected closures of logging businesses may affect local economies and related industries in the study area. Economic contribution analysis is a descriptive analytical technique that estimates gross changes in a region's economy that can be attributed to an existing industry, event, or policy (Watson et al. 2007). In other words, it estimates the relative importance of an existing industry to an economy. Economic impact analysis, on the other hand, estimates net changes in economic activity attributed to an industry, event, or a policy in an existing regional economy (Watson et al. 2007). That is, it estimates the net changes to the economic base of a region owing to an exogenous shock such as the entry or exit of a firm (Henderson et al. 2017).

The economic contribution and impact analysis techniques are based upon the input-output modeling approach—an analytical framework developed by Professor Wassily Leontief in the late 1930s to analyze the macroeconomic impact of production input and interdependence of industries in an economy (Miller and Blair 1985). It is used to understand how change in final demand for a product in a region affects the overall economy of that region.

Leontief's input-output framework explicitly tabulates the flow of goods and services between industries in an economy. It shows how output from each industry or sector is used by other sectors as their inputs, thus highlighting inter-industry transactions (Henderson and Evans 2017, Miller and Blair 1985). The framework also includes information about final

demands and final payments. Final demands are the value of sales to consumers for final consumption and final payments are the value of payments for other non-industrial inputs to production such as labor, depreciation of capital, indirect business taxes, and imports (Henderson and Evans 2017, Miller and Blair 1985). Mathematically, the input-output model can be expressed in the following matrix form:

$X= (I-A)^{-1} Y$

where, X is a vector of gross industry outputs, Y is a vector of final demands, A is the matrix of technical coefficients (a_{ij}) which represents intermediate input supplied by industry i per unit of gross output in industry j, and I is the identity matrix. The matrix $(I-A)^{-1}$ is called the Leontief inverse or the total requirements matrix, which is a matrix of multipliers that represent the relationship between the initial change in final demand and its total impacts (Miller and Blair 1985).

The methods used in this study can be separated into three parts: Single region economic contribution analysis of the logging industry to each state and to the three-state combined region; economic impact analysis of projected logging business closures in each state; and economic contribution analysis of top five forest products industries using logs and roundwood as inputs for production before and after import substitution.

First, we used the single region economic contribution analysis to estimate the economic contribution of the logging industry in individual states of Michigan, Minnesota, and Wisconsin and the three-state region using 2017 IMPLAN data. Using IMPLAN, economic effects can be measured at direct, indirect, and induced levels. Direct effects are economic activities associated with an industry or sector under consideration in the study region (in this case, the logging industry). Indirect effects are those associated with inter-industry transactions in the supply chain, that is, the effect of local industry's (logging industry) purchasing goods and services from other industries located within the study region leading to other's employments, outputs, and labor income. Induced effects are those associated with labor income via goods and services purchased due to the direct and indirect spending by industries in the study region.

When estimating the economic contribution of relevant industry sectors using the desktop version of IMPLAN also known as IMPLAN Pro, adjustments need to be made to the direct effect values to avoid overstating the results obtained from analysis (Parajuli et al.

2018). This is because, economic contribution analysis estimates direct and indirect effects associated with an industry of interest without assuming any external change in final demand vector (Henderson and Evans 2017). For this, there are two commonly used approaches. The first approach makes internal adjustments to the IMPLAN software. It nullifies cross-sector commodity coefficients and local use ratios in IMPLAN to eliminate the indirect and induced effects of the sectors of interest (Parajuli et al. 2018). Approach two is external to the software and uses matrix inversion of SAM multipliers associated with the sectors of interest to adjust the input values used in estimating economic contributions of the sectors of interest (Parajuli et al. 2018). This approach is also referred to as method two of economic contribution analysis (Parajuli et al. 2018). Both methods are equally used by practitioners and have their own strengths and limitations (Parajuli et al. 2018). For this study, we used method two of economic contribution analysis to estimate the economic contribution of the logging industry in the study area. In the new cloud-based version of IMPLAN, no adjustments need to be made to estimate economic contribution analysis.

Second, to estimate the economic impact of the projected loss of logging businesses from a region, a hypothetical scenario was created where it was assumed that 20% of logging businesses in each of the three states left the market resulting in an associated loss in logging employment in the respective states. Twenty percent was selected based upon the review of logging business literature in the Lake States region (Gc et al. 2020, Rickenbach et al. 2015). The data for the number of logging businesses in Michigan was obtained from the Michigan Department of Natural Resources (DNR). According to the Michigan DNR, there are 800 logging and related trucking businesses in the state (Michigan Department of Natural Resources 2022). In Minnesota, no official record of the total number of logging businesses could be found. However, there were 383 logging businesses enrolled in the Minnesota Logger Education Program in 2017 (Gc et al. 2020). This number was used as a proxy for total logging businesses in Minnesota. In Wisconsin, a recent survey of logging businesses (Gc et al. 2020) indicated that there were 911 logging businesses in the state in 2017. That number was used for this study. A note of caution is that these numbers are considerably higher than the number of logging establishments reported by the U.S. Bureau of Labor Statistics (BLS) Quarterly Census of Employment and Wages for the 2017 calendar year (U.S Bureau of Labor Statistics 2022). A potential reason for low establishment numbers in BLS

data could be because of the exclusion of sole proprietors from BLS database.

The number of employees per logging business used in this study are based upon past state-level surveys of logging businesses in Michigan, Minnesota, and Wisconsin. The average number of employees per logging business in Michigan is six employees (2017 MI survey data, Abbas et al. 2014); in Minnesota, it is five employees per logging business (Blinn et al. 2015) and in Wisconsin, it is three employees per logging business (Rickenbach et al. 2015). Given this data, a twenty percent loss in the number of logging businesses in each state translates into 160 logging businesses and 960 jobs in Michigan, 77 logging businesses and 385 logging jobs in Minnesota, and 182 logging businesses and 510 logging jobs in Wisconsin. The 2017 IMPLAN data was then used to conduct the economic impact analysis using the projected loss in logging employment in each state. It should be noted that using average employee number to estimate the loss in logging employment could over-, or under-estimate logging jobs lost based upon the size of businesses that exit the market. The exact number of employees likely to leave logging businesses in each of the three states could not be deciphered with certainty from past surveys of logging businesses, as not all surveys asked questions about logging employment per business. However, to account for loss in logging businesses that are relatively smaller in size, we additionally estimated the economic impact of a 20% loss in logging businesses but with half the employee number per business in each state (that is, 3 employees per business in Michigan, 2.5 employees per business in Minnesota and 1.4 employees per business in Wisconsin). Using the reduced employee number per business, the loss in 20% of logging businesses results in a loss of 480 jobs in Michigan, 193 jobs in Minnesota and 255 jobs in Wisconsin.

Third, to understand the economic effect of substituting lost logging capacity within a state via imports, the top five forest products industry sectors utilizing logs and roundwood as inputs for their production in each state were identified. Next, single region economic contribution analysis of the selected five forest products industry sectors were conducted for two scenarios: before logging capacity loss and after substitution of the lost logging capacity through imports. Capacity loss was assumed to be 20% in each state for this study. The difference between the two economic contribution analyses for the selected sectors then provides the effect of substituting lost logging capacity with imports. In IMPLAN, this can be done by modifying the regional purchase coefficient (RPC) which is the proportion of total

demand for a commodity by all users in the study area that is supplied by producers located within the study area. The 20% capacity loss used in this study reflects the scenario that is probable if logging businesses that indicated the intent to exit from the market in the recent survey of logging businesses in the study area (Gc et al. 2020) ended up doing so, without replacement.

Examining the Lake States 2017 IMPLAN data revealed that there are 18 industry sectors that demand logs and roundwood in the region, the only commodities produced by the logging industry. Thirteen of these 18 sectors are classified as forest products industries (Leefers et al. 2020). The change in economic contributions made by all 13 forest products industries using logs and roundwood could be considered to assess the total effect of import substitution on forest products industries in each state. We want to focus on the effects on major log and roundwood using sectors, so we chose the top five in each state. The top five sectors represent 86% of log and roundwood use in Michigan, 89% of use in Wisconsin, and 84% of use in Minnesota.

The economic measures based on IMPLAN that are used for the study include employment, labor income, value added, industry output, and social accounting matrix (SAM) multipliers. Employment includes full-time and part-time employees as well as self-employed individuals associated with an industry. Labor income is the dollar total of employee compensation and proprietor income. Output refers to the total value of production or service by an industry within an area for a specified period. Value added is the sum of labor income, other property income (e.g., rents and profits), and indirect business taxes. SAM multipliers are obtained by dividing the sum of direct, indirect, and induced effects by direct effects and represent the ripple effects of changes in the regional economy due to changes in the industry activity. The economic values for contribution analysis of logging industry in each state and region are presented in 2017 nominal dollars.

5.4 Results

5.4.1 Economic contribution of the logging industry in Michigan, Minnesota, and Wisconsin and the three-state region

Economic contribution analysis results were estimated from the individual state models and the combined regional model for the logging industry in Michigan, Minnesota, and Wisconsin (Table 5.1). Across the three-state Lake States region, logging businesses

directly employed 12,188 individuals, and contributed $528.5 million in labor income, $643.6 million in value added, and $911.5 million in output to the region's economy. Including indirect and induced effects, the industry supported a total of 17,803 jobs and $774.8 million in labor income, $1,051.9 million in value added, and $1,617.9 million in total output to the region's economy. Direct income per job for the logging industry in the region (obtained by dividing labor income by employment number) was found to be $43,364. Among the states, Wisconsin had the highest number of direct and total logging jobs followed by Michigan and Minnesota, respectively (Figure 5.2). Wisconsin also led the other two states in output generated by the logging industry in 2017 (Figure 5.3) as well as direct labor income obtained per logging job (Figure 5.4).

SAM multipliers for employment, labor income, value-added, and output across the region were 1.5, 1.5, 1.6, and 1.8 respectively. This means that every job within the commercial logging industry in the Lake States region generated an additional 0.5 jobs. Likewise, the output multiplier of 1.8 indicates that every $1 million in output in the region's logging industry supported an additional $800,000 in output to the rest of the economy. The SAM multiplier values for the commercial logging industry obtained in this study are comparable with those obtained by previous economic contribution analysis studies of the logging industry in other parts of the country (Bailey et al. 2020, Lee 2014).

The economic contribution analysis results obtained by aggregating state level data produces conservative estimates as compared to that obtained by running the combined three-state regional model (Table 5.1). For example, total employment contributions calculated by summing individual states is 17,555 jobs whereas the three-state model yields 17,803 jobs. This is because the larger the geographic area analyzed, the lesser the leakage of economic activity outside of the study area, thus resulting in higher multipliers (Brandeis and Guo 2016).

Table 5.1 Economic contributions of the logging industry in Michigan, Minnesota, Wisconsin, and the Lake States economy in 2017 nominal dollars from IMPLAN software version (3.1.1001.12) and 2017 IMPLAN data.

	Economic Contribution of Logging Industry				
State		Employment (Jobs)	Labor Income (Millions of 2017 Dollars)	Value-added	Output
Michigan	Direct Contributions	4,487	159.1	182.1	280.8
	Indirect Contributions	670	24.0	33.7	54.6
	Induced Contributions	1,176	53.3	92.7	161.3
	Total Contributions	6,329	236.3	308.4	496.4
	SAM Multiplier	1.41	1.49	1.69	1.77
Minnesota	Direct Contributions	2,495	54.8	86.1	141.0
	Indirect Contributions	296	11.9	17.8	31.8
	Induced Contributions	432	21.8	37.0	63.3
	Total Contributions	3,222	88.5	140.9	235.9
	SAM Multiplier	1.29	1.62	1.64	1.67
Wisconsin	Direct Contributions	5,207	314.6	375.3	489.8
	Indirect Contributions	694	24.7	34.5	55.5
	Induced Contributions	2,106	93.1	164.9	284.5
	Total Contributions	8,004	432.3	574.4	829.4
	SAM Multiplier	1.54	1.37	1.53	1.69
Lake States	Direct Contributions	12,188	528.5	643.6	911.5
	Indirect Contributions	1,691	62.4	89.6	151.2
	Induced Contributions	3,934	184.4	319.2	556.0
	Total Contributions	17,803	774.8	1051.9	1617.9
	SAM Multiplier	1.46	1.47	1.64	1.78

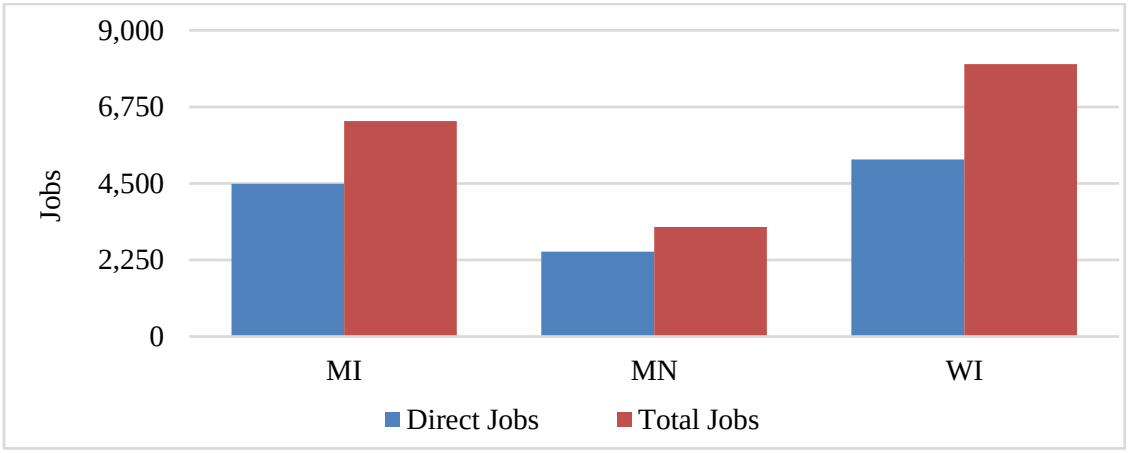


Figure 5.2. Direct and total employment generated by the commercial logging industry in Michigan, Minnesota, and Wisconsin in 2017.

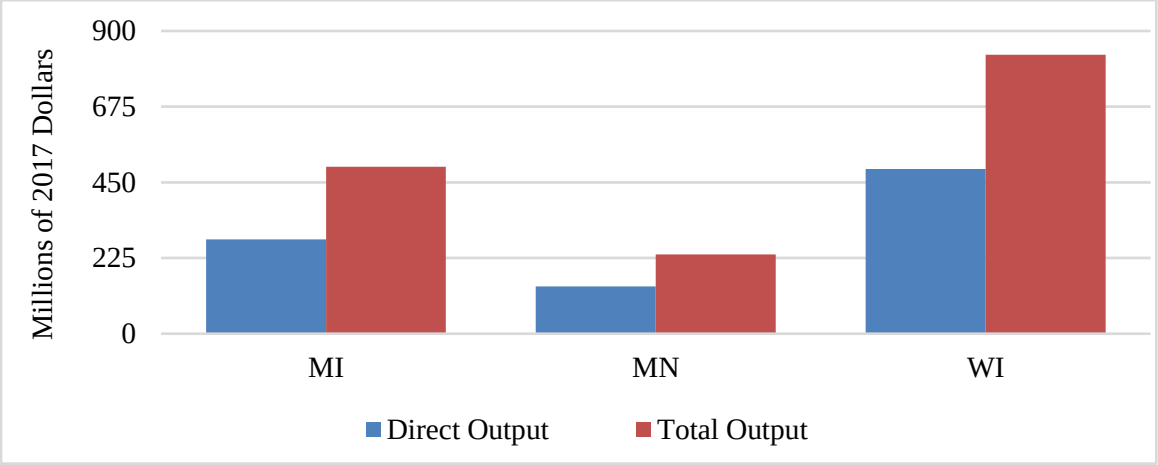


Figure 5.3. Direct and total output generated by the commercial logging industry in Michigan, Minnesota, and Wisconsin in 2017.

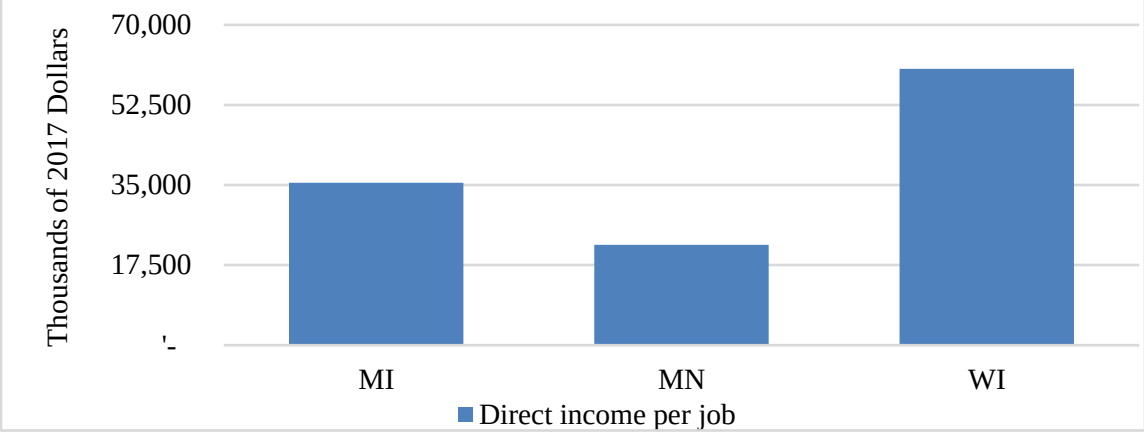


Figure 5.4 Direct labor income obtained per job in the logging industry in Michigan, Minnesota, and Wisconsin in 2017.

5.4.2 Economic impacts resulting from projected loss of logging businesses in the study area.

As stated earlier, if there was a 20% loss in the number of logging businesses in Michigan, Minnesota, and Wisconsin, then it could translate into a loss of 960 logging jobs in Michigan, 385 logging jobs in Minnesota, and 510 logging jobs in Wisconsin given that we use average employee number per logging business in each state. The economic impact of projected loss in logging employment in the study area using 2017 IMPLAN data follows the pattern set by the direct job losses (Table 5.2). That is, impacts are the greatest in Michigan and the least in Minnesota.

In Michigan, the direct logging job loss of 960 is accompanied by a loss in labor income of $34.0 million, value added of $39.0 million, and output or sales of $60.1 million in 2017 dollars. Including indirect and induced effects, the job loss impact is equivalent to 1,355 jobs, $50.6 million in labor income, $66.0 million in total value added, and $106.3 million in output or sales (Table 5.2). In terms of employment, the loss of 960 direct logging jobs in Michigan results in a loss of 143 indirect jobs and 252 induced jobs within the state. The top three IMPLAN sectors that are affected the most in terms of employment, via backward linkages, because of direct logging job loss in Michigan include sector 10 (all other crop farming), sector 19 (support activities for agriculture and forestry), and sector 15 (forestry, forest products, and timber tract production) respectively. These three sectors lose 38, 37, and 28 total jobs due to the direct loss of 960 logging jobs in Michigan. When considering the total output, the top three IMPLAN sectors that are impacted the most by direct logging job loss in Michigan include sector 441 (owner-occupied dwellings), sector 395 (wholesale trade), and sector 440 (real estate).

In Minnesota, the direct logging job loss of 385 is accompanied by a loss in labor income of $8.5 million, value added of $13.3 million, and output or sales of $21.8 million in 2017 dollars. Including indirect and induced effects, the job loss is equivalent to 497 jobs, $13.7 million in labor income, $21.7 million in total value added, and $36.4 million in output or sales (Table 5.2). In terms of employment, the direct loss of 385 logging jobs in Minnesota results in a loss of 46 indirect jobs and 67 induced jobs within the state. The top two industry sectors that are impacted the most in terms of total employment in Minnesota include sector 15 (forestry, forest products, and timber tract production) and sector 10 (all other crop farming). The third most affected sector is wholesale trade followed by support activities for agriculture and forestry. When looking at the total output, the sectors in Minnesota most affected by direct logging job loss are wholesale trade, owner occupied dwellings, and real estate.

In Wisconsin, the direct logging job loss of 510 is accompanied by a loss in labor income of $30.8 million, value added of $36.8 million, and output or sales of $48.0 million in 2017 dollars. Including indirect and induced effects, the job loss impact is equivalent to 784 jobs, $42.4 million in labor income, $56.3 million in total value added, and $81.3 million in output or sales (Table 5.2). In terms of employment, the direct job loss of 510 in the logging

industry in Wisconsin results in a loss of 68 indirect and 206 induced jobs within the state. Again, most of the indirect jobs lost are in sectors 10 (all other crop farming), 19 (support activities for agriculture and forestry), and 395 (wholesale trade). In terms of total output, the top three sectors that are most affected by direct logging job loss in Wisconsin are owner occupied dwellings, wholesale trade, and real estate.

If the projected loss in logging businesses results in a loss of smaller-sized logging operations rather than average sized businesses, then the magnitude of economic impacts felt by such loss would be relatively smaller (Table 5.3).

Table 5.2 Economic impact resulting from the projected closure of 20% of logging businesses in Michigan, Minnesota, and Wisconsin using 2017 IMPLAN data.

State	Impact Type	Employment	Labor Income	Total Value Added	Output
			(Millions of 2017 Dollars)		
	Direct Effect	960	34.0	39.0	60.1
	Indirect Effect	143	5.1	7.2	11.7
	Induced Effect	252	11.4	19.9	34.5
Michigan	Total Effect	1,355	50.6	66.0	106.3
	Direct Effect	385	8.5	13.3	21.8
	Indirect Effect	46	1.8	2.7	4.9
	Induced Effect	67	3.4	5.7	9.8
Minnesota	Total Effect	497	13.7	21.7	36.4
	Direct Effect	510	30.8	36.8	48.0
	Indirect Effect	68	2.4	3.4	5.4
	Induced Effect	206	9.1	16.2	27.9
Wisconsin	Total Effect	784	42.4	56.3	81.3

Table 5.3 Economic impact resulting from the projected closure of 20% of logging businesses in Michigan, Minnesota, and Wisconsin that are smaller in size (with half the number of average employees) using 2017 IMPLAN data.

State	Impact Type	Employment	Labor Income	Total Value Added	Output
			(Millions of 2017 Dollars)		
Michigan	Direct Effect	480	17.0	19.5	30.0
	Indirect Effect	72	2.6	3.6	5.8
	Induced Effect	126	5.7	9.9	17.3
	Total Effect	678	25.3	33.0	53.2
Minnesota	Direct Effect	193	4.2	6.7	10.9
	Indirect Effect	23	0.9	1.4	2.5
	Induced Effect	33	1.7	2.9	4.9
	Total Effect	249	6.8	10.9	18.3
Wisconsin	Direct Effect	255	15.4	18.4	24.0
	Indirect Effect	34	1.2	1.7	2.7
	Induced Effect	103	4.6	8.1	13.9
	Total Effect	392	21.2	28.1	40.6

5.4.3 Economic effect of substituting imports for lost logging capacity within a state

To understand how the substitution of imports for lost logging capacity within a state may affect the contributions made by related forest products industry sectors within that state, the top five forest products industry sectors utilizing logs and roundwood as their inputs for production were identified. These included sectors 47 (electric power generation using biomass), 134 (sawmills), 136 (veneer and plywood manufacturing), 147 (paper mills), and 148 (paperboard mills) in both Michigan and Wisconsin. In Minnesota, four out of the top five forest products industry sectors using logs and roundwood as their input were the same as in Michigan and Wisconsin. Instead of sector 136 (veneer and plywood manufacturing), sector

141 (other millwork including flooring) made it to the list of top five forest products industry sectors using logs and roundwood in Minnesota in 2017. In each of the three states, the top five forest products industries represented more than 80% of the total gross demand for logs and roundwood in that state according to 2017 IMPLAN data. The economic contributions of these five forest products industry sectors were then estimated in each state using 2017 IMPLAN data and software (Tables 5.4, 5.5, and 5.6 for Michigan, Minnesota, and Wisconsin, respectively).

The RPC of logs and roundwood for 2017 Michigan IMPLAN model was found to be 0.763, meaning that 76.3% of all logs and roundwood demand in Michigan in 2017 was met by logs and roundwood produced within the state. Likewise, the RPCs of logs and roundwood for the 2017 Minnesota and Wisconsin models were noted to be 0.764 and 0.861, respectively. This shows that Wisconsin was more self-reliant in 2017 when it came to meeting the demand for logs and roundwood compared to the other two states. The RPC of logs and roundwood was reduced by 20% of its original value (to 0.611 in Michigan, 0.611 in Minnesota, and 0.689 in Wisconsin) to assess how the substitution of imports for lost logging capacity affects related forest products industry sectors in each of the three states. After changing the RPCs, the model was reconstructed using multipliers in IMPLAN, and the economic contribution analysis of the top five identified forest products industry sectors was again conducted using method two of economic contribution analysis (Parajuli et al. 2018) (Tables 5.4, 5.5, and 5.6, respectively, for the Michigan, Minnesota, and Wisconsin models).

Our findings reveal that before the loss of local logging capacity in Michigan and import substitution, the selected five forest products industry sectors directly employed 6,573 individuals and contributed over $542 million in labor income, $837 million in value added, and just over $3.5 billion in direct output to Michigan's economy (Table 5.4). Including indirect and induced effects, the selected sectors generated a total of 26,414 jobs and contributed $6.5 billion in total output to the state's economy (Table 5.4). In terms of total employment, the top three sectors supported by the selected five forest products industry sectors in Michigan were commercial logging, sawmills, and paper mills. After a 20% reduction in the RPC of logs and roundwood, the total jobs created by the same five forest products industry sectors declined by 867 jobs (706 indirect and 161 induced jobs). Likewise, the total labor income declined by $32 million, value added declined by $42 million, and

output declined by $68 million (Table 5.4). In terms of employment, the most notable loss was in the commercial logging industry (615 jobs), followed by the wholesale trade (10 jobs), real estate (9 jobs), and truck transportation (5 jobs).

In Minnesota, before the reduction in local logging capacity, the selected five forest products industry sectors directly employed 4,096 individuals and contributed close to $387 million in labor income, $878 million in value added, and 2.7 billion in output or sales to the state's economy (Table 5.5). Including indirect and induced effects, the sectors employed a total of 17,610 people and generated a little over $5 billion in output or sales to Minnesota's economy (Table 5.5). When looking at the total employment supported by the selected five forest products industry sectors in Minnesota, the top three sectors included paper mills, commercial logging, and wholesale trade.

After a 20% reduction in the RPC of logs and roundwood in Minnesota, the total contributions made by the same five forest products industry sectors declined by a total of 394 jobs (341 indirect and 53 induced jobs), $11 million in labor income, $17 million in value added and $29 million in total sales or output (Table 5.5). When looking at employment, the most notable declines were in the commercial logging industry (305 jobs), followed by the wholesale trade (5 jobs), real estate (3 jobs), and trucking (2 jobs) sectors.

In Wisconsin, before local capacity loss and reduction in the RPC, the five selected forest products industry sectors directly employed 14,549 workers and generated $1.2 billion in labor income, $2.2 billion in value added and over $9.4 billion in direct output to the state's economy (Table 5.6). Including indirect and induced effects, the industry contributions were 58,683 jobs, $3.7 billion in labor income, $6.2 billion in value added and over $16.7 billion in total output to Wisconsin's economy. The top three sectors that were supported by the selected forest products industry sectors in terms of employment in Wisconsin included paper mills, wholesale trade and commercial logging. After a 20% reduction in the RPC of logs and roundwood in Wisconsin, the economic contributions made by the same selected five forest products industry sectors declined by 1,088 total jobs (802 indirect and 287 induced), $59 million in labor income, $78 million in value added, and $113 million in total output (Table 5.6). The most notable decline in terms of employment in the reduced RPC model was in the commercial logging industry (708 jobs), followed by the wholesale trade (16 jobs), full-service restaurants (15 jobs), real estate (13 jobs), and limited-service restaurants (13 jobs)

sectors.

These findings highlight the interconnection of the logging industry with other related forest products industries within the study area and show how substitution of imports for a commodity produced by the local logging industry (logs and roundwood) reduces the economic footprint of the existing forest products industry sectors in each state. The reduction in economic footprint stems mainly from the contraction of indirect effects (which are the effects resulting from business-to-business purchases in the supply chain) and some reduction in induced effects because of import substitution (Figure 5.5). Among the states, the highest percentage reduction in indirect effects in terms of employment and output generated was observed in Minnesota, followed by Michigan and Wisconsin, respectively (Figure 5.5). Minnesota exhibited the least household spending impact (or induced effect) after import substitution of logs and roundwood for both output and employment compared to the other two states (Figure 5.5).

Table 5.4 Economic contributions of five selected forest products industry sectors in Michigan before and after import substitution using 2017 IMPLAN data.

Before local logging capacity reduction and import substitution				
Impact Type	Employment	Labor Income	Total Value Added	Output
		(Millions of 2017 Dollars)		
Direct Effect	6,573	542.5	837.1	3,466.0
Indirect Effect	11,745	700.0	1,011.2	1,905.4
Induced Effect	8,096	367.3	638.6	1,111.7
Total Effect	26,414	1,609.9	2,486.9	6,483.1
After reduction in logging capacity and substitution of logs through import				
Impact Type	Employment	Labor Income	Total Value Added	Output
		(Millions of 2017 Dollars)		
Direct Effect	6,573	542.5	837.1	3,466.0
Indirect Effect	11,039	675.0	981.6	1,859.5
Induced Effect	7,935	360.0	625.9	1,089.5
Total Effect	25,547	1,577.5	2,444.6	6,415.1

Table 5.5 Economic contributions of five selected forest products industry sectors in Minnesota before and after import substitution using 2017 IMPLAN data.

Before local logging capacity reduction and import substitution				
Impact Type	Employment	Labor Income	Total Value Added	Output
		(Millions of 2017 Dollars)		
Direct Effect	4,096	386.9	878.2	2,713.2
Indirect Effect	7,617	504.8	769.0	1,436.8
Induced Effect	5,897	297.2	504.4	862.8
Total Effect	17,610	1,188.9	2,151.6	5,012.8
After reduction in logging capacity and substitution of logs through import				
Impact Type	Employment	Labor Income	Total Value Added	Output
		(Millions of 2017 Dollars)		
Direct Effect	4,096	386.9	878.2	2,713.2
Indirect Effect	7,276	496.6	756.3	1,415.7
Induced Effect	5,844	294.5	499.9	855.1
Total Effect	17,216	1,178.1	2,134.4	4,984.0

Table 5.6 Economic contributions of five selected forest products industry sectors in Wisconsin before and after import substitution using 2017 IMPLAN data.

Before local logging capacity reduction and import substitution				
Impact Type	Employment	Labor Income	Total Value Added	Output
		(Millions of 2017 Dollars)		
Direct Effect	14,549	1,227.8	2,236.3	9,477.7
Indirect Effect	25,645	1,669.3	2,519.0	4,798.9
Induced Effect	18,489	820.7	1,449.5	2,505.0
Total Effect	58,683	3,717.7	6,204.8	16,781.7

After reduction in logging capacity and substitution of logs through import				
		Labor Income	Total Value Added	Output
Impact Type	Employment	(Millions of 2017 Dollars)		
Direct Effect	14,549	1,227.8	2,236.3	9,477.7
Indirect Effect	24,843	1,623.2	2,463.4	4,724.9
Induced Effect	18,202	808.0	1,427.0	2,466.3
Total Effect	57,595	3,658.9	6,126.7	16,668.9

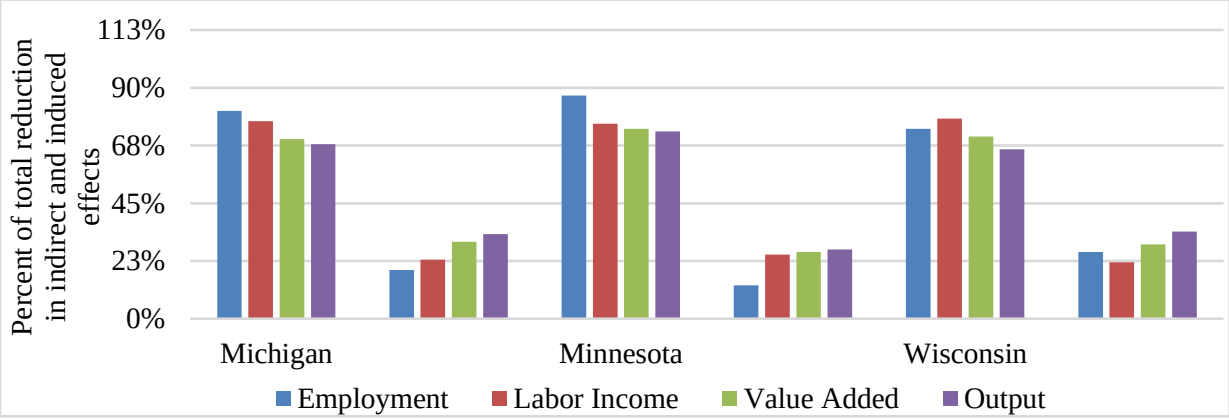


Figure 5.5 Percent of total reduction in economic measures (indirect and induced effects) resulting from the top five forest products industry sectors due to import substitution of logs and roundwood in Michigan, Minnesota, and Wisconsin.

5.5 Discussion and Conclusions

A strong and capable logging industry that can harvest and deliver timber in a cost-effective manner is crucial for production forestry to thrive (McConnell 2013). Additionally, a robust logging industry is essential for sustainable management of forest resources as timber harvesting is a tool for managing forests for purposes ranging from timber production to wildlife habitat management, recreation, and maintenance of forest health (Parajuli et al. 2020). The logging industry also provides a much-needed source of income and employment in rural America where employment opportunities are often limited. Literature on logging businesses and business statistics data suggest that, despite playing a crucial role in the sustainable management of forest resources and being an integral component of the forest products industries, the industry is struggling to fulfill its role and remain profitable at the same time. Given this, our study looked at the economic effects of the logging industry in the Lake States region of Michigan, Minnesota, and Wisconsin, with the aim of informing concerned stakeholders and policy makers of the importance of the logging industry to the regional economy. We began by assessing the economic contribution of the logging industry to each state and the regional economy using 2017 IMPLAN data and software and moved on to show how logging businesses are backward-linked to other industry sectors in the study region and how changes in the logging industry can be felt by these related industries. Next, we modeled a hypothetical but probable scenario of logging job loss in each state and its effects on the local economy. Finally, we estimated the change in economic footprint of major forest products industries, if a percentage of logs and roundwood (the commodities produced by logging industry) demanded by these industries is supplied by imports rather than through local suppliers.

Our findings show that the logging industry in the Lake States region directly employed over 12,000 people in 2017 and generated more than 900 million in direct economic output to the regional economy. Including ripple effects, the contributions were much higher. Direct income per logging job in the region as was found to be $43,364 which is close to the national average ($43,645) for the logging industry but less than that obtained nationally by the construction ($60,735) and mining industries ($76,278) in 2017 (U.S. Bureau of Labor Statistics QCEW, 2022). Among the states, the logging employees in Wisconsin received higher incomes per logging job compared to both Michigan and Minnesota, highlighting that

Wisconsin logging businesses have better wage opportunities than the other two states.

In a study assessing the trends in the U.S forest products industries, markets, and technologies, Espinoza (2020) noted that the changing demographics of forest products industries, particularly the logging industry with its aging workforce, may impact the overall productivity of forest products industries in the decades to come. With many in the existing logging workforce approaching retirement age, and not many new people interested in joining the profession, there remains a possibility of a labor shortage in the logging industry in the near future. Innovations in timber harvesting technology such as automation, robotics, and precision forestry may not be able to offset the labor shortages in the logging industry, at least in the next two decades (Espinoza 2020). Given this, it seems important to increase efforts for retaining and hiring logging employees in the coming years. Offering wages and benefits that are at least as attractive as other competing jobs (such as construction and mining) in the area could be one approach for making the profession more attractive for potential hires. Besides that, efforts could be made to meet the training and educational needs for new hires.

Next, to assess the economic impact of projected logging job loss on local economies, we modeled a hypothetical scenario where 20% of logging businesses in each state were assumed to leave the market. Though the scenario modeled is hypothetical, a recent mail survey of logging businesses in the Lake States region (Gc et al. 2020) indicated that more than 20% of logging businesses intended to exit from the market in the short-term future. Therefore, the modeled scenario is not improbable. Our findings reveal that a loss of 960 direct logging jobs in Michigan would lead to an additional loss of 395 jobs in other backward-linked industries (predominantly, all other crop farming; support activities for agriculture and forestry; and forestry, forest products, and timber tract production) within the state. Similar results were obtained for Minnesota and Wisconsin. These findings emphasize the interconnection of the logging industry with other backward-linked industries in the study region and show how changes in logging industry dynamics can impact these related industries. Since the predicted job losses are mostly rural jobs by nature, the negative economic impacts could be felt more severely by rural communities than urban ones.

We also noted that there were 18 industry sectors (including 13 forest products industries) in the three-state study region that used logs and roundwood as inputs for their production in 2017. Among the three states, Wisconsin was found to be more self-reliant in

terms of the demand for logs and roundwood that was met by producers located within that state. To assess the effect of import substitution to meet local demand for logs and roundwood in each state, we modeled a hypothetical scenario where a 20% loss in local logging capacity was assumed to be met through imports for five selected forest products industry sectors in each state. The selected five forest products industry sectors comprised more than 80% of the total gross demand for logs and roundwood in each state. Though the results obtained showed no change in direct economic contributions made by the selected five forest products industry sectors before and after import substitution, a sizable reduction in the indirect economic effects and some reduction in induced economic effects were noted after import substitution. Thus, if local demand for products generated by the logging industry needs to be met through imports, then a considerable portion of indirect and induced economic effects which could be realized within the state leak out of that state.

It is important to note here that the results obtained are based upon simplifying assumptions. IMPLAN is a static model, meaning that it does not account for dynamics such as price changes for labor and logs as the industries undergo change. IMPLAN is based upon the assumptions of fixed input structure and does not consider changes that are possible due to technological advancements. In reality, however, when there is a shortage for logs demanded by the primary forest products industries within a state, some industries may be able to pay more for logs while others may not.

In the case of import substitutions, the individual state models rely on imports to meet demand from various forest products industries. The three states are major timber trading partners with firms across the border. In 2018, of the total timber volume imported in Michigan, the majority (75%) came from Wisconsin, 21% came from Canada, and the remaining (4%) came from other U.S. states like Indiana, Ohio, and New York (U.S. Forest Service, Timber Products Output 2018). Likewise, of the total timber volume imported in Minnesota the same year, 91% came from Wisconsin and Michigan, 7% came from Canada, and 2% came from other U.S. states. In Wisconsin, 90% of the total timber volume imported in 2018 came from Michigan and Minnesota, 2% came from Canada, and the rest came from other U.S. states (U.S. Forest Service, Timber Products Output 2018). These statistics indicate that if there is a loss in within state logging capacity without replacement in Michigan, Minnesota, or Wisconsin, then the demand for timber within that state could most likely be

met by importing it from the other two states located in the region. However, if the decline in logging capacity is a regional phenomenon, as suggested by logging business literature, then it will be a challenge to meet the demand for timber in the region as only a small percentage of imported timber comes from states outside of the three Lake States. Imports in that case may have to originate from states located farther away or even out of the country. It is in the economic interest of a state to utilize local timber resources in a sustainable manner by using local human resources, as much as possible. Hence, our findings further emphasize the need to strengthen the logging industry, to not only have vibrant forest products industries but to have forest products industries whose economic footprints are more localized.

In general, our results reinforce that a change in an output from one industry in a region can not only have an impact on that industry, but also have ripple effects in all other related industries, thus influencing other industries' contributions to the regional economy. The true effect of a loss in capacity of a certain industry on other related industries may not be evident when only considering direct effects; nonetheless the effects are real and can be significant when indirect and induced effects are considered. The magnitude of the effect of a setback in one industry may be felt differently by related industries depending on their level of reliance on the affected industry for inputs. Though this study only considered the effect of a change in logging industry on other related forest products industries in the study region, the reverse is equally true. Closure of pulp and paper mills as well as sawmills can negatively impact the employment and output generated by the logging industry. Our findings are based upon simplifying assumptions; nonetheless, they provide important information about the logging industry's role in the economies of the Lake States region and their interconnections with other industry sectors in the study region. Such information can help concerned stakeholders understand the repercussions of changes in logging industry dynamics for local economies and related industries.

LITERATURE CITED

Abbas, D., R. Handler, B. Hartsough, D. Dykstra, P. Lautala, and L. Hembroff. 2014. A survey analysis of forest harvesting and transportation operations in Michigan. Croatian Journal of Forest Engineering. 35(2):179–192.

Allred, S.B. 2009. Logging firm succession and retention. Forest Products Journal. 59(6):31-36.

Allred, S., C. Michler, and C. Mycroft. 2011. Midwest logging firm perspectives: Harvesting on increasingly parcelized forestlands. International Journal of Forestry Research. 2011:1-7.

Aruna, P.B., F. Cubbage, K.J. Lee, and C. Redmond. 1997. Regional economic contributions of the forest-based industries in the South. Forest Products Journal. 47(7/8): 35-45.

Bailey, M.R., M.S. Crandall, A.R. Kizha, and S. Green. 2020. The economic contribution of logging and trucking in Maine. Economic development. 16. Available online at https://digitalcommons.library.umaine.edu/mcspc_ecodev_articles/16; last accessed April 28, 2022.

Baker, S.A., and W.D. Greene. 2008. Changes in Georgia's logging workforce 1987-2007. Southern Journal of Applied Forestry. 32(2):60-68.

Baker, S.A., B. Mei, T.G. Harris, and W.D. Greene. 2014. An index for logging cost changes across the US South. Journal of Forestry. 112 (3):296-301.

Blinn, C.R., T.J. O'Hara, D.T. Chura, and M.B. Russell. 2015. Minnesota's logging businesses: An assessment of the health and viability of the sector. Forest Science. 61(2):381-387.

Brandeis, C., and Z. Guo. 2016. Decline in the pulp and paper industry: Effects on backward-linked forest industries and local economies. Forest Products Journal. 66(1/2):113-118.

Conrad, J.L., W.D. Greene, and P. Hiesl. 2018. A review of changes in US logging businesses 1980s-present. Journal of Forestry. 116(3):291-303.

Egan, A., and D. Taggart. 2004. Who will log? Occupational choice and prestige in New England's north woods. Journal of Forestry. 15(6):20-25.

Espinoza, O. 2020. Trends in the U.S. forest products sector, markets, and technologies. In: Dockry, Michael J., Bengston, David N., Westphal, Lynne M., comps. Drivers of change in U.S. forests and forestry over the next 20 years. Gen. Tech. Rep. NRS-P-197. Madison, WI: U.S. Department of Agriculture, Forest Service, Northern Research Station: 26–49. https://doi. org/10.2737/NRS-GTR-P-197-paper4.

Gc, S., and K. Potter-Witter. 2011. An examination of Michigan's logging sector in the emerging bioenergy market. Forest Products Journal. 61(6):459-465.

Gc, S., K. Potter-Witter, C.R. Blinn, and M. Rickenbach. 2020. The logging sector in the Lake States of Michigan, Minnesota, and Wisconsin: Status, issues, and opportunities. Journal of Forestry. 118(5):501-514.

Goergen, M., J. Harding, C. Owen, M. Rey, and L. Scarlett. 2013. The state and future of U.S. forestry and forest industry. Available online at the-state-and-future-of-the-u.s.-forest-

industry.pdf (usendowment.org); last accessed April 28, 2023.

He, M., M. Smidt, W. Li, and Y. Zhang. 2021. Logging industry in the United States: Employment and Profitability. Forests 2021, 12, 1720. https://doi.org/10.3390/f12121720.

Henderson, J.E., and G.K. Evans. 2017. Single and multiple industry economic contribution analysis using IMPLAN. Forest and Wildlife research center, Research bulletin FO468, Mississippi State university. 12p.

Henderson, J.E., O. Joshi, R. Parajuli and W.G. Hubbard. 2017. A regional assessment of wood resource sustainability and potential economic impact of the wood pellet market in the U.S. South. Biomass and Bioenergy. 105(2017):421-427.

Jolley, G.J., C. Khalaf, G.L. Michaud, and D. Belleville. 2020. The economic contribution of logging, forestry, pulp and paper mills, and paper products: A 50 state analysis. Forest Policy and Economics. 115(2020)102140: 1-20.

Joshi, O., D.L. Grebner, J.E. Henderson, S.C. Grado, and I.A. Munn. 2012. Input-output modeling of wood-based bioenergy industries in Mississippi. Forest Products Journal. 62 (7-8):528-537.

Joshi, O, J.E. Henderson, S. Tanger, L. Boby, M. Pelkki, and E. Taylor. 2017. A synopsis of methodological variations in economic contribution analyses for forestry and forest-related industries in US South. Journal of Forestry. 115(2):80-85.

Lee, D.S. 2014. Economic contribution of the logging industry in New Hampshire. The center for rural partnerships. Plymouth State University. 14p.

Leefers, L., J. Poudel, D. Neumann, and Public Sector Consultants. 2020. Forest Products Industries' Economic Contributions: Michigan. Lansing Public Sector Consultants. 44p.

Leon, B.H., and J.G. Benjamin. 2012. A survey of business attributes, harvest capacity and equipment infrastructure of logging businesses in the Northern Forest. The University of Maine School of Forest Resources. 29p.

Malinen, P. 2001. Like father, like son? Small family business succession problems in Finland. Enterprise and Innovation Management Studies. 2(3):195-204.

McConnell, T.E. 2013. Segmentation of Ohio's logging industry based on productivity and cost variables. Forest Products Journal. 63(5-6):174-181.

Michigan Department of Natural Resources. 2022. Forest products industry. Michigan's forests provide renewable products and skilled jobs. Available online at Forest products industry (michigan.gov); last accessed April 29, 2023.

Miller, R., and P. Blair. 1985. Input-output analysis-Foundations and extensions. Prentice Hall Upper Saddle River, NJ.784p.

Mulkey, D. and A.W. Hodges. 2000. Using IMPLAN to assess local economic impacts. FE168. UF/IFAS Extension. Available online at http://edis.ifas.ufl.edu/pdffiles/FE/FE16800.pdf; last accessed August 31, 2019.

Munn, I.A., and J.E. Henderson. 2003. Forestry in Mississippi: The impact of the forest products industry on the Mississippi economy: An input-output analysis. Research Bulletin FO 216. Forest and Wildlife Research Center, Mississippi State University. 22p.

Parajuli, R., J.E. Henderson, S. Tanger, O. Joshi, and R. Dahal. 2018. Economic contribution analysis of the forest-product industry: A comparison of the two methods for multisector contribution analysis using IMPLAN. Journal of Forestry. 116(6):513-519.

Parajuli, M., P. Hiesl, M. Smidt, and D. Mitchell. 2020. Factors influencing productivity and cost in the whole-tree harvesting system. Clemson cooperative extension, land-grant press by Clemson extension. Clemson, SC. 8p.

Powell, M. 2021. Timber prices and inventories plummet in the Lake States. Forest2Market. Available online at Timber Prices & Inventories Plummet in the Lake States (forest2market.com); last accessed April 27, 2022.

Regula, J., R. Germain, S. Bick, and L. Zhang. 2018. Assessing the economic viability of loggers operating tree-length harvest systems in the Northeast. Journal of Forestry. 116(4):347-356.

Rickenbach, M., M. Vokoun, and S. Saunders. 2015. Wisconsin logging sector: Status and future direction. The University of Wisconsin Extension (G4073), Madison, WI. 23p.

Tilley, B.K., and I.A. Munn. 2007. Evaluating the change in regional economic contributions of forest-based industries in the South. Research Bulletin FO 310. Forest and Wildlife Research Center, Mississippi State University.

U.S. Bureau of Labor Statistics. 2022. Quarterly census of employment and wages. Available online at Bureau of Labor Statistics Data (bls.gov); last accessed April 21, 2022.

U.S. Forest Service, Forest Inventory and Analysis. 2022. EVALIDator web-application Version 1.8.0.01. Available online at EVALIDator Version 1.8.0.01 (usda.gov); last accessed April 29, 2022.

U.S. Forest Service, Timber Products Output. 2018. Forest inventory and analysis TPO data reporting tool. Available online at https://public.tableau.com/views/TPOREPORTINGTOOL/MakeSelection?:showVizHome=no; last accessed June 7, 2023.

Watson, P., J. Wilson, D. Thilmany, and S. Winter. 2007. Determining economic contributions and impacts: what is the difference and why do we care? Journal of Regional Analysis and Policy. 37(2):1-15.

CHAPTER 6. CONCLUSIONS

The overall goal of this study was to gain an insight into the current condition, capacity, structure, and economic potential of the logging industry in the Lake States region of the United States, composed of Michigan, Minnesota, and Wisconsin and to understand the recent challenges and prospects encountered by logging businesses. Since logging businesses are a critical component of the wood products supply chain, the health and vitality of the logging industry is crucial for the smooth functioning of all forest products industries. Timely and updated information about logging businesses is crucial for gauging the performance of the industry and for understanding its trajectory in the future.

To this end, in the second chapter of this dissertation, we used mail survey data collected from coordinated surveys of logging business owners in Michigan, Minnesota, and Wisconsin, to gain an understanding of the status and outlook of the logging industry in the region.

The results revealed many similarities among logging businesses in all three states. Despite the presence of many small logging businesses across the region (those harvesting 5,000 cords or less volume annually), volume production was found to be dominated by a few large producers (logging businesses harvesting more than 15,000 cords annually) who seemed to have an advantage over their smaller-sized counterparts. Across the region, large logging businesses were noted to be operated by relatively younger owners, had greater amounts of capital invested in their business, and owned newer equipment for business operation compared to smaller-sized logging businesses. A greater percentage of large logging businesses in the region indicated that they operated at full operational capacity compared to small producers.

Many logging businesses across the region were found to operate below their full operational capacity and to generate break-even profit levels. Low-capacity use can reduce the technical efficiency of logging businesses and make them less profitable. In the future, efforts to increase the capacity use of logging businesses through investment in better equipment, long term fiber agreements with mills, or flexibility in regulatory harvesting policies where appropriate may prove to be beneficial for the industry.

Logging businesses and business owners across the region were found to be aging and not many businesses had identified successors, raising concerns about the future of logging

businesses once the current owner retires. When asked about their plans for the short-term future, about a quarter of the logging businesses across the region said that they intended to exit from the market by 2022. To exacerbate the matter, not many enticing factors were noted to attract new people into the logging profession. In the future, a follow-up study of logging businesses in the region that intended to exit from the market by 2022 could be conducted to assess if such indicated market departures materialized or not.

Difficulty in recruiting and retaining employees in logging businesses has been a recurring issue highlighted in past logging business studies in the Lake States region and beyond. This is substantiated by the findings of our study. Looking at the age-class distribution of the logging business owners across the region, and the duration that their business has been in operation, the industry seems to lack young owners and new businesses. Only five percent of logging businesses in the region had owners who were 35 years or younger and 9% of logging businesses had opened their operations five years prior to the survey. The sense of independence that logging profession offers, the sense of accomplishment, and the enjoyment obtained from working outdoors, were listed as some of the important reasons for joining the logging profession by our respondent logging businesses owners. However, in addition to these factors, if wages and benefits offered by the profession are not as attractive as other competing jobs in the area, it is going to be a challenge to attract and retain employees in logging businesses in the future. Current loggers and logging business owners are predominantly white males. In the future to address the demand for logging workforce, efforts to diversify the pool of workers including women and people of other racial groups may be helpful.

In the third chapter of this dissertation, we assessed the similarities and differences between mechanized and chainsaw-based logging businesses in each of the three states. Many logging businesses in all three states utilized some form of mechanized felling equipment such as feller-bunchers or cut-to-length harvesters for felling timber. Approximately 33% of logging businesses in Michigan, 30% in Wisconsin and 17% in Minnesota harvested timber exclusively using chainsaws in 2016. Some variations in owner and business characteristics were noted among mechanized and chainsaw-based logging businesses in the study area. Mechanized logging businesses had a higher number of owners per business (statistically significant in the case of Minnesota and Wisconsin), were significantly more likely to be

family-run operations and had relatively younger owners (statistically significant in case of Minnesota and Wisconsin) as compared to chainsaw-based logging businesses. Mechanized logging businesses also had significantly greater amounts of capital invested in their business and were significantly more productive compared to chainsaw-based logging businesses. They obtained most of their timber from industrial, state and county forests and travelled 30 to 60 miles on average to get to the harvest site. Unlike mechanized logging businesses, chainsaw-based businesses operated on average within 30 miles of the business location and harvested most of the timber from nonindustrial private forests.

Although chainsaw-based logging businesses in the study area seemed to have a niche and were found to operate at good self-indicated profit levels at the time of the survey, the outlook for such logging businesses may not necessarily be optimistic, particularly in Wisconsin. The findings from the binary logistic regression model estimated to assess the factors influencing logging business owners' short-term longevity revealed that mechanized logging businesses in Wisconsin are more likely to remain in business in the short-term future than are non-mechanized businesses. The same variable was, however, not statistically significant in predicting logging business owners' short-term longevity in Michigan or Minnesota. Nonetheless, when looking at the proportion of total timber volume harvested by mechanized versus chainsaw-based logging businesses in Minnesota in the past (Blinn et al. 2015), the trend has been towards increasing harvest volumes by large logging businesses which tend to be mechanized operations and shrinking harvest volumes contributed by chainsaw-based logging businesses. In the U.S. South, most of the volume harvested is conducted by mechanized logging businesses (Conrad et al. 2018).

Our findings also revealed that a greater number of mechanized logging businesses compared to chainsaw-based businesses in the study area have thought about their business succession once the current owner retires. Approximately 50% or more of chainsaw-based logging businesses in all three states said that no one was going to take over the ownership of their business in the future, suggesting potential loss of such businesses after the existing owner retires. Since chainsaw-based logging businesses are found to concentrate their harvests on nonindustrial private woodlands which are known to be smaller in size compared to industrial and public forests, an important concern that arises with their predicted departures is who will conduct timber harvests on smaller-sized private woodlands in the

future. Mechanized logging businesses may likely fill the gap that will be left by departing chainsaw-based businesses in the future. But it remains to be seen if such harvests will be economically worth the outcome for mechanized logging businesses in the region, given their high equipment moving costs.

In the fourth chapter of this dissertation, we delineated the procurement areas for 115 logging businesses in Michigan individually and combined individual procurement areas to develop the wood basket for all respondent logging businesses within the state. The condition of timber resources and ownership type in the wood basket was then noted using FIA data. Also, areas with high versus low competition for timber resources were identified within the state. Approximately 15% of the total forest acres present in the combined wood basket of all respondent logging businesses in Michigan was found to have relatively low competition for timber resources while one percent had very high competition. Low competition areas were predominantly located in the Southern Lower Peninsula and upper portions of the Eastern Upper Peninsula regions of the state. High competition areas were concentrated in the Western Upper Peninsula and the upper portions of the Northern Lower Peninsula regions of the state. For logging businesses, low competition areas may offer a better bargaining opportunity with both landowners and mills for their logging services. On the contrary, for landowners, this may mean lower access to information on sales and prices than in higher competition areas.

The net annual growth (gross growth minus mortality) to removals ratios in the combined wood basket of all respondent logging businesses in Michigan was found to be 2.3 indicating that there is a potential for increased timber harvests without negatively impacting forest resources within the state. However, increased timber harvests in the future may have to come from forest ownership types other than corporate private ownership. This is because net growth to removals ratios for different forest ownership types in the wood basket indicated that corporate private owners are already removing timber almost at the levels of growth. To maintain the sustainable supply of timber resources within the state, increased harvests in the future should come from ownership types that have high net growth to removals ratio such as federal, state, and nonindustrial private ownership. Except for the corporate private ownership, annual mortality in all other ownership types in the wood basket was noted to be greater than removals, which is alarming from the standpoint of forest health and demands

closer attention from all concerned forest stakeholders.

Based upon their level of reliance on NIPFs for stumpage, we also categorized Michigan's respondent logging businesses as NIPF dependent and nondependent businesses in this chapter and similarities and differences between the two groups were explored. The results revealed that NIPF dependent logging businesses harvested significantly less volume per business and purchased a higher percentage of their own stumpage rather than obtaining it through brokers or mills compared to nondependent logging businesses. A significantly higher percentage of nondependent logging businesses used mechanized felling equipment compared to NIPF dependent businesses. Since NIPF ownership is the most prominent forest ownership type in Michigan, information about logging businesses that are heavily reliant on such businesses is important to understand as it can help inform how changes in such businesses may impact management of forest resources owned by NIPF owners and vice versa.

Finally, in the fifth chapter of this dissertation, we used 2017 IMPLAN data to understand the economic importance of the logging industry to each state and to the regional economy of the Lake States region. The findings from economic contribution analysis revealed that the logging industry employed over 12,000 people and generated more than $900 million in direct economic output to the regional economy of the three Lake States in 2017. Including indirect and induced effects, the contributions were much higher. The direct income per logging job in the region was estimated to be $43,364 which is much lower than that offered on average by other competing jobs such as construction and mining industries. This likely contributes to the difficulty in hiring and retaining logging employees in the region.

Given the aging cohort of logging business owners across the region and the indicated intentions of business owners to depart from the market in the short-term future, this chapter also conducted economic impact analysis to understand what it would mean if such departures did happen without replacement. The findings revealed that a loss of 960 logging jobs in Michigan would translate into an additional loss of 395 jobs in other backward linked industries within the state. Indirect and induced jobs losses were noted mainly in all other crop farming, support activities for agriculture and forestry, and forest products and timber tract production industries. Similar results were obtained in Minnesota and Wisconsin. Since the predicted job losses are mostly rural area-based jobs by nature, the negative economic impacts

of logging employment loss would be felt more severely by rural communities than the urban ones if it happened.

Additionally, in this chapter, we explored what role might import substitution play if there is a logging capacity loss in each state. The results revealed that if there is a loss in logging capacity within a state, which needs to be met through imports, then a considerable portion of the indirect and induced economic effects resulting from forest products industries within a state, leak out of that state. This results in a reduced localized economic footprint of forest products industries within each state. It is therefore in the economic interest of a state to use the local timber resource in a sustainable manner by using the local human resources, as much as possible.

Since Michigan, Minnesota, and Wisconsin are major timber trading partners due to their close geographic proximity, an assumption would be that a loss in logging capacity in one state may be fulfilled by increased production from the other two states. However, based upon the findings of the survey data from logging businesses in all three states, it is evident that potential loss in logging jobs is not an individual state issue, but is a regional phenomenon. A region level loss in logging capacity without replacement could mean a shortage of timber supply for forest products industries in the future. It is therefore in the interest of forest products industries in all three states to have a healthy logging industry that can respond to their timber supply needs.

One strategy to address potential logging capacity loss in the region is to focus on increasing the capacity use of existing logging businesses that are operating below their full operational capacity as mentioned earlier. Future research targeted at understanding the factors that limit logging businesses from operating at their full potential in the region, could shed light on targeted measures that could be taken to improve capacity use in the future. Other approaches that could assist logging businesses in improving their productivity and logging capacity could involve training programs to improve their operational efficiency, keeping logging business owners informed about advancements in logging technology through continuing education programs, and assisting them in upgrading their logging equipment though financial assistance.

Additionally, providing logging businesses with the support needed for their successional planning and business transition decisions, offering training programs to get new

business owners ready for business, and diversifying the pool of logging workforce could be other measures for supporting and strengthening the logging industry in the region. For such efforts to come to fruition, a collaborative effort will likely be needed on the part of forest products industry, forestry associations, government agencies, logging equipment vendors and academia alike.

Other approaches to support the logging industry in the long run which may not be as direct, would be by advocating for policies that promote sustainable forestry practices which also addresses the challenges faced by the industry. This could include efforts to raise awareness among the public about the importance of the logging industry in supplying renewable wood products, and in maintaining healthy forest systems. This could help dispel the misconception that is prevalent among the public about the logging industry's environmental impact and may help attract new employees into the profession.

Of note, this study is not without its limitations. The results obtained from Chapters 2, 3, and 4 are based upon the survey data collected from logging business owners in Michigan, Minnesota, and Wisconsin. Though the response rates for Wisconsin and Minnesota logging surveys are high compared to other logging business studies across the country, it is not the case for Michigan. Despite the lack of evidence concerning non-response bias in the obtained dataset for Michigan, its impact in case of lower response rate cannot be ruled out completely. To address this issue of low response rate in Michigan in the future, efforts could be made to maintain a robust list of all operating logging businesses within the state. Besides that, some form of monetary incentive may help to improve the response rate in future surveys.

The wood basket areas with high versus low competition for timber resources estimated in Chapter 4 are based upon the data collected from a limited number of logging businesses located in Michigan. In the future, similar analysis could be conducted using a broader sample size and larger geographic area incorporating logging businesses in the adjoining state of Wisconsin to provide a more holistic picture of competition levels among logging businesses in the state. In the same chapter, resource condition estimates including growth, removals and mortality that are obtained using FIA data are subject to sampling error.

Likewise, results obtained from economic contribution and impact analysis in Chapter 5 are based upon the simplifying assumptions and the findings obtained from IMPLAN are subject to limitations of the model. IMPLAN is a static model that does not account for

dynamics such as price changes for labor and logs as industries undergo change. Also, IMPLAN is based upon the assumptions of fixed input structure and does not consider changes that are possible due to technological advancements.

Nonetheless, the results obtained from the study provide useful baseline information about the status, structure, and capacity of logging businesses in the Lake States region. It also emphasizes challenges faced by the industry in recent times and highlights the economic importance of logging industry to regional economies. Periodic surveys of logging businesses conducted across the region using comparable questionnaires could be useful in gauzing the performance of the industry over time and in understanding how the industry evolves.

A significant event that has affected societies and global economies in the recent years has been the outbreak of a pandemic caused by a new coronavirus in 2019 also known as Covid-19 pandemic. To contain the spread of this virus, several different measures were taken globally regionally, and at state levels including self-isolation, travel restrictions, and shutting down of portions of the economies. Relevant to forest products industries, disruptions were noted in supply chains, labor shortages, and modifications in demand for wood products. Given this, an important area of future research regarding logging businesses in the Lake States region and beyond would be to assess the impact of Covid-19 related market disruptions on the productivity and profitability of the industry.

APPENDIX A. SURVEY QUESTIONNAIRE

Michigan 2017 Logger Survey

Department of Forestry
MICHIGAN STATE UNIVERSITY

1885
Michigan Tech
School of Forest Resources
and Environmental Science

Michigan 2017 Logger Survey

1. Do you own or manage an independent logging business?

○ Yes → **Go to Question 3, below**

○ No

2. Have you owned or managed an independent logging business in the past? If so, please indicate the year you stopped logging.

○ Yes, stopped logging in: ____

○ No

Please go to page 12 if you do <u>not</u> currently own or manage an independent logging business.
You do not need to complete the questionnaire, but we welcome your comments on the logging industry in the box on the back cover.

3. In what county is your business based? ____

4. We would like to begin with some questions about timber you harvest. In answering these questions please provide your best estimates. Remember, all your answers will remain strictly confidential.

In 2016, what was the total volume of timber you harvested? Please use the units that best fit your recollection. For example, "10,000 cords and 20,000 board feet."

	Volume	
a.		Cords
b.		Thousand board feet (MBF)
c.		Cunits
d.		Green tons (biomass)
e.		Green tons (clean chips)
f.		Other unit (please specify below):

Please continue to Question 5 above. ↗

5. What log rules do you use for sawtimber volumes?

a. International	
b. Doyle	
c. Scribner decimal C	

6. In 2016, of the timber you harvested, what percentage of your stumpage was purchased by others, such as a mill, and what percentage was purchased by you? These should total 100%.

	Percent
a. Stumpage purchased by others	
b. Stumpage purchased by you	
Total	**100%**

7. In 2016, how many of your timber sales were in each of the following acreage categories? If none, please write in "0".

	Number of sales completed	Number of sales partially completed
a. 0-5 acres		
b. 6-10 acres		
c. 11-20 acres		
d. 21-40 acres		
e. 41-80 acres		
f. 81-160 acres		
g. 161 acres or more		

8. In 2016, what percentage of your harvest volume was in each of the following product categories? If none, please write in "0." These should total 100%.

	Percent of volume
a. Veneer	
b. Hardwood pulp	
c. Hardwood sawtimber	
d. Softwood pulp	
e. Softwood sawtimber	
f. Clean chips	
g. Biomass	
h. Other (please specify)	
Total	100%

9. For this question, think about the landowner, not the permit holder. In 2016, what percentage of your harvest volume came from the following ownership categories? If none, please write in "0." These should total 100%.

	Percent of volume
a. Private woodlands/non-industrial forests	
b. Industrial or corporate owned forests	
c. National forests	
d. State forests	
e. County forests	
f. Tribal forests	
g. Other (please specify):	
Total	100%

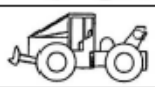
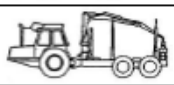
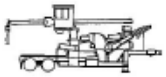
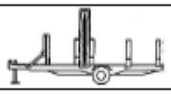
10. In 2016, what was your average one-way travel distance, in miles, from your primary business location to the timber harvest site?

- ○ 30 miles or less
- ○ 31 to 60 miles
- ○ 61 to 90 miles
- ○ 91 to 120 miles
- ○ 121 to 150 miles
- ○ More than 150 miles

11. In 2016, what was your average one-way travel distance, in miles, from your harvest site to the mill?

- ○ 30 miles or less
- ○ 31 to 60 miles
- ○ 61 to 90 miles
- ○ 91 to 120 miles
- ○ 121 to 150 miles
- ○ More than 150 miles

12. In 2016, not including older pieces of machinery that were non-operational or used only for spare parts, how many of the following pieces of in-woods equipment did you own and actively use? If none, write "0" in the "Number of Pieces" column. Also, please indicate the age in years of the newest piece of equipment for each category.

			Jan 1st 2016		Dec 31st 2016	
			Number of pieces	Age of newest piece	Number of pieces	Age of newest piece
a.	Chainsaws / hand delimbing					
b.	Cut-to-length (CTL) Harvesters					
c.	Feller-bunchers					
d.	Cable skidders					
e.	Grapple skidders					
f.	Forwarders					
g.	Mechanical delimbers					
h.	Chippers					
i.	Grinders					
j.	Slashers					
k.	Flail debarkers	(no image)				
l.	Loaders	(no image)				
m.	Bulldozers					
n.	Other (please specify):					

13. In 2016, what percentage of your harvest volume was felled by each of the following felling methods? If none, please write "0." These should total 100%.

		Percent of volume
a.	Chainsaw	
b.	Cut-to-length (CTL) harvester	
c.	Drive-to-tree feller-buncher	
d.	Reach-to-tree feller-buncher	
e.	Other (please specify below)	
	Total	100%

○ Did not fell timber

14. In 2016, not including older pieces of machinery that were non-operational or used only for spare parts, how many of the following pieces of over the road equipment did your logging business own and actively use? If none, please write "0."

		No. of pieces	Age of newest piece
a.	Tractor (semi)		
b.	Pulp/sawtimber trailer		
c.	Self-loading truck/trailer		
d.	Lowboy		
e.	Pole trailer		
f.	Van/walking floor trailer		
g.	Other (please specify below)		

15. In 2016, what percentage of your harvest volume was transported to mills by trucks you own, and what percentage by trucks you contracted? If none, please write "0." These should total 100%.

	Percent of volume
Owned	
Contracted	
Total	100%

16. In 2016, about how many gallons of fuel did your logging business use?

		Number of gallons
a.	Off road fuel purchases in gallons	
b.	On road fuel purchases in gallons	

17. In total, how much capital is invested in your logging business?

○ Less than $100,000
○ $100,000 to $499,999
○ $500,000 to $999,999
○ $1,000,000 to $1,999,999
○ $2,000,000 to $2,999,999
○ $3,000,000 or more

18. What percentage of that capital is invested in each of the following categories? If none, please write "0." These should total 100%.

		Percent of capital
a.	Harvesting equipment	
b.	Off-road transport equipment	
c.	Over-the-road hauling equipment	
d.	Stumpage	
e.	Other	
	Total	100%

19. In general, how difficult is it for your business to access capital, such as loans and letters of credit?

- ○ Very easy
- ○ Somewhat easy
- ○ Neither easy nor hard
- ○ Somewhat hard
- ○ Very hard

20. How would you rate the profitability of your business in 2016?

- ○ Very poor
- ○ Poor
- ○ Average (broke even)
- ○ Good
- ○ Excellent

21. Operating at full capacity means that no additional volume can be produced. In 2016, did your logging business operate at full capacity?

- ○ Yes → **Go to question 23**
- ○ No

22. In 2016, if you had operated at full capacity, how much more could you have harvested with your existing equipment?

	Volume	
a.		Cords
b.		Thousand board feet (MBF)
c.		Cunits
d.		Green tons (biomass)
e.		Green tons (clean chips)
f.		Other unit (please specify measurement unit below):

23. Including paying yourself, what volume of wood do you need to harvest annually to break even financially?

	Volume	
a.		Cords
b.		Thousand board feet (MBF)
c.		Cunits
d.		Green tons (biomass)
e.		Green tons (clean chips)
f.		Other unit (please specify measurement unit below):

24. In 2016, of the timber you harvested, what percent was hardwoods and softwoods? These should total 100%.

		Percent of volume
a.	Aspen	
b.	Other hardwoods	
c.	Pine	
d.	Other softwoods	

25. In 2016, of the timber you harvested, what type of timber product do you have difficulty selling? Please mark with an X

a.	Pulpwood	
b.	Sawlogs	
c.	Veneer bolts	
d.	Whole tree chips	
e.	Poles/posts	
f.	Other (please specify below)	

26. In 2016, did your logging business produce clean chips?

○ Yes → Go to question 29
○ No

27. If not, would you be interested in producing clean chips in the future?

○ Yes
○ No

28. If you did not produce clean chips in 2016, what were the barriers to doing so?

29. In 2016, how many timber sales did you harvest in areas that include wetlands?

	Percentage of harvest area in wetlands	No of timber sales harvested
a.	0-25% wetlands	
b.	26-50% wetlands	
c.	51-75% wetlands	
d.	76-100% wetlands	

30. In 2016, what percentage of your production came from wetland sites?

Percent

31. Does harvesting on wetland sites take longer, shorter, or the same amount of time compared to what it would have taken you to harvest the same sales had they occurred on non-wetland sites?

Longer	Shorter	Same amount of time
○	○	○

32. In 2016, on what percentage of your logging jobs did you leave logging residues (tops, chips, sawdust, bark etc.) on site?

Percent

33. Are you a Certified Master Logger or chain of custody certified through the Forest Stewardship Council (FSC) or Sustainable Forest Initiative (SFI)?

	Yes	No
Certified Master Logger		
FSC		
SFI		

34. How many years has this company been in operation as of 2016?

Years

35. Do you expect to be in the logging business 5 years from now?

○ Yes → Go to Question 37
○ No

36. Why you do expect you will not be in the logging business 5 years from now?

37. A family business is one in which the family plays a central role in the leadership and daily workings of the business and includes at least two family members, such as a father and son, or a husband and wife. Based on this definition, is your company a family business?

○ Yes
○ No

38. Looking into the future, who will most likely take over ownership of your business?
Check only one response.

- ○ Family member (son, daughter, niece, nephew, spouse, sibling)
- ○ Current employee or sub-contractor
- ○ Other
- ○ Don't know
- ○ Nobody

39. For each of the following technologies, please indicate whether you have it available in your home or office for business use. For each technology available, please indicate how often you or someone else within your business uses it for business purposes by placing X in the appropriate box.

	Technology	Available in home or office		Frequency with which you access or use technology					
		Yes	No	Never	Once a year or less	Once per month	Once per week	Once a day	Multiple daily uses
a.	Dial-up internet	○	○	○	○	○	○	○	○
b.	High speed or broad band internet	○	○	○	○	○	○	○	○
c.	Smartphone	○	○	○	○	○	○	○	○
d.	Desktop computer	○	○	○	○	○	○	○	○
e.	Laptop computer	○	○	○	○	○	○	○	○
f.	Tablet computer	○	○	○	○	○	○	○	○
g.	Global positioning system (GPS)	○	○	○	○	○	○	○	○
h.	Geographic information system (GIS)	○	○	○	○	○	○	○	○

40. For each of the following standard measures, please indicate how often you or someone else within your business uses the standard measures by placing X in the appropriate box.

	Standard measure	Frequency with which you use standard measure					
		Never	Once a year or less	Once per month	Once per week	Once a day	Multiple daily uses
a.	No. of loads delivered	○	○	○	○	○	○
b.	Unit cost of production ($/MBF/$/Cord, $/ton)	○	○	○	○	○	○
c.	Machine utilization rate	○	○	○	○	○	○
d.	Customer/client satisfaction	○	○	○	○	○	○
e.	Number of acres harvested	○	○	○	○	○	○
f.	Visual assessment of jobsite	○	○	○	○	○	○
g.	Financial measures (profits, return on investment)	○	○	○	○	○	○
h.	Other	○	○	○	○	○	○

41. For the next two questions, the term employee refers to any worker for whom you withhold taxes, pay unemployment insurance, pay worker's compensation insurance, and/or report as an employee to the IRS. The term subcontractor refers to any worker who is considered self-employed and for whom you do not withhold taxes, pay unemployment insurance, pay worker's compensation insurance, and do not report as an employee to the IRS.

In 2015 and 2016, how many employees and subcontractors did your logging business employ or work with? Please report position types based on each worker's primary responsibility. Include yourself by circling the position type that best describes how you spend the majority of your time.

	2015		2016	
	Employees	Subcontractors	Employees	Subcontractors
a. Woods workers				
b. Truck drivers				
c. Procurement				
d. Mechanics				
e. Office and clerical				
f. Supervisor/manager				
g. Landowner assistance forester				

42. Thinking only of your woods worker subcontractors, please indicate the number you contracted with according to how many months they contracted with you in 2015 and 2016.

	Number of woods worker subcontractors who contracted with me…			
	Less than 1 month	1 to 3 months	4 to 6 months	More than 6 months
2015				
2016				

43. In making your decision to enter the logging business, how important were the following?

	Not at all	A little	Somewhat	Very	Extremely
a. I am from a logging family	○	○	○	○	○
b. I enjoy working outdoors	○	○	○	○	○
c. I enjoy the sense of independence	○	○	○	○	○
d. It gives me a sense of accomplishment	○	○	○	○	○
e. I like that it is challenging work	○	○	○	○	○
f. It pays well	○	○	○	○	○
g. It is a respected profession in my community	○	○	○	○	○
h. It is in line with my career goals	○	○	○	○	○
i. It gives me the flexibility to stay in the area	○	○	○	○	○
j. Other, please specify below :	○	○	○	○	○

44. Would you encourage members of your family or your close friends to become a logger?

- ○ Yes
- ○ No
- ○ Not sure

45. Listed below are aspects of the logging business that may affect a decision to become a logger. In general, how much do you think each of the following encourages or discourages the entry by new people into the logging business?

	Greatly discourages	Somewhat discourages	Neither encourages or discourages	Somewhat encourages	Greatly encourages
a. Physical demands of the job	○	○	○	○	○
b. Work environment	○	○	○	○	○
c. Pay or wages	○	○	○	○	○
d. Benefits package	○	○	○	○	○
e. Prestige associated with work	○	○	○	○	○
f. Availability of competing jobs in the area	○	○	○	○	○
g. Skills necessary to perform logging operations	○	○	○	○	○
h. Health of logging industry	○	○	○	○	○
i. Other, please specify:	○	○	○	○	○

46. How many owners does your business have in total?

☐ **Number of owners**

47. For each owner of this business, what is the owner's age in years? Also, not necessarily only as the owner, how many years in <u>total</u> has each owner worked in the logging industry?

	Age of owner in years	Total number of years in logging industry
a. Owner A (You)		
b. Owner B (if applicable)		
c. Owner C (if applicable)		

(Attach additional sheets if necessary)

48. What is the highest level of education completed by each owner of this business?

	Owner A (YOU)	Owner B (if applicable)	Owner C (if applicable)
Junior high school or less (grade 8 or less)	○	○	○
Some high school – no diploma	○	○	○
High school graduate, or GED	○	○	○
Some college	○	○	○
College graduate – vocational or 2-year college (associate's degree)	○	○	○
College graduate – 4- or 5-year college (bachelor's degree)	○	○	○
Some graduate school – no degree	○	○	○
Graduate school – master's, doctorate, or other advanced	○	○	○

(Attach additional sheets if necessary)

49. In your opinion what are the major issues facing the future of your logging business? Please indicate how important each is to your business. Please also rank the top 5 issues in order of importance by writing a number (1 to 5) in the "Rank column".

		Not at all important	Not very important	Neither important nor unimportant	Somewhat important	Very important	Rank (top 5 only)
a.	Stumpage prices	○	○	○	○	○	
b.	Mill prices	○	○	○	○	○	
c.	Private stumpage available for sale	○	○	○	○	○	
d.	Public stumpage available for sale	○	○	○	○	○	
e.	Assessing timber sales (roads, permission etc)	○	○	○	○	○	
f.	Regulatory requirements	○	○	○	○	○	
g.	Attracting and hiring employees	○	○	○	○	○	
h.	Retaining employees	○	○	○	○	○	
i.	Employee training	○	○	○	○	○	
j.	Benefits (not including worker's compensation)	○	○	○	○	○	
k.	Worker's compensation	○	○	○	○	○	
l.	Operating costs (e.g., fuel)	○	○	○	○	○	
m.	Insurance costs	○	○	○	○	○	
n.	Equipment maintenance	○	○	○	○	○	
o.	Equipment replacement	○	○	○	○	○	
p.	Competition for stumpage	○	○	○	○	○	
q.	Small contracts from mills for products	○	○	○	○	○	
r.	Contract length	○	○	○	○	○	
s.	Other, please specify below	○	○	○	○	○	

50. Would you like to receive a copy of the results of this survey? (Expected in Spring 2018.)

○ Yes
○ No → Go to question 51

To receive a copy of the results, please write your name and mailing address in the space below.

Name:

Address:

City: State: Zip code:

51. If you have additional comments on the logging industry, please tell us.

Thank you for your help with this study!

Please return your completed questionnaire
in the postage-paid envelope provided to:

Michigan Logger Study
208 A Natural Resources Building
480 Wilson Road
Department of Forestry
Michigan State University
East Lansing, MI 48824
karen@msu.edu