

# An Examination of Michigan's Logging Sector in the Emerging Bioenergy Market

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## Abstract

Logging firms, as suppliers of raw material, form an important part of Michigan's forest products industry. Given the increasing interest in wood-based bioenergy production, their role has become increasingly important. For this study, we used a mail survey of Michigan's logging firms to provide an outlook of the logging sector within the state. The aim was to understand the status of existing logging businesses and to explore their potential role in the woody biomass supply chain. Our findings reveal that the state's logging firms have been facing difficulty in retaining their business and in running operations profitably in recent years. Mill closures in the past decade have had significant negative impacts on half of the responding firms. Given this situation, the introduction of wood-to-energy facilities could provide new market opportunities for logging firms in the state. Loggers in general were found to be supportive of introducing such facilities in their wood basket. Availability of timber to meet the feedstock demands of new and existing facilities could, however, become a challenging issue in the future. Insufficient timber sales and high stumpage prices were identified as the major barriers to increased harvesting by the logging firms in our survey. On average, the responding firms reported that in the majority (83%) of their logging jobs, they leave logging residues on site, suggesting that there is little or no market for such materials at present. This could change, however, with market development and improvement in the logging and transportation facilities in the future.

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In light of increasing concerns over energy security, economic growth, and environmental health, woody biomass has recently gained significant attention as a source of energy (Perez-Verdin et al. 2008, Benjamin et al. 2009, Galik et al. 2009, G.C. and Mehmood 2010). Nationwide, pressure is mounting to meet increasing energy demands through renewable local resource mobilization rather than through importing unsustainable fossil fuels (Healthy Forests Restoration Act of 2003, Energy Policy Act of 2005, the Energy Independence and Security Act of 2007). Michigan is not exempt from these pressures. The state is rich in forest resources that can be used for generating renewable energy. Michigan's forests cover approximately 19.9 million acres, of which 19.3 million acres are considered to be timberlands (US Department of Agriculture [USDA] Forest Service 2009). The total forest area in the state increased by 1.5 million acres between 1980 and 2008 (USDA Forest Service 2009), and the inventory data indicate that there is greater wood accumulation than there is removal in recent years (Pugh 2008). Currently, the average annual live tree removals from Michigan timberlands is approximately 378 million cubic feet per year, which is less than half of the average annual net growth of 763 million cubic feet per year (USDA Forest Service

2009). This shows a large surplus inventory, which if used in a sustainable manner, can not only generate economic opportunities at the local level but also contribute toward energy security and environmental health. However, the amount of biomass available for conversion to bioenergy is determined, among other things, by the capacity of the logging sector in the state.

Logging firms are responsible for commercial harvest of timber and form a bridge between forest resources and wood-based industries. They not only help meet society's demand for wood products, but also assist forest owners in realizing varied management objectives (Rickenbach et al. 2005). Through their operations, loggers shape the structure and composition of forests and determine both the present and future productivity of the regions' forests (Rickenbach et al. 2005). Hence, they play an indispensable role in the maintenance of overall forest health and productivity.

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Given the emerging bioenergy market, the role of the logging sector becomes even more critical. Information on current harvesting capacity of the logging firms in Michigan, their strengths and weaknesses, and the challenges they face is crucial for understanding both the current and future roles of this sector in the bioenergy supply chain.

Few studies have been conducted to date to provide an outlook on the logging firms in the United States (Greene et al. 2001; Egan 2004, 2009; Rickenbach et al. 2005; Milauskas and Wang 2006; Bolding et al. 2010). Concern about logging capacity and perceived reduction in the logging workforce has been the motivation for some of these studies (Egan 2004, Egan and Taggart 2004). However, none of them have focused on the logging sector from a bioenergy perspective. This study was, therefore, an attempt to address this gap at a critical time. The aim was to identify the status of professional logging firms in Michigan, which is essential for exploring harvesting potential should market conditions for timber products and wood-based biomass improve in the future. Also, results of the study will provide insight into the challenges faced by Michigan's logging firms and their opinions on the establishment of new wood-to-energy facilities in their wood basket. Such information will assist policy makers and concerned stakeholders in making informed decisions regarding the promotion of wood-based bioenergy while considering the potential impact that such measures can have on the logging sector, forest resources, and forest-based economies in the state. Also, the results are expected to provide a time-series baseline of Michigan's logging sector for future comparisons.

### Study Methods

To gather information about logging businesses in Michigan, a mail survey was conducted in the fall of 2008. The list of loggers for the survey was obtained from a database of the Michigan forest products industry maintained by the Michigan Department of Natural Resources (DNR) and was supplemented with the list of 2007 state forest timber sale bidders also maintained by the DNR. A census of all 1,085 logging firms located in Michigan was conducted based upon the tailored design method by Dillman (2000). The method involved sending a presurvey postcard and then mailing the survey, including a cover letter and business reply envelope, to all the logging firms in the state. Two weeks after sending out the initial survey, reminder postcards with a thank you note were sent to all the loggers. Following this, a full mailing of the survey was sent to the loggers who had yet to respond. The questionnaire focused on logging firm characteristics, business characteristics, timber supply, and the opinion of logging firms on the introduction of additional wood-using facilities, including bioenergy, in their operating area. Of the total questionnaires mailed initially, 122 respondents returned the survey. The overall response rate was 12 percent after taking into account the undeliverable addresses. Of the total surveys returned, 50 percent of the respondents ( $n = 61$ ) indicated that they were no longer in the logging business. The respondents who had gone out of business at the time of the survey were not required to fill out the remaining section of the questionnaire. Hence our analysis includes the responses of 61 logging firms that were operating in the state of Michigan at the time of the survey. Though the response rate for this study is relatively low, studies with similar response

rates (Greene et al. 2001, Milauskas and Wang 2006) have been observed in different parts of the country in the past. A monetary incentive to the respondents or follow up with a telephone survey could be a beneficial approach for augmenting better response rates in the future.

Because we are trying to understand the status of logging firms in Michigan, it is important to be able to say with some certainty that the responses obtained are representative of the logging firms in the entire state. For this, it is essential to conduct a nonresponse bias test before generalizing the results for the population. The nonresponse bias test for this study was conducted using the method described by Armstrong and Overton (1977). If the responses of the early and late respondents (those that respond immediately after receiving the survey and those that need additional stimulus, for example, a second wave of survey to respond) are similar, then generalizing the response data across the sample population should be valid (Armstrong and Overton 1977). The responses of the first 30 respondents were, therefore, compared with those of the last 30 respondents using two-sample  $t$  tests and Mann-Whitney  $U$  tests (a nonparametric equivalent of two-sample  $t$  test). The variables compared included the number of employees, duration of ownership, operating capacity, percentage of the production delivered to different facilities, source of timber for logging facilities (nonindustrial private forests, state forests, and national forests), and delivery distance. No significant differences in the responses of the early and late respondents were observed, thus ruling out the concern for nonresponse bias.

### Results

The results of the study are presented for the entire state and for four geographic subregions: the Eastern Upper Peninsula (EUP), the Western Upper Peninsula (WUP), the Northern Lower Peninsula (NLP), and the Southern Lower Peninsula (SLP). The regional breakdown of the data is done to assess potential variability in the logging sector as a result of varied physiographic conditions, forest conditions, forest ownership patterns, and forest management practices existent in these regions. Of the total surveys received, the highest percentage of responses came from the NLP (34%), followed by the WUP (26%), the EUP (25%), and the SLP (15%). Since there are relatively larger numbers of logging firms located in the NLP and WUP compared with the EUP and the SLP (Michigan DNR 2010), such a response pattern was expected. Both parametric and nonparametric statistical tests were conducted to determine whether significant differences existed among the regions. An alpha level of 5 percent was used for all the statistical tests.

### Logging firm characteristics

The current logging businesses in Michigan have been in existence for an average of 29 years. Relatively few (11%) of the 61 responding firms that are still in business are less than 10 years old, whereas a substantial percentage of them (42%) have been operating for more than 30 years (Fig. 1). These findings are consistent with those obtained by Rickenbach et al. (2005) from their study of the logging sector in Wisconsin and Michigan's Upper Peninsula. The results indicate long-term commitment on the part of loggers toward their business. Among the regions, the logging firms in the NLP are relatively older operations

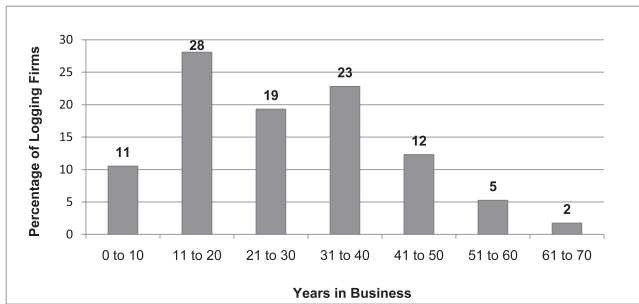


Figure 1.—Distribution of the logging firms in Michigan by the number of years in business.

(mean operation age, 36 years) compared with those in the other three regions (EUP, 29 y; WUP, 28 y; SLP, 19 y). However, the difference was not statistically significant using a 1-way analysis of variance test ( $P = 0.074$ ).

Responding firms employed 1 to 45 individuals to run their operations in 2007, with the mean statewide number being 7 employees. Approximately 60 percent of the responding firms had 5 or fewer employees, whereas 6 percent had more than 20 employees (Fig. 2). This shows the prevalence of a large number of small logging businesses within Michigan. The median number of employees was more or less consistent among the regions (EUP, three employees; WUP, four employees; NLP, four employees; SLP, five employees), and no significant difference was observed using independent samples median test ( $P = 0.936$ ).

## Production

The logging firms in our survey were asked to indicate the percent capacity at which they operated in 2007. On average, Michigan logging firms were found to operate at 82 percent of their full capacity. Among the regions, logging firms in the NLP operated at the highest capacity (86%) followed by those in the SLP (83%), the EUP (79%), and the WUP (76%). Although the difference among regions was not statistically significant in the independent samples median test ( $P = 0.136$ ), it was consistent with the distribution pattern of primary wood products manufacturing facilities in the state. According to the Michigan DNR (2010), there are 138 primary wood products manufacturing facilities located in the NLP, 111 in the SLP, 41 in the EUP, and 25 in the WUP. The average logging firm harvested a median volume of approximately 225 thousand board feet

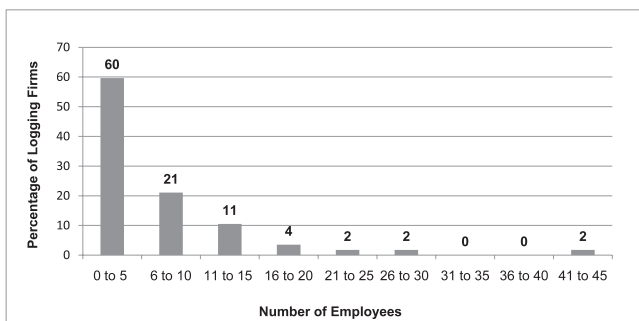


Figure 2.—Distribution of the logging firms in Michigan by the number of employees.

(MBF) of sawtimber, 500 cords of boltwood, and 3,788 cords of pulpwood roundwood in 2007. No significant difference in the median volume of sawtimber, boltwood, or pulpwood roundwood volume harvested was observed among the regions using nonparametric median tests ( $P = 0.184, 0.054, \text{ and } 0.830$ , respectively). However, it should be considered that only 38 percent of the logging firms in the SLP indicated that they harvested pulpwood, while 88 percent of them harvested sawtimber in 2007. In other regions, 78 percent or more responding firms harvested sawtimber, boltwood, and pulpwood in 2007. Among the species, aspen (*Populus* spp.) contributed approximately one-fifth (21%) of the total sawtimber volume harvested; other hardwoods contributed 66 percent, pine (*Pinus* spp.) 10 percent, and other softwoods 3 percent. The average stumpage price for sawtimber ranged from \$63/MBF for aspen to \$204/MBF for other hardwoods. Likewise, the average delivered price ranged from \$159/MBF for aspen to \$492/MBF for other hardwoods. Pine formed the major source of boltwood roundwood volume harvested in 2007. It contributed approximately 41 percent of the total boltwood volume harvested, followed by hardwoods other than aspen (28%), aspen (23%), and softwoods other than pine (7%). In the case of pulpwood, hardwoods other than aspen contributed 37 percent of the harvested volume, followed by aspen (28%), pine (23%), and other softwoods (11%). The average stumpage price for boltwood ranged from \$22 per cord for softwoods other than pine to \$45 per cord for pine. Likewise, the average delivered price for boltwood ranged from \$104 per cord for pine to \$116 per cord for hardwoods other than aspen. In the case of pulpwood, the average stumpage price ranged from \$19 per cord for hardwoods other than aspen as well as softwoods other than pine to \$29 per cord for pine. Similarly, the average delivered price for pulpwood ranged from \$75 per cord for aspen to \$92 per cord for pine. Only 4 percent of the total pulpwood volume harvested was chipped at the logging site.

The average logging firm in our survey indicated that on 83 percent of their logging jobs they leave logging residues on site after harvesting timber. This number varied significantly among the regions when using the independent samples Kruskal-Wallis test ( $\chi^2 = 10.182, df = 3, \text{ and } P = 0.017$ ). The logging firms located in the EUP and the WUP left logging residues on site in a significantly higher percentage of their logging operations (85% and 90%, respectively) compared with those in the NLP (64%). This was evident from the Mann-Whitney  $U$  test for the EUP and NLP ( $P = 0.025, U = 184.00$ ) and the WUP and NLP ( $P = 0.008, U = 211.00$ ). The data thus suggest the opportunity to increase logging residue removal in Michigan, particularly in the Upper Peninsula, since logging residue could prove to be an important source of feedstock for generating bioenergy in the future. One factor contributing to the difference in logging residues removal among regions could be the difference in harvesting systems employed by the logging firms in these regions. Higher recovery of logging residues in the NLP could be suggestive of more harvesting operations employing whole tree harvesting in this region. Likewise, lower recovery of logging residues in the Upper Peninsula could be suggestive of more cut-to-length operations in this region. If that is the case, it might take some time and considerable investment before cut-to-length operations can be geared toward recovering harvest residues.

The logging firms were also asked if they would expand their operation if market conditions in the future were favorable. To this, 75 percent of the respondents indicated that they were willing to do so. Among the regions, 88 percent of the respondents in the SLP, 77 percent in the WUP, 72 percent in the NLP, and 69 percent in the EUP were willing to expand their operation if market conditions improved in the future. This does not include the respondents who were out of business at the time of the survey. Some of these logging firms may not have liquidated their equipment and capital and hence could resume the business in case of favorable market conditions in the future.

### Source of timber

Nonindustrial private forests (NIPFs), comprising 8.7 million acres of forest area, were found to be the dominant source of timber supply for Michigan's logging sector. Approximately 64 percent of the total timber logged in 2007 came from this ownership group, followed by the state forests (16%), industrial forests (11%), and national forests (4%; Fig. 3). No significant difference in the source of timber was observed among the regions using independent samples median test ( $P = 0.433$  for NIPFs,  $P = 0.688$  for forest industry,  $P = 0.834$  for state forests,  $P = 0.533$  for national forests, and  $P = 0.381$  for other public lands).

### Harvesting conditions

The respondent logging firms indicated that more than half (54%) of their total production in 2007 involved buying stumpage and selling logs or chips to mills (with or without a delivery contract). Approximately 31 percent of the production involved harvesting stumpage owned by another company or individual, and the remaining 15 percent involved harvesting timber for their own company's use. The percentage of total production obtained from harvesting stumpage owned by another company or individual varied significantly among the regions when using the independent samples Kruskal-Wallis test ( $\chi^2 = 8.892$ ,  $df = 3$ , and  $P = 0.031$ ). In the WUP the percentage of production generated from harvests on land owned by another company or individual was higher compared with the EUP ( $P = 0.010$ ,  $U = 107.00$ ) or the NLP ( $P = 0.011$ ,  $U = 141.00$ ). Likewise, significant differences among regions were observed in the percentage of production obtained from buying stumpage and selling logs or chips without a delivery contract using the Kruskal-Wallis test ( $\chi^2 = 10.027$ ,  $df = 3$ , and  $P = 0.018$ ).

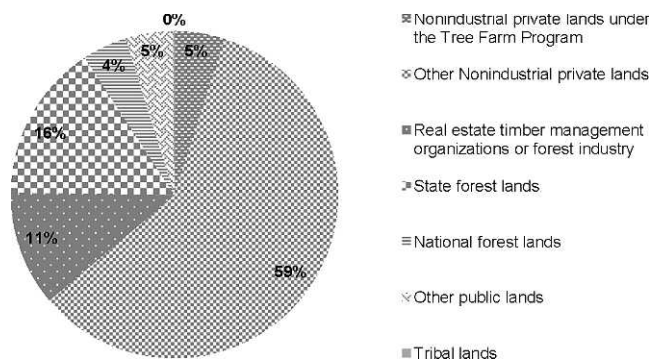


Figure 3.—Percentage of the timber harvested by Michigan's logging firms in 2007 by forest ownership.

A significantly higher percentage of the total production in the NLP came from buying stumpage and selling logs or chips to mills without a delivery contract compared with the EUP ( $P = 0.025$ ,  $U = 123.00$ ) or the WUP ( $P = 0.009$ ,  $U = 40.500$ ).

### Delivery method and distance

Forty-seven percent of the respondent logging firms used their own company trucks for transporting harvested roundwood or chips to the mills. Approximately 40 percent used contract trucking, and the remaining 12 percent delivered logs at the roadside, which were then hauled by others. This indicates that a large number of logging firms in Michigan are equipped with their own trucking facilities. No significant difference in the delivery method was observed among regions using the independent samples Kruskal-Wallis test.

Approximately 90 percent of the sawlogs produced by the respondent logging firms were delivered to mills located within a 90-mile radius of the logging site. Similarly, 72 percent of the pulpwood produced and 64 percent of the chips produced were also delivered to facilities within a 90-mile radius of the logging site. No significant difference in the delivery distance was observed among regions for sawlogs, pulpwood, or chips using the independent samples Kruskal-Wallis test.

### Market

On average, logging firms delivered the highest percentage of their total output to pulp and paper mills (29%) and hardwood sawmills (29%), followed by oriented strand board (OSB) mills (16%) and softwood sawmills (10%). A small percentage of output was supplied to rail or other landings (8%), veneer mills (5%), and direct fired wood power generators (1%). However, negligible amounts were supplied to the wood pellet fuel mills (0.19%) and other wood-based biofuel plants (0.24%). The independent samples Kruskal-Wallis test revealed significant differences among regions in the percentage of total production supplied to hardwood sawmills ( $\chi^2 = 10.027$ ,  $df = 3$ , and  $P = 0.018$ ), pulp and paper mills ( $\chi^2 = 10.027$ ,  $df = 3$ , and  $P = 0.018$ ), and OSB mills ( $\chi^2 = 10.027$ ,  $df = 3$ , and  $P = 0.018$ ). The logging firms in the SLP supplied a significantly higher percentage of their total output to hardwood sawmills compared with those in the EUP ( $P = 0.005$ ,  $U = 77.500$ ), the WUP ( $P = 0.007$ ,  $U = 10.000$ ), and the NLP ( $P = 0.030$ ,  $U = 87.500$ ). Likewise, the logging firms in the Upper Peninsula supplied a significantly higher percentage of their total production to pulp and paper mills compared with those in the Lower Peninsula ( $P = 0.001$  and  $U = 18.000$  for EUP and NLP;  $P = 0.001$  and  $U = 6.500$  for EUP and SLP;  $P = 0.005$  and  $U = 113.500$  for WUP and NLP; and  $P = 0.005$  and  $U = 70.000$  for WUP and SLP). The NLP logging firms, on the other hand, supplied a significantly higher percentage of their total production to OSB mills compared with those in the WUP ( $P = 0.015$  and  $U = 32.000$ ) and the SLP ( $P = 0.006$  and  $U = 20.000$ ). This corresponds with the distribution pattern of primary wood products manufacturing facilities in different regions of Michigan. A relatively higher number of pulp and paper facilities in the state are located in the Upper Peninsula, whereas more sawmills and OSB mills are located in the Lower Peninsula (Michigan DNR 2010).

## Preference for doing business

The logging firms in our survey were asked to indicate their preference for doing business with different landownership groups using a Likert scale format ranging from 1 to 5 (1 representing the most desirable and 5 indicating the least desirable options). Private lands were preferred by the loggers (median response = 1), followed by the Forest Stewardship Council (FSC) or Sustainable Forestry Initiative (SFI) certified lands (median response = 2), private lands under the Tree Farm Program (median response = 2), and state forest lands (median response = 2). National forests were not rated as desirable by the logging firms for carrying out business operations (median response = 5). This is probably because of the complicated administrative procedures involved in conducting business with national forests. However, this was not asked in the survey and hence cannot be inferred with certainty.

Approximately 80 percent of the respondent logging firms indicated that stumpage prices resulting from sealed bid sales on the state and national forests are usually higher than the average stumpage price paid by the logging firms during the time of our survey. In the case of private forests, however, approximately 50 percent of the respondents indicated that the stumpage price is more or less similar to the average price paid by the logging firms. Interestingly, 23 percent indicated negotiated sales on private lands to be lower than the average stumpage price paid by these firms. Relatively lower stumpage prices in private forests could be one of the reasons why loggers prefer private forests for doing business over state or national forests.

## Effect of recent mill closures

Given that a number of mill closures have occurred in Michigan in the past decade (Leefers and Vasievich 2010), the logging firms in our survey were asked to indicate how these mill closures have affected their business. Approximately 49 percent of the respondents who were in business at the time of the survey indicated that they had not been significantly influenced by the mill closures. However, the remaining (51%) either lost business, forcing them to downsize and restructure their firms, or had to transport their outputs farther distances at increased costs and lower profit margins. Still others relocated their business, and some even changed the species mix harvested to cope with these closures. Overall, mill closures have imposed considerable negative impacts on the majority of the logging firms in Michigan (recall 50% of responding firms indicated that they were no longer in business), and if this trend continues, it is likely to threaten the sustainability of forest products industry in the state.

## Barriers to increased harvesting

When asked to indicate the most significant barriers to increased harvesting in their area should the market expand in the future, the logging firms reported a wide range of factors likely to limit their harvesting decisions (Table 1). High stumpage and low delivered prices were identified as the major barriers to expansion, followed by the insufficient labor force, competition for stumpage, and insufficient timber supply from government-owned forests. A number of smaller logging firms noted competition from larger firms having a negative impact on their business, while others reported high fuel prices, poor road conditions, and lack of

Table 1.—Barriers to increased harvesting in case of market expansion as identified by Michigan's logging firms in 2007.

Barriers to increased harvesting in Michigan	Percentage of respondents
High stumpage price	18
Insufficient labor force	16
Competition for stumpage	13
Insufficient timber supply	11
Insufficient sale from government-owned forests	11
Fuel prices	9
Competition from big companies	7
Low mill price	4
Cost of doing business in Michigan	4
Poor road condition	2
Parcelization (property splits)	2
Financing for equipment	2

financing as limiting factors for increasing harvests in the future (Table 1).

## Perception toward the introduction of different wood-using firms in their wood basket

Logging firms in our survey were asked to rate different wood-using facilities as desirable or undesirable additions to their operating area using a 5-point Likert scale ranging from 1 (very undesirable) to 5 (very desirable) options. Loggers in general were supportive of introducing any type of wood-using facility in their wood basket, with the median response exceeding 3 in the case of all wood-using firms except particle board or other panel manufacturing. The median value for particle board or other panel manufacturing was 3, indicating a neutral response for such facilities. A higher percentage of loggers in general favored larger facilities such as pulp and paper manufacturing (54%), wood-based biofuel manufacturing (50%), and wood pellet fuel mills (46%), compared with other wood-using firms (Fig. 4). Such results are encouraging for the addition of wood-to-energy facilities in the future. The response pattern was consistent across the regions, and no significant difference was observed in the independent samples median test.

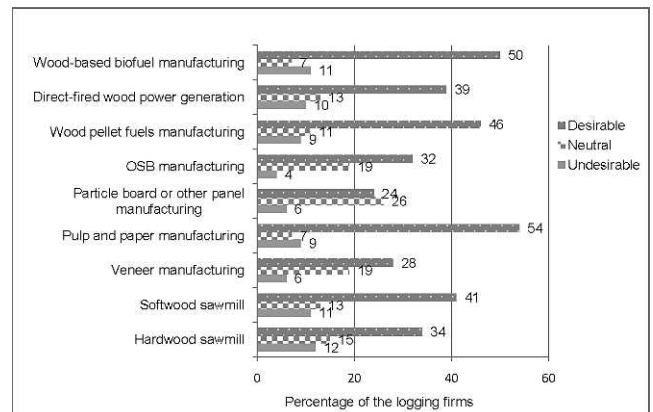


Figure 4.—Perception of Michigan's logging firms of the introduction of different wood-using facilities in their wood basket.

## Discussion and Summary

This study provides a general outlook of the logging sector in Michigan with an emphasis on its potential role in the woody biomass supply chain. Our survey results indicate logging firms in the state to be long-running operations with few new firms entering the market in the last decade. High investment costs required for the start up and functioning of a logging business coupled with a nonconductive financing environment could be limiting factors for new facilities to enter the business. In addition, other social factors such as low prestige associated with the logging business, as identified by Egan and Taggart (2004) from their study of northern New England loggers, could also be a potential reason for fewer firms entering the business in recent times. Given this situation, if the aim is to promote wood-based bioenergy generation within the state without having a negative impact on the existing forest-based industries, it is crucial to ensure the retention of existing logging firms while creating a favorable environment for new firm entry and expansion. This is even more evident at present, since 50 percent of the respondent logging firms in our survey indicated that they are no longer in the logging business.

Recent mill closures in Michigan have imposed considerable negative impacts on the logging sector, threatening their performance as well as retention. In this scenario, the introduction of a new market opportunity in the form of bioenergy could be a promising step for enhancing the logging business and forest-based economies within the state. A positive attitude among the logging firms toward the introduction of wood-to-energy facilities and a willingness to expand operations in case of favorable market conditions are encouraging observations for the development of a wood-based bioenergy sector in Michigan. However, wood availability to meet the feedstock demands of new and existing facilities could become a challenging issue in the future. Insufficient timber sales and high stumpage prices are identified as the major barriers to increased harvesting by the logging sector in our survey. Private woodlands are by far the major suppliers of stumpage for logging firms in Michigan, contributing more than 60 percent of the total timber harvested in the state. However, the composition of this ownership group is constantly changing, with a larger number of forest owners holding smaller forest parcels in recent decades (Butler and Leatherberry 2004), making it difficult to carry out economical harvesting operations. Also, the majority of these owners emphasize amenity benefits from their forests more than they do strict economic returns (Leatherberry et al. 1998). Thus, future timber sales from smaller woodlands are likely to be less intensive, yielding less timber per acre (Rickenbach et al. 2005). This could be a major hindrance for the smooth functioning of both logging firms and forest-based industries. One potential alternative for tackling this problem could be the introduction of timber sale aggregation as noted by Rickenbach et al. (2005). Timber sale aggregation can be achieved by coordinating multiple forest owners where all the forest owners agree to carry out harvesting operations in their forests at the same time (Rickenbach et al. 2005). This increases the total harvest volume and reduces the cost of harvesting, thus facilitating the logging sector in the state. Forestry extension and outreach programs could play a significant role in promoting such efforts. In addition, increased stumpage supply from government-owned forests at reasonable prices and a more conducive business

environment could help sustain logging business in the state to some extent.

The survey data also indicated that in the majority of the logging operations (83%) conducted in Michigan, the logging residue is not recovered from the site after timber harvest. Recovery of harvest residues in a sustainable manner could not only provide feedstock for bioenergy facilities, but also reduce the cost of forest management for landowners and help reduce the competition for stumpage between bioenergy facilities and other traditional forest products industries. The findings from this study suggest the lack of a developed market for accepting harvest residues at present. Another limitation for the recovery of harvest residues could be the technical capacity of current logging operations. Harvesting equipment in use today is configured for working with high-value sawlogs and pulpwood rather than for handling small-diameter trees and residue (Damery et al. 2009). Therefore, some degree of change will be necessary to collect and use residues left by harvest operations, which could mean additional investment in equipment. It was also observed that only a small percentage (4%) of the total pulpwood volume harvested in Michigan was chipped at the logging site. Increasing such practice could also help reduce the cost of transportation in the future.

Finally, regional variation was observed among the type of forest products marketed in the state. The logging firms located in the Upper Peninsula relied heavily on pulp and paper mills, whereas those in the Lower Peninsula relied more on sawmills and OSB mills. Since bioenergy facilities are likely to require a similar kind of stumpage to those currently used by pulp and paper mills, the location of wood-to-energy facilities in the vicinity of areas providing high pulpwood volume could be beneficial if there is currently excess logging capacity. This could, however, increase competition for the pulp and paper mills and have an unintended consequence if enough resources are not made available for all uses. The current average annual removals of live trees in Michigan's timberlands is only 50 percent of the net annual growth, suggesting that there is enough timber inventory in the state to support new facilities, including bioenergy. Actual availability may, however, be constrained by economic, ecological, and social factors and will vary by region and by species.

## Conclusions

Healthy logging businesses are crucial for the smooth functioning of a forest products industry and for meeting the forest management goals of landowners in Michigan. It is, therefore, essential to evaluate the status of the logging sector and to identify the challenges faced by them so that effective policy measures can be taken by the concerned parties to support and strengthen this sector in the future. Our survey results indicate that recent depressed market conditions have had a significant negative effect on the logging sector. Given this situation, the introduction of wood-to-energy facilities could have a positive and stabilizing effect on the logging businesses, which would be welcomed in Michigan. The availability of timber resources to meet the feedstock demands of existing and new facilities could, however, pose a challenge in the future. Increasing timber harvest from private and government-owned forests is essential for the sustainable coexistence of these firms. Improved equipment and transportation meth-

ods as well as increased market opportunities for non-merchantable timber and logging residue removals could help address this issue to some extent. It will, however, take some time before this can be realized as the equipment that is currently used is geared toward working with high-value products. In the meantime, it could be beneficial to explore the current logging equipment configuration in the state and to examine loan availability for expanding and purchasing additional equipment in the future.

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