Milling the Future:
Sustainable Forestry and Sawmill Operations in Northern Wisconsin

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December 2010

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Geography 565 Undergraduate Major Colloquium

Abstract

The logging and sawmill industries have played a crucial role in shaping the landscape, economy, and culture of northern Wisconsin. They proved to be an influential force behind the foundation of Wisconsin, influencing the human geography of the state. Since the nineteenth century, ensuring the longevity of forest resources through the implementation of sustainable practices has been a concern for foresters, mill operators, and citizens alike. To identify the characteristics of these sustainable practices, we interviewed three large-scale sawmills in northern Wisconsin, analyzed logging records, and evaluated aerial images of the land. Achieving these sustainable operations relates to how the forest resources are managed (i.e. tailoring management to specific tree species), how sawmills track logs throughout the milling process, and how the sawmills make use of their by-products. Understanding the characteristics of sustainable practices can ultimately influence the endurance and future availability of valuable forest resources.

Introduction

The goal of our research project is to identify the characteristics associated with sustainable forestry and sawmill operations in northern Wisconsin. From these characteristics, we will formulate a definition of 'sustainability' within the forestry and sawmill industries. We seek to understand the process of logging and milling as a whole, explore connections, and document approaches to logging and milling that promote both long-term stability and healthy, diverse forests.

In order to identify sustainable characteristics of forestry and sawmill operations we conducted interviews with three sawmills located in northern Wisconsin. The three mills include Menominee Tribal Enterprises located in Neopit, Kretz Lumber Company in Antigo, and Pukall

Lumber Company in Arbor Vitae. Two of these three sawmills, Menominee Tribal Enterprises and Kretz Lumber Company, own their own private forestland from which they harvest all or a portion of the logs processed at their mills. Through these interviews, we seek to identify what types of sustainable forest management practices are implemented on their land and what factors influence these management types (i.e. tree species, species diversity, etc.). This information will hopefully help us answer questions we have regarding the relationship between sustainability and sawmills. For example, how are logs that are harvested in sustainably managed forests tracked throughout the milling process? How does each sawmill make use of by-products and waste? What is done during the milling process to ensure long-lasting product quality? And, what are (if any) the benefits to running a sustainable operation? These questions, when answered, will ultimately help us create a new, sawmill specific definition of sustainability.

For the purpose of this paper, we began our research with a very general definition of sustainability. We initially defined sustainability as a management practice that preserves a resource for present use while maintaining it for future use as well. We realize this a notoriously vague definition but we feel that it is a beneficial starting point as it allows our definition to morph into a more concise one based on identified and documented characteristics as a result of our research. Throughout our research process, we fully anticipate and hope that our definition of sustainable forestry and sawmill operations will become narrowed and catered to specific standards within each respective operation.

The logging and sawmill industries are closely tied to the economy and culture of northern Wisconsin as they have been prominent industries throughout Wisconsin's state history, making this topic one of particular interest. The development and prosperity of these industries

has strongly shaped Wisconsin's human and landscape geography. A brief overview of each respective industry is helpful for the foundation of our research.

Forestry and Logging History in Northern Wisconsin

Wisconsin's first settlers reached the area in the early nineteenth century. The region was lush and provided strong motivation for development in the area as settlers moved West. The landscape was ideal for logging and milling operations due to intricate connections of waterways (rivers, lakes, etc.) that were key for the transportation of logs to and from sawmills. For example, one particular lake, Boom Lake, was capable of holding 100 million board feet (Olsen 1981: 31). Land was also cheap, costing about $1.25 to purchase an acre of land (Olsen 1981: 1).

White pine and Hemlock were the dominant logged species. White pine, a softwood, was primarily used for construction. It is pliable, soft, easy to work with a saw, and is capable of floating down river, a predominant method of log transportation for softwoods (See Appendix A, Image 1). Unfortunately, the last great white pine harvest occurred in 1899 (Olsen 1981: 37). Afterwards, hardwoods such as birch, oak, and maple were harvested at an increasing rate, replacing pine and taking over many of the forests. Hardwoods are not capable of floating, therefore logging hardwoods became less dependent on the proximity of rivers, while the importance of railroads to transport hardwoods became more geographically significant.

There was no forest crop law in Wisconsin until 1927 and before that time, selective logging was impractical, mostly due to increased taxes on lumber as a result of the expanding economy (Rosholt 1980:9). This created a "cut out and get out" logging philosophy, which led to rapidly increasing extraction of forest resources (Rosholt 1980: 9). The exploitation of the

whole region took about forty to fifty years, with a peak logging year in 1892 (Olsen 1981: 30). In 1892, sawmills were capable of cutting 100,000 board feet per day (Olsen 1981: 31) whereas today, based on the information from the sawmill interviews, only 50,000 board feet per day are milled on average. This is a large disparity caused by the endless demand of lumber for a growing state and nation. These large harvests occurred at a time when the state of Wisconsin was in its formative years and there was a need to "build the state" with lumber resources from the region. The vast forests appeared to be endless, giving the settlers the notion that the forests could be vigorously harvested without long- term effects. The increase in logging and forestry eventually created high demand for sawmills in Wisconsin.

Sawmill History in Northern Wisconsin

It is estimated that in 1809 the first sawmill opened in De Pere, Wisconsin yet the first mill in Wisconsin for which there is actual documented evidence was built in 1826 near Green Bay, Wisconsin. This mill was built on land leased from the Menominee Tribal Enterprises to a man named John B. Arndt (Rosholt 1980: 232). The sawmill industry was not constrained to Green Bay and eventually spread from as far south as Prairie du Chien to the Black River country in Black River Falls, to as north as the Chippewa River and the upper Wisconsin River. Many mills were also located as far north as the Wisconsin-Michigan border where white pine was especially abundant. By 1894, Wisconsin had become the leading producer of forest products in the nation, and there was scarcely a city or village in northern Wisconsin without its own sawmill. It was such a booming industry that in 1895 the city of Marinette alone had nine large sawmills (Rosholt 1980: 233).

Similar to the logging industry, the location of sawmills was highly dependent on water availability (See Appendix A, Image 2). Water was needed to power mills and transport logs to the mill. Colonel John Shaw was interviewed in 1885 and stated that when he built his mill in 1819 he built it near the first "big fall" in the Black River, showing that a change in water elevation was necessary to power water wheels or fuel steam engines (Rosholt 1980: 232). Thus, location and distance to rivers ultimately shaped the human geography of the state.

Sawmilling was a top industry in northern Wisconsin at the time and is still a dominant industry in the state today. It fueled the creation of cities around sawmill sites in northern Wisconsin, but also throughout the entire state. Throughout its existence, the sawmill industry has created many jobs and stimulated the movement of people to logging and milling regions in Wisconsin. The logging and sawmill industry is undoubtedly a crucial aspect of history that helped shape the land, culture, and identity of Wisconsin.

Literature Review

The following literature review aims to establish a background knowledge of practices and techniques related to sustainable forestry and milling operations. It is important to review the literature in order to critically evaluate each aspect of the industry and how sustainability can be applied throughout the various processes. Exploration of forest management techniques and sustainable milling practices are discussed below.

Sustainable Forestry Management Practices

Sustainable logging can be assessed and understood by examining resource management practices utilized around the world. By looking at the history of tree species management, a

better understanding of how sustainable logging practices are crucial in the application and creation of a sustainable sawmill. To achieve sustainable logging practices, it is important to closely consider how forests are managed to ensure diverse ecological forests and financial success. Forest management greatly depends upon the type and age of trees logged and what the trees require in terms of re-growth after logging. Two management options, uneven and even-aged management, reflect these management techniques (See Figure 1 below).

Thomas Vale, in *Plants and People*, defined uneven-aged management as the selective cutting of trees of various ages and sizes (Vale 1982: 30). This can be done through individual selection of single trees or selection of small patches of trees, called group selection. Disturbance under this management system is modest (Vale 1982: 30). In contrast to uneven-aged management, even-aged management is when large tracts of land are cleared, regardless of size or age. This type of management includes techniques such as shelter-wood cutting, which removes all but a few canopy trees as protective cover for re-growth, seed-tree cutting, and clearcutting. Clearcutting removes all trees in the selected area while seed-tree cutting focuses on removing most of the larger trees and leaving just a few large trees. The end result is a forest with trees of similar age (Vale 1982: 30).

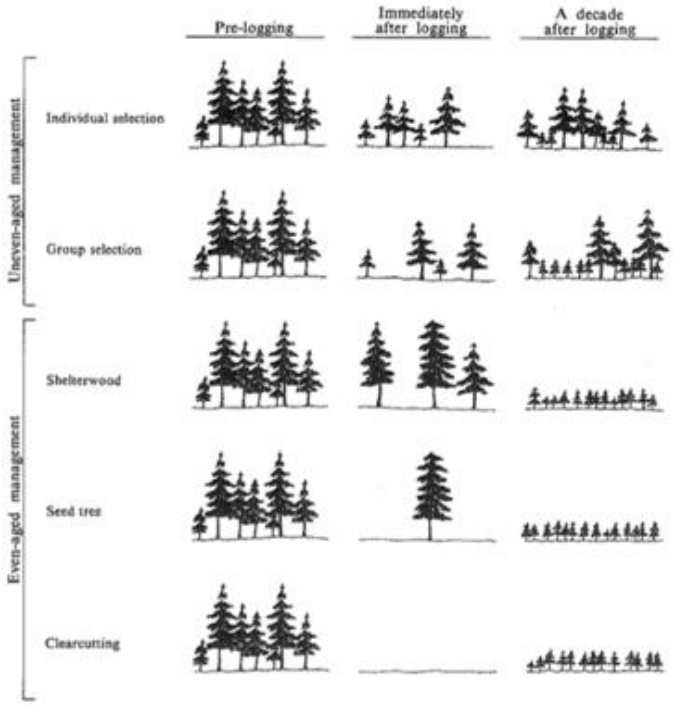

FIGURE 14 SILVICULTURAL SYSTEMS. Redrawn from Stephen H. Spurr, "Silviculture." Copyright © 1979 by Scientific American, Inc. All rights reserved.

Figure 1: Uneven and Even-Aged Forest Management (Vale 1982: 30)

Though uneven-aged management initially appears to be the most beneficial management strategy, even-aged management can be seen as an effective management technique, specifically clearcutting, when applied to specific tree species (Vale 1982: 31). For example, as Vale described, the Douglas fir is best managed by clearcutting the forest followed by burning the cleared land (Vale 1982: 31). This is done to imitate the natural process of re-growth that the Douglas fir goes through after natural catastrophes such as fires. Therefore some tree species such as the Douglas fir require unique harvesting methods for re-growth (Vale 1982: 31). Although it is difficult to manage each species individually, the management practices chosen should strive to address as many species as possible.

Another management technique, called conventional logging (CL), has been a popular practice for its ability to swiftly log forest tracts with minimal land preparation and planning in

order to maximize profits (Putz et al. 2008: 1427). However, the minimal land preparation in turn leads to destructive environmental impacts of tree felling, yarding, and hauling. Putz et al. investigated logged areas in Southeast Asia, Africa, and South and Central America to better access this technique (2008: 1428). Results show that conventional logging turns out to be profitable and easy to operate but at the cost of environmental degradation. Overall these practices tend to destroy the surrounding ecosystems and support unsustainable operations. The tree species and landscape again must be taken into account.

In contrast, reduced impact logging (RIL) techniques have been crafted within the last two decades to moderate the environmental impacts caused by conventional logging (Putz et al. 2008: 1428). Reduced impact logging is a technique defined as "…intensively planned and carefully controlled timber harvesting conducted by trained workers in ways that minimize the deleterious impacts of logging" (Putz et al. 2008: 1428). This technique has the potential for great success, but relies heavily on the forest managers to adapt the technique to varying forest types and conditions. Before harvesting, the forest managers must individually score each tree and map the regions of harvest to minimize log yarding destruction and loggers' safety. Although RIL training may provide workers more environmentally friendly and safer methods of logging, it does not apply to all forests and therefore could allow for a far greater range in quality control than desired. Thus RIL techniques should never be considered as full forest management but rather a prerequisite for sustaining timber yields and more importantly, sustainable forest management (Putz et al. 2008: 1420).

An unsustainable operation can be explained clearly by the forest production cycle (See Figure 2 below). An example of the forest production cycle can be seen in Newton's exploration of Amazonian tree species and their risk of extinction at different phases throughout the cycle

(Newton 2008: 199). The first phase of the cycle is the expansion phase when forest resources are extracted due to demand or abundance of the resource. A stabilization phase follows when supply and demand is at equilibrium. A declining phase then occurs due to loss in supply of the resource as a result of over-exploitation or rising harvest costs. Newton explains that within the expansion phase, there is a risk of extinction to the species if heavy harvesting continues through the stabilization phase. Understanding the tree species phase in northern Wisconsin, especially the expansion and stability phases, could be of great benefit to companies addressing the sustainable logging practices in the future.

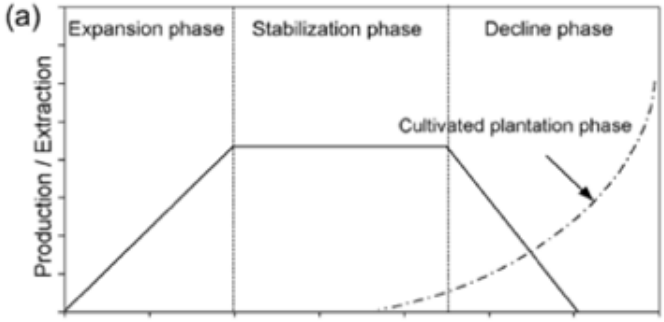

Figure 2: Forest Production Cycle of Amazonian Tree Species (Newton 2008: 199)

Sustainable Wood Products

Sustainable Northwest, a nonprofit environmental group based in Portland, Oregon, attempted to combat the variability of the lumber industry by creating a market for 'green wood' (Carlton 2010: para. 1). The group buys lumber products produced from trees that do not come from threatened forests. They bring these products to a central lumberyard and sell them to customers who are looking for green and sustainable wood products. This green wood distribution center has helped numerous small-town mills in the Pacific Northwest during recent economic downturns (Carlton 2010: para. 2). Aside from helping these small-town mills stay in business, Sustainable Northwest also promotes the protection of old-growth forests. The mills

saw trees that are younger and more diverse because they are more plentiful and allow the older mature trees to anchor the forest.

Sustainable Northwest has experienced some difficulty as they opened their business in 2008 when the economy was in turmoil (Carlton 2010: para. 3). Business has increased allowing their goal of connecting urban customers to rural mills with green wood products to become a reality. There is predicted growth as the market for green wood increases and as more customers take advantage of the distribution center. The survival of a mill depends on its ability to sell and market its lumber. Sustainable Northwest enables mills to buy sustainable logs and then sell green lumber. A distribution center such as this could be beneficial in northern Wisconsin. It would give the mills somewhere to send their green products ultimately establishing a place from which customers can buy. In order for these products to be labeled 'green', they must be certified sustainable logs.

Log and lumber certification has become a significant factor in determining the sustainability of logging and sawmill operations. It is one of the leading promoters of sustainable practices as becoming certified is a tedious process and is closely monitored. Forest Stewardship Council (FSC) certification is a certification that "represents the world's strongest system for guiding forest management toward sustainable outcomes" (Wisconsin's Group Certificate 2009: para. 3). On 16 December 2008, over 41,000 parcels of land enrolled in Wisconsin's Managed Forest Law (MFL) Program were awarded FSC forest management certification. The Wisconsin Group Certificate brought 31,000 landowners into the FSC system as well as made it more affordable and easier to obtain. This amounted to more than two million acres of privately owned land in Wisconsin (Wisconsin's Group Certificate 2009: para. 2). From a forestry standpoint, it is beneficial to become involved with the MFL program and ultimately become FSC certified.

Through the MFL program, as long as landowners follow sustainable forest management the Wisconsin DNR will reward them with tax benefits and technical assistance (Wisconsin's Group Certificate 2009: para. 2). The market for FSC logs and lumber is still rather small. There is no distinct difference between certified and non-certified lumber other than the certification and price.

If a sawmill processes FSC certified logs, chain-of-custody certification is typically achieved as well. In their article on certified wood products in Wisconsin, Hubbard and Bowe define "chain-of-custody" as a process designed to track logs harvested in certified forests through subsequent processing and distribution networks to the end consumer (2005: 33). Tracking certified logs throughout the manufacturing process is beneficial for mills as it establishes credibility and makes the mill competitive in the marketplace. As Stevens et al. (1998) argued, this ultimately allows the forest landowners and sawmills to validate claims of "sustainable forest stewardship and wood utilization" (as cited in Hubbard & Bowe 2005: 33). Hubbard and Bowe also mentioned that the number of years a company has been in business, the types of wood products manufactured, the customers they sold their wood products to, and the overall size of the company expressed in terms of total employees are variables that influence whether or not a forest or sawmill is chain-of-custody certified (2005: 35). In 2005, after analysis of self-administered questionnaires, Wisconsin forest and sawmill operations were determined to be generally unaware of chain-of-custody certification and ultimately not widely adopted into practice. However, companies certified at the time of this study did report having "gained new knowledge and perceive enhanced credibility with the public by becoming certified" (Hubbard & Bowe 2005: 38).

Case Studies in Sustainable Sawmill Practices

Although sawmills have been taking steps towards reducing their environmental impact a 'sustainable sawmill' is a relatively new idea. It is therefore beneficial to look at case studies regarding individual mills that have taken steps towards sustainability. For example, sustainable practices related to the handling of by-products of lumber production are becoming increasingly popular. The family-owned Lakeland Sawmill in Prince George, British Columbia began using their by-products (e.g. sawdust, bark, wood scraps, etc.) as fuel in the form of bio-energy. The sawmill signed a five-year contract worth $1.7 million with the University of Northern British Columbia that provides the university with mill residues such as bark and sawdust (Targeted News Services 2010: para. 1). These residues will power a biomass gassification system that will reduce the university's reliance on fossil fuels by 85 percent (Targeted News Service 2010: para. 2). This will increase the sustainability of the university as well as the sawmill. They are reducing their waste and utilizing as much of the tree as possible. The location of the mill and university are in close proximity which further reduces their carbon emissions. If the biomass does not have to be transported very far then there are not as many fossil fuels being used. These facilities are very expensive to construct, this particular one costing $15 million, but the benefits can be great. The bio-energy plant at the university will give them the smallest carbon footprint of any large campus in Canada (Targeted News Service 2010: para. 2). They will be saving money and producing a lower impact on the environment. The mill is also taking in trees being killed by the mountain pine beetle, accounting for about three fourths of their log supply (Targeted News Service 2010: para. 4). It is important for sawmills to utilize trees that are not always ideal because it leaves healthier trees in the forest ultimately creating a more diverse ecosystem.

A similar example of maximizing timber usage in northern Wisconsin occurred during the summer of 2007. During this summer, a tornado ripped through northeastern Wisconsin and destroyed stands of timber one-half-mile wide in most places and even a mile wide in one specific area. The result was a mess of damaged and tangled trees. Forests and loggers worked together to salvage these trees and the mills had to give them priority to make sure they would get used before the trees began to rot. The Menominee Tribal Forest, one of the premier sustainable stands in the Lake States, was heavily impacted by the tornado. Menominee's head forester, Marshall Pecore, estimated that 31 million board feet of timber and 41,000 cords of pulpwood were blown over in their forest (Monte 2010: 18). This is an immense amount of lumber that would have gone to waste had the foresters and loggers not implemented methods to utilize the timber. The tornado also damaged a stand of red oak owned by Kretz Lumber Company (Monte 2010: 19). It was more difficult and time consuming to log these trees because they were twisted as a result of the storm. The trees had to be carefully unraveled in order to saw the logs, ultimately increasing the cost to log. However, the Menominee and Kretz Lumber Co. cases demonstrate the environmental consciousness of people in the industry, both as a result of conservational and cultural perspectives.

The degree of sustainability is evident with respect to these two cases as they show how mills can behave sustainably throughout the entire process. Salvaging the trees damaged by the tornadoes shows that sustainability begins with harvesting the trees and the importance of how the tree is logged. The tornado changed the forest management plan but it did not change the main goal of maintaining a healthy forest. However, it is still important to consider what happens after the logs are cut into lumber. Sawdust, bark, and wood scraps are often forgotten because there may not seem to be much use for them. Lakeland Sawmill was able to find an

environmental friendly use for their wood byproducts. Using them to power bio-energy facilities is going to gain prominence in the upcoming years as they are a renewable alternative fuel source. Sustainable sawmills have to be able to look at each part of the operation and determine how they can improve. Ultimately, these articles portray the main goal of being a sustainable operation from start to finish.

By-products and Energy

The desire to practice sustainable methods within sawmills is increasing due to the new market of by-products. By-products of the sawmill industry include sawdust, bark, and wood chips, collectively called woody fuels, and are possible substitutes for fossil fuels (Vidlund 2004: 4). Timber is sectioned off in the following ways: 50 percent becomes sawn wood, 30 percent becomes wood chips, 10 percent becomes sawdust, and 10 percent is bark (Vidlund 2004: 24). Sawmills play an important role economically for loggers. According to Parikka's research on the usage of biomass for production of biofuels, if logs are not sent to mills to be sawed and instead are sawed on site, 8-10 percent of the tree will be wasted, and if squared on site as opposed to the mills, 30-50 percent of the tree will be wasted (Parikka 2004: 615). Therefore, whether or not loggers believe in sustainable forestry, sending logs to the mills to be processed into wood products will yield more and economically benefit them. Sending logs to mills will also provide a sustainable sawmill with the potential to transform 'waste' products into biofuels. On average, approximately 45-55 percent of the log will not be part of the final wood product. At some sawmills, these woody extras will become waste. At a sustainable sawmill the extras have potential to become a useful by-product. For example, the use of bark as a by-product. The first step in the sawmilling process is the debarking of a log. Bark composes 10-22 percent of the

volume of a tree and is considered an industrial raw material. This is just one example of biomass that can potentially be used as a fuel source for the mill (Parikka 2004: 616). When sawmills attempt to use as much of the log as possible, it will economically benefit the company and help to sustain its own energy production.

Vidlund's study on the sustainable production of bio-energy products in the sawmill industry analyzes the economic opportunities for saving on energy and the use of by-products as biofuel for the upkeep of the sawmill. The heating of the mill and the drying processes of the wood use a large amount of the total energy of a sawmill (2004: 15). The study focuses on the sawmill industry in Sweden where they have taken the lead in the market for upgraded and renewable biofuels. The biofuel market creates incentives for sawmills to make a profit off of their own by-products and become a larger player as producers in the national energy system. The market also helps to promote the idea of using the geographic proximity of on-site by-products as energy to become self-sustained sawmills. The study shows that there is now a market for bark and sawdust that can either be sold to external customers such as paper mills (for the production of paper products) or used internally to power their individual mills (Vidlund 2004: 4).

The reference sawmill researched by Vidlund located in Sweden had an annual lumber production capacity of 100,000 m3/year representing a fairly large sawmill (2004: 21). The manufacturing process of the sawmill starts with the debarking of the incoming timber, sawing the timber into planks and boards, and then drying the sawn wood. The study researched the desire to improve the drying characteristics within the sawmill industry to create a more self-sustainable business. For centuries past, simple air-drying was the most popular method of drying sawn wood but weather conditions and the time required to completely air-dry planks

were factors that limited the efficiency of the air-drying process. Hence the introduction of drying kilns into the sawmill industry.

The reference sawmill studied in Sweden dries 70 percent of its sawn wood in a High Temperature Dryer (HTD). The goal of the mill is to remove almost all of the moisture in the log to stabilize the shape and size of the boards produced otherwise the wood will shrink and warp after use. It is important to dry the wood as completely as possible to remove any bound water stored in the wood cells to eliminate the possibility of distortion and to ensure the sustainability and long lifespan of the wood. With that said, the drying of the wood uses a large amount of energy within sawmills.

The study stated that little effort has been placed on the potential for heat recovery during the drying process. The commercial methods from drying sawn wood are steam powered and include warehouse pre-drying, low temperature kiln drying, and conventional kiln drying. It is noted that 80 percent of the energy used in a sawmill can be traced to the drying processes of sawn wood (See Figure 3 below) (Vidlund 2004: 24).

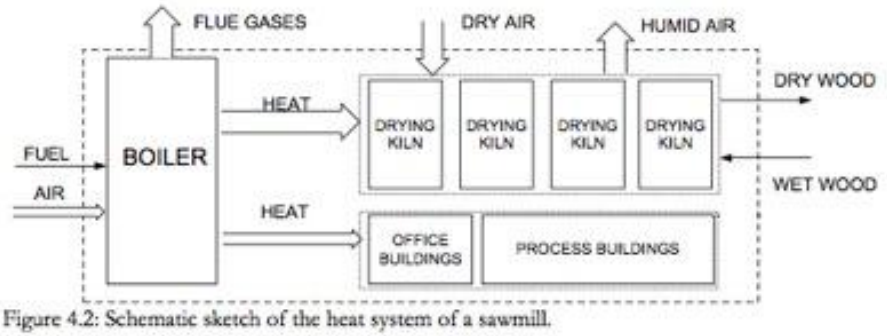

Figure 4.2: Schematic sketch of the heat system of a sawmill.

Figure 3: Heat System of a Sawmill and Re-Usable Potential Humid Air (Vidlund 2004: 15)

The drying process emits Carbon Dioxide and can have a negative effect on the environment. Carbon Dioxide emissions can be lowered by re-circulating exhaust air from the HTD kilns and using the exit air from the dryers "as the combustion air in the biofuel boiler" (Vidlund 2004: 36). However, re-circulation has yet to be fully utilized in the sawmill industry today. The result of the study is that 9-50 percent of the heat duty of the sawmill can be recovered. Nevertheless, the investment costs of biofuel upgrading in mills and waste heat utilization in district heating are high and sawmills may be reluctant to invest in complicated techniques (Vidlund 2004: 34).

The history of by-product usage is a short one. When timber was significantly less expensive, the tops of trees, sawdust, slabs, edgings, and other by-products of sawmills were usually wasted and did not go to use after the trees were logged. Now, there has been an increase in the usage of chipping machines to reduce slabs and edgings smoothly resulting in the production of usable chips as biofuel (Griffin 1965: 3). According Bjornstad's study on forestry and Carbon Dioxide emissions, the sawmill industry will not be negatively affected by the production and use of chips and other by-products. In fact, there will be no dramatic effects on forestry practices in terms of crop rotation length as a result of jointly producing timber and bio-energy raw materials, such as woodchips or bark, at the same time (Bjornstad et al. 2002: 462). Therefore, by-products and the idea of using as much of a log as possible can help a sawmill sustainably operate.

Globally, more countries are becoming involved with international by-product trade but the energy potential seems to be sought out only if there are promising economic benefits. Sawmills can economically benefit from the use of by-products as a fuel-energy source. Yet internationally, the potential for biomass energy can only increase if there is a demand for it.

Parikka notes the potential demand for energy in the future: "the total sustainable word-wide biomass energy potential is about 100 EJ/a, which is about 30% of total global energy consumption today" (Parikka 2004: 618). The present and future demand for alternative energy and fuel sources, such as by-products of sawmills, will increase if sustainable milling proves to be economically profitable and promotes the success of sawmills.

Methods

Interviews

As mentioned previously, we interviewed Menominee Tribal Enterprises in Neopit, Wisconsin, Kretz Lumber Company in Antigo, Wisconsin, and Pukall Lumber Company in Arbor Vitae, Wisconsin (See Appendix B for Map of Sawmill Locations). The goal of these interviews was to understand how a sawmill operates and understand any processes implemented in order to create a sustainable sawmill operation. Gomez and Jones explain that the goal of interviews is to find answers to "questions about how certain events, practices, or knowledges are constructed," not just to generalize a population (2010: 199).

Prior to the interviews, each group member received the Collaborative Institutional Training Initiative (CITI) certification. This certification represents our ability to perform ethical research while maintaining the protection of human research subjects (Braunschweiger & Hansen). Upon arrival at the sawmill, a privacy statement was given to the interviewee to ensure his/her understanding of the project and the rights he/she holds (Refer to Appendix B for Privacy Statement). A set of ten questions was then administered at each mill (Refer to Appendix B for Interview Questions). During the interviews and sawmill tours, two group members took notes while the other two group members asked the questions.

After conducting the interviews we compared and contrasted the methods that each mill uses to achieve sustainability. This will give us a better understanding of what it takes to make a sawmill sustainable and if this is a truly realistic goal. From the interview responses we will also further investigate sustainable methods of management. We will critically analyze the information we receive from the interviews in order to draw conclusions. Gomez and Jones say that one should pay attention to 'silences, paradoxes, and unspoken assumptions' in the conversations for a clear interpretation (2010: 202).

-Pershing Frechette, MTE plant manager, represented Menominee Tribal Enterprises for the face-to-face interview on 22 October 2010.
-Lloyd Godell, a human resources representative, and Dennis Fincher, a Kretz forester, represented Kretz Lumber Co. for the face-to-face interview on 22 October 2010.
-Rick Wilson, vice president, represented Pukall Lumber Co. for the face-to-face interview on 23 October 2010.
-Steve Ory, owner, represented Enterprise Sawmill for the face-to-face interview on 18 November 2010.

Aerial Images

Gomez and Jones state that topographical analysis of aerial photography is beneficial for "landscape study" (2010: 234). Using aerial images, we analyzed the landscape of Menominee Tribal Enterprises private forestland and compared it to surrounding land characteristics and uses. The Menominee forestland was chosen for this analysis as it is known to exhibit the physical forest qualities that are a result of sustainable management.

Using a GoogleMaps image of Menominee County in northern Wisconsin, we looked at the density of the forest cover, the development of roads, and types of neighboring land use practices in an attempt to illustrate what the landscape of a sustainably managed forest looks like. This type of analysis is beneficial as it helps establish a visual standard for sustainable practices

that can lead to strong conclusions in favor of the benefits of sustainability for forestry and sawmill industries.

Logging Records and Statistics

Statistics can be a powerful way to strengthen an argument because it gives us quantitative information to go with our qualitative analysis. Gomez and Jones define a statistic as a "number that summarizes a variable or relationship between variables in some way" (2010: 280). In our research, the relationship between sustainability and productivity is an important connection to make. It can potentially influence the decision to become a sustainable sawmill or not. Statistics such as logging records (in board feet) can help visualize the importance of things such as species diversity and logging management techniques like clearcutting.

Daily milling records from Enterprise Forest Products, a mill once in operation in northern Wisconsin from 1991-2001, were gathered for statistical analysis. We calculated the total board feet milled each month and created a representative table and graph in order to gain a better understanding of how mill production fluctuates on a daily basis. This fluctuation is important as it has implications regarding forest resource availability which can perhaps be related to sustainable management. It is also valuable to analyze this fluctuation because criteria for a sustainable mill should include consistent production. It is important to look at why a mill produces fluctuating amounts to explore what factors may play a role in this fluctuation. Economic factors such as cost of production and the demand for sustainable wood can influence the mills choice in logging techniques. Resource availability also plays a major role and is tracked through the use of logging records. These records are also beneficial for the future of a mill and may play a role in the decision to potentially practice sustainability.

Results

The following results highlight the findings of our interviews, statistical analysis of logging records, and examination of aerial images. Prior to these results, there is some brief background information provided for each interviewed sawmill (i.e. Menominee Tribal Enterprises, Kretz Lumber Co., Pukall Lumber Co.). There are many sawmills located in Wisconsin but for the following reasons, we chose three mills for the purpose of our research. Firstly, Menominee Tribal Enterprises was chosen due to its 150 years of sustainable forestry and sawmill practices. Secondly, Kretz Lumber Co. was chosen because it is a large mill founded in 1929 and has a history of hardwood milling that is comparable to the MTE hardwood production. Kretz is also unique because of its Ray Kretz Industrial Forest that is used as an educational tool for forest management. Lastly, we chose Pukall Lumber Co. because it is one of the largest softwood manufacturers in the state.

Mill Introductions

Menominee Tribal Enterprises

Located in Neopit, Wisconsin, Menominee Tribal Enterprises (MTE) is a forestry and milling industry owned and operated by the Menominee Indian Tribe of Wisconsin. The Menominee Tribe has inhabited the region for generations on just over ten million acres of land. In 1854, as a result of various land treaties, the Menominee Indian Tribe was confined to 235,000 acres within their northern Wisconsin reservation. Though a substantial piece of land, the Menominee recognized the need to ensure the survival of the forests and its resources. As population increased and development in the area progressed, it became crucial to manage the forests for future generations (Menominee Tribal Enterprises, "Forestry: para. 1).

In 1908, MTE built a sawmill in Neopit, Wisconsin. The mill immediately began producing and manufacturing sustainable forest products based on a "sustained yield" philosophy (i.e. the harvest rate of lumber never exceeds the ability of the forest to replace itself) (Menominee Tribal Enterprises, "Forestry": para. 2). All of the trees sawed at the mill come from the Menominee Forest. Today the mill is a leader in sustainable forestry and milling operations. The entire operation employs about 300 people with about 160 employees at the mill during the peak season. Because the sawmill is not federally subsidized, the success of the industry depends on a steady and regular flow of timber products from the Menominee forests to the consumer market. The mill manufactures around 15 million board feet annually, including hard and soft wood products (Menominee Tribal Enterprises, "Mill Facts"). MTE is proud of the fact that as a result of their forest management strategies, there is more standing timber today (1.9 million board feet) than there was in 1854 (1.2 million board feet) (Menominee Tribal Enterprises, "Forestry": para. 3).

Kretz Lumber Co.

Kretz Lumber Co. opened its sawmill in 1929 and is an employee owned operation under the Employee Stock Ownership Plan. The company currently owns, manages, and harvests logs from nine-thousand acres of forestland in Antigo, Wisconsin. In addition to these nine thousand acres, the company also manages and harvests logs from thousands of acres of privately-owned forestland. The sawmill manufactures 18 million board feet annually, including hard and soft wood products (Kretz Lumber Co. "About Kretz": para 2).

The company exercises a "vertical integration" approach in their sawmill which enables the mill to track the quality of the logs throughout the manufacturing process, specifically with

regards to tracking sustainably harvest logs throughout the process (Kretz Lumber Co. "About Kretz ": para. 1). The Kretz foresters promote and educate their private landowners in sustainable forest management practices. They work closely with the company loggers to ensure that the logs are harvested in a sustainable way. The company embraces the idea that "forests are more than just trees- they are a multi-generational treasure" (Kretz Lumber Co. "Forestry Services": para. 1).

Pukall Lumber Co.

Pukall Lumber Company is a family owned and operated company that opened in Arbor Vitae, Wisconsin in 1937. It is the largest pine manufacturing mill in the state of Wisconsin, producing mainly red and white pine products, in addition to other softwood products. The mill also manufactures various hardwoods. Pukall Lumber Co. does not own any company forestland. It manufactures logs sourced from the states privately, state, and federally owned forestlands, all within sixty miles of the location of the mill. The mill produces 12 million board feet annually and offers 80 different job positions within the company (Pukall Lumber Co. "About Us": para. 4).

Although Pukall does not own any company forestland, it nonetheless participates in ensuring sustainably managed products that are manufactured at the mill. Upon request, Pukall does supply certified sustainable lumber. Pukall's Environmental Statement illustrates the company's commitment to recognizing forest resources as valuable and worth careful management. "Wood is a renewable resource. In fact, more trees are grown each year in the U.S. than are harvested or lost to disease, insects and fire." (Pukall Lumber Co., "FSC Certified Lumber-Environmental Statement": para. 3). In attempt to help customers recognize the benefits

of wood products and the value of sustainably managing these resources, Pukall describes the advantages of wood products for home construction over other materials such as aluminum or plastic products. (Pukall Lumber Co., "FSC Certified Lumber- Environmental State": para. 1).

Sustainable Forestry Results

Sustainable forestry practices play a crucial role in the success of the sawmill industry. They ultimately ensure the longevity of forest resources upon which sawmills depend. The following findings highlight characteristics such as the implementation of management practices, whether or not these practices pay attention to species diversity, and the variability of the lumber market which are all linked to sustainable forestry.

Not all sawmills own private forestland but for those that do, ownership allows the mills to incorporate and oversee sustainable forest management practices. Because Pukall Lumber Co. does not own their own forestland, the following information regarding sustainable forestry will focus on MTE and Kretz Lumber Co. Unfortunately, we did not have the opportunity to speak with a forester from the MTE company forestland. We did however, tour Kretz Lumber's Ray Kretz Industrial Forest, a 29 acre educational forest located on the south end of their company forestland (See Figure 4 below). This land is harvested, accounting for a small portion of their total board feet milled each year, but it is primarily used for educational purposes. By visiting and touring the land, public and private landowners, especially the government (e.g. Department of Natural Resources) can visualize what a well managed forest looks like and the processes that play a role in that management.

Figure 4: Map of Kretz Lumber Co. Ray Kretz Industrial Forest- Educational Forest. *Retrieved from Kretz Lumber Co. Inc (http://www.kretzlumber.com/rkif)*

Sustainable Forestry Results: Forest Management Practices

Each interviewed sawmill manufactures logs from different sources which reflects different management practices. Menominee Tribal Enterprises (MTE) is unique in the way that all of the wood processed in the mill comes from the Menominee Forest. The Menominee Forest consists of 220,000 acres of forest land and is centrally located in the middle of the vast forest. As stated previously, Kretz Lumber Co. gets a small percent of sawn logs from its company owned forestland as well as contracting loggers to harvest timber from private land owners. Pukall Lumber Co. lumber is sourced entirely from private land owners., with a small percent of softwoods harvested from MTE forests.

Due to the differences in the location of the sawmill's timber sources, different management plans are in place at each mill. For example, MTE harvests logs based on "What's

best for the forest?" philosophy. The sawn logs are cut on a sustained yield practice with approximately a fifteen year cycle to thin and cut forest areas. A Continuous Forest Inventory (CFI) system is used to monitor the health and growth forest. The sustainable forest management implemented by MTE is certified by the Forest Stewardship Council (FSC). When talking with Pershing Frechette regarding management practices he referred to Chief Oshkosh and said that when cutting logs one should,

> "Start from rising sun and cut towards the setting sun. Only take the sick, the dying, and the mature trees. When you reach the setting sun, return to the rising sun. If you do this, the trees will last forever" (Pershing Frechette, 22 October 2010).

Kretz Lumber Company uses the Ray Kretz Industrial Forest as an educational forest for private and government education. In 1927, the forest was heavily logged due to a shortage in timber supply. Since then, the Industrial Forest has practiced over seventy-five years of forest stewardship. During our interview process we spoke with Dennis Fincher, an educational forester, about the management of company and privately owned forestland. From Dennis' experience working with private landowners, 'there are three main goals of forest management- enhancement of timber quality, forest aesthetics, and wildlife habitat.' Of these three goals, wildlife habitat enhancement was the most desired goal for private landowner forests. Therefore, it is not only economic profitability that landowners seek (Dennis Fincher, 22 October 2010).

Pukall Lumber Company relies solely on private landowners for their timber supply. Rick Wilson, the Vice President of the company, said that 'Pukall has strong relationships with

these private landowners because the company has been around a long time and is one of the few softwood mills in the state' (Rick Wilson, 23 October 2010). As a result, the mill survives largely due to loyalty and word of mouth. Not all of these private landowners are sustainably certified. For those that are, the Sustainable Forestry Initiative (SFI) is an option for landowners and loggers to achieve certification, in addition to FSC certification. Rick believed 'the SFI standards to be more intense than FSC standards' (Rick Wilson, 23 October 2010). Due to the Leadership in Energy and Environmental Design (LEED) rating system, FSC is the only recognized management method therefore Pukall Lumber cannot count SFI for LEED projects. When asking Rick what he thought of sustainable forestry practices he replied,

> "Not a huge demand for FSC logs. People who request these morally want them or the government is required to use them. The FSC logs cost more for essentially the same product" (Rick Wilson, 23 October 2010).

SFI is an independent, non-profit organization that began in the 1990s in response to concerns about the current forest management and illegal logging taking place in developing countries. The land is certified only after "social concerns are addressed through extensive forest regulations, effective enforcement and an open, democratic governance system" (SFI Standard 2010). SFI believes in meeting social responsibilities through community collaboration such as partnerships with Habitat for Humanity, The Conservation Fund, and Ducks Unlimited. The Sustainable Forestry Initiative® label indicates that wood and paper products are derived from sustainably managed sources. These sources are tested by third party certification audits.

In order to inform the customer that SFI standards have been met, there are two different lines of product labels. One label shows how much of the product's wood comes from forests that meet SFI certification requirements. The other label is a fiber sourcing label as shown below in Figure 5. This label tells the consumer that the company has met laws regarding threatened and endangered species, encouraged landowners to reforest harvested lands, and encouraged economically, environmentally and socially sound practices.

Figure 5: Sustainable Forestry Initiative Label. Retrieved from Sustainable Forestry Initiative Standard (http://www.sfiprogram.org)

Sustainable Forestry Results: Management Focus on Species and Diversity

As Dennis Fincher walked us through the Ray Kretz Industrial educational forest he made it abundantly clear that when establishing management plans, foresters should pay close attention to species and the environment. The Ray Kretz Industrial forest was originally logged for hemlock, elm, and Dutch elm until 1929 when the mill opened. At that time, 'the land was actually zoned for agriculture and once the mill started operations, the land was broken down into management units' (Dennis Fincher, 22 October 2010). Since then, each unit has been assigned to a different forester and that forester manages the respective unit. Each unit has, to a varying degree, a different species composition and therefore requires individual management plans. The different units also allow the foresters to exhibit different management strategies for educational purposes.

A particular unit of the Industrial Forest has a large aspen stand (See Appendix C, Image 1). This area was recently clear cut in order to mimic a natural disturbance. Dennis stated that 'Aspen trees regrow better and quicker after clear cutting in a way that is more beneficial than other management practices, such as selective cutting' (Dennis Fincher, 22 October 2010). Not only is it beneficial for regrowth, but 'the clear cutting also acts as a mechanism for habitat regeneration' (Dennis Fincher, 22 October 2010). For example, the wild grouse and deer population in Kretz's forest benefited from clear cutting as it improved their natural habitat.

Managing the natural habitat of the forest is important to Kretz foresters. While on the tour, there was a cherry tree within the Industrial Forest that would have been ready to harvest years ago. It was a good size and would have been profitable to harvest but because of growing characteristics of the cherry tree, 'they decided not to cut it, as they knew it would grow to be even larger' (Lloyd Godell, 22 October 2010). Cherry trees are also more valuable than species such as oak or maple. This is due to the scarcity of cherry trees, making it more profitable to let the tree grow larger. Kretz foresters did not cut the tree and it is still growing today, marked each time it is assessed for harvesting (See Appendix C, Image 2). Over time the tree will produce more veneer, a thin covering of wood for cabinets and furniture, ultimately making it more profitable than it would have been in previous years (Dennis Fincher, 22 October 2010). As a result, it will be easier to use more of the tree and waste less throughout the milling process if the tree is larger.

Kretz Lumber Co. emphasized the need to create diverse habitat through selective harvesting practices. Trees of large size that may be economically profitable to harvest are not always harvested if they have knots. These knots in the trees provide habitat for wildlife. Dennis explained that a tree was cut at "economic maturity." Economic maturity in these terms applies

to the size of the tree as well as the wildlife it is supporting, not just in terms of monetary value (Dennis Fincher, 22 October 2010). Essentially, the value is dually defined where the tree has both an 'economic *and* ecological value' (Dennis Fincher, 22 October 2010). The harvesting practices include not disturbing vernal pools while logging. In order to avoid disturbing the vernal pools, the harvesting can take place in the winter when it is frozen. These disturbances have been fewer due to foresters recognizing the importance of the composition of the forests. At the close of the visit, Dennis said that 'foresters are doing a better job today than ever before with regards to managing forests in northern Wisconsin' (Dennis Fincher, 22 October 2010).

MTE manages their forests on a species by species basis as well. The variety of forest species and habitats directly impacts the types of management plans implemented in order to ensure optimum growth, quality, and structure within the forests. The result of these management plans, both at Kretz and MTE, is forest diversity. And as Dennis said, 'diversity is key to healthy forests' (Dennis Fincher, 22 October 2010).

Sustainable Forestry Results: Market Variability

It is very useful to incorporate statistics while researching sawmills because it portrays the trials and tribulations that mills face and gives a better understand of how they operate. The success of a sawmill depends on statistics for grading logs and measuring/counting lumber. Enterprise Sawmill opened in 1990 in Enterprise, WI. The owner, Steve Ory, wanted to expand his logging business and have a milling operation as well. Many of the logs that were milled early on came from his logging operation, Enterprise Forest Products. Loggers brought logs to the mill based on the quality of the wood. Before Enterprise milled the logs, they were graded

based on size, diameter, if they were straight, and if they had many knots or limbs. Therefore, the logging industry had a big influence on the tree species that were being milled.

The interconnectedness of the industry promotes market profitability. For example, Enterprise Sawmill 'sold approximately 90 percent of the lumber that wasn't dried to Kretz Lumber Company' (Steve Ory, 18 November 2010). Enterprise sold their logs to Kretz to dry the lumber because he kilns at Kretz have a larger capacity. Enterprise also occasionally bought lumber from Pukall Lumber Company, located near Enterprise mill. The mill faced difficult times in 2002 and was forced to shut down periodically. It has not been operating at full capacity since but does run occasionally. The statistics that were analyzed came from the daily records kept by the lumber grader, Chip Wagner, and were recorded in notebooks.

The statistics recorded the sizes of lumber cut, how much was cut of each size, what species were cut, and the total board feet milled each day. There were also details describing mill break downs or when the mill had to close for repairs. To analyze the statistics, the board feet for each species was totaled for each month from September 1991 to December 2002. There were obviously some challenges when analyzing these statistics because some days were missing and there were also other factors such as vacations and break downs. The records were hand written making some of the books hard to decipher as not all species used the same name consistently (See Appendix C, Image 3). By analyzing statistics it is clear which species were dominant and the variability of the market.

Enterprise Sawmill milled different species that were sold for multiple purposes. The amount milled of each species depended on the logs that were brought in yet they also were heavily influenced by the various markets to which the wood was sold. A table was created to show how many board feet of each species were cut per year from 1991-2002 (See Appendix C,

Image 4). Aspen, bass, and hard maple were the dominant species that were milled at Enterprise Sawmill. Ash, birch, soft maple, red oak, and pine were the main secondary species with a few others milled occasionally (See Figure 6 below). There was a solid market for aspen and bass trees because they grow back fast and are plentiful in northern Wisconsin. The low grade aspen and bass lumber was sold to pallet makers while the upper grade aspen and bass lumber was used for venetian blinds. Hard maple trees are more valuable than soft maple because they have more character. Hard maple, red oak, and cherry are mainly used for cabinetry, molding, and flooring. The pine lumber that was sawed was used for dimensional lumber and any cedar that was sawed was used for decking. These statistics give a better understanding of how important tree diversity is to a mill and the importance of maintaining that diversity in forests.

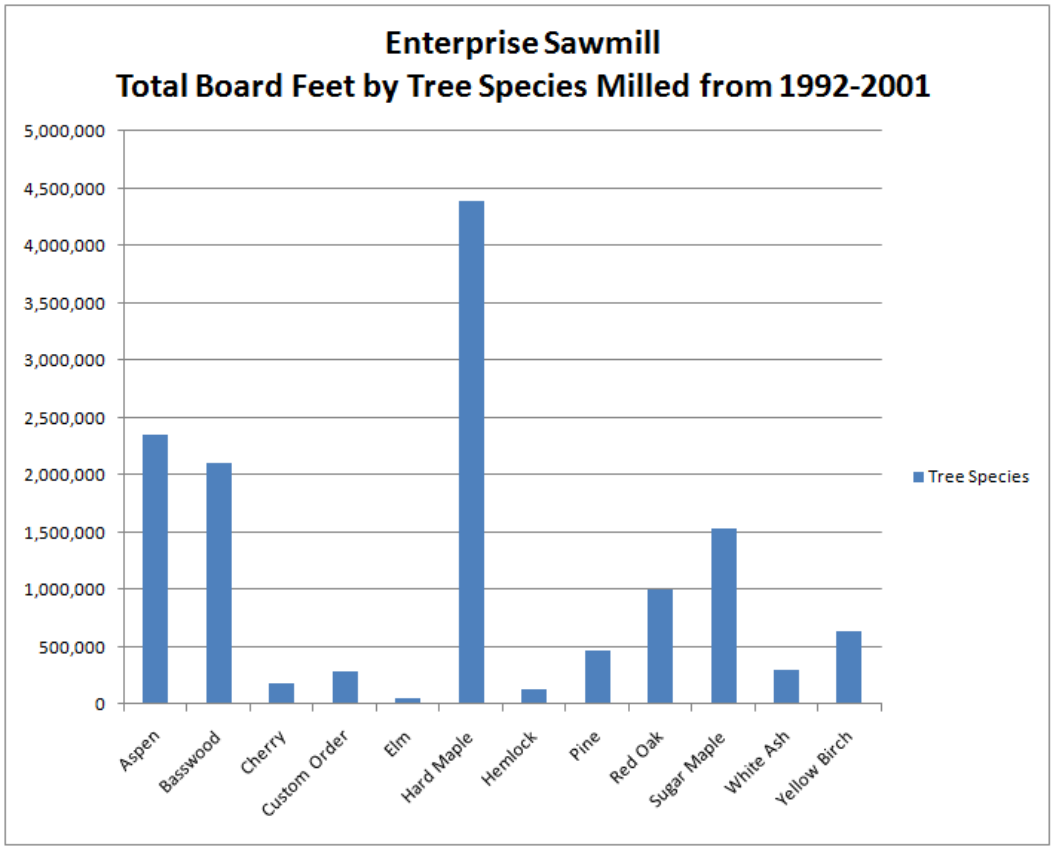

Figure 6: Enterprise Sawmill, Total board feet by tree species milled from 1992-2001. Graph shows variability in type of species milled and total amount milled.

Sustainable Sawmill Results

After a tree is cut down, it is transported to a sawmill to undergo the manufacturing process. Sawmill operations vary quite a bit but there are key components that are common across mills. As a result of the interviews, the components that can be linked to sustainability are: where the mills timber supply originates, the technology used throughout the milling process, and what is done with regards to the wood by-products. The three mills toured all focused on these factors to help improve their operations and become more sustainable.

Sustainable Sawmill Results: The Milling Process

The production and sustainability of a sawmill can rely heavily on the technology of the sawmill equipment. Sawmills use many pieces of equipment to turn a raw log into a quality piece of lumber. All three of the toured sawmills began the production process with a debarking machine. The log goes through the debarker to get stripped of its bark making it easier to saw. Once the logs are debarked, they are sawed into squares. This allows the lumber to be cut more efficiently down the line. At MTE, they have two machines squaring the logs at a time to make the process more efficient. MTE uses two Cleereman sawmills for squaring which are equipped with a band saw. Cleereman Industries has been one of the leaders in mill technology for over 50 years and many sawmills in Wisconsin use their equipment. Lasers are used to determine the best possible cut by maximizing the total amount of board feet that can be sawed from a particular log. The lasers then direct the saw where to make this cut. This helps reduce waste. The next step is to saw the squared logs into boards. The squared logs are measured with lasers and the thickness is evaluated to determine the logs optimal board size. The rough board is then

processed through an edger to straighten the sides and cut its width. This can be a tedious process but it is necessary to get the boards to the correct dimensions.

All of the equipment is very expensive and difficult to replace. Therefore it is vital to the productivity of the mill to keep the equipment in working condition to avoid breakdowns. MTE and Pukall Lumber both had separate work rooms to sharpen the blades daily and apply necessary repairs. Keeping the mill operational is crucial to consistent production. Breakdowns can be very costly and if the mill is not running lumber is not being produced. One aspect of sustainability is being able to maintain production consistently. When the statistics from Enterprise Sawmill were analyzed it was clear that the days the mill had breakdowns its production dropped significantly. The importance of upkeep and repairs cannot go unnoticed because they can be very costly to the mills.

MTE has recently implemented new technology with the hopes that it will increase production and allow them to maximize the use of each log. One particular technological implementation was the MTE Planning Room. Here the lumber is graded and marked with black chalk. A black light scanner reads the black chalk and sends the information to a computer. The mill then knows how much of each grade of lumber they have. At the end of the day, the over-run and under-run is calculated. Over-run is if more lumber was produced then projected and under-run is if less lumber was produced then projected. Mills like to be as close as possible to their estimate but prefer to be over-run at the end of each day. This is done to compare how accurate the projected value was when the log was initially graded to the actual amount of board feet produced. Keeping close track of their inventory allows MTE to track production and limit operator defects such as bad cuts and inaccurate grading. Accurate inventory also insures that they are minimizing waste.

Sustainable Sawmill Results: Location of Forests

A crucial characteristic in achieving a sustainable sawmill operation depends upon where the forests are located in relation to the sawmills. The closer the mill is to the land from which its logs are harvested, the sawmill can be considered more sustainable and environmentally friendly. MTE is fortunate in that it acquires all timber resources from their own forest, located down the street from the mill. Kretz Lumber Co. does own company land but only a portion of its logs are harvested from this forestland. Therefore, Kretz needs to derive logs from other sources located at various distances from the mill. Pukall Lumber Co. relies solely on private landowners and therefore brings in logs for outside sources.

Utilizing logs from nearby land is a sustainable option as it requires less transportation and therefore produces smaller fuel demands. The result of this is a smaller carbon footprint as logs travel shorter distances. Therefore, Pukall Lumber Co. limits the distance from which it transports logs for manufacturing to sixty miles. Perhaps this is done to regulate fuel demands and environmental impact. Further research is needed outside of this project to calculate the carbon footprint in order to quantify the role location plays for sustainable sawmills.

Sustainable Sawmill Results: Tracking Sustainably Harvested Logs

When the logs are first delivered to MTE, they are tagged with a bar code sticker (See Appendix C, Image 5). They are tagged according to species, grade, volume, length, and whether or not they are FSC certified and the information is coded in the tag. The bar code allows the mill to track the individual logs throughout the milling process. Because the mill was actually in operation when we toured MTE, we got to see how these logs are tracked throughout

the mill. As the logs move through the various stages of milling, they are scanned at the beginning so the workers know how to process the log throughout production.

Tagging the logs is also beneficial with regards to FSC logs to track the production output. For consumers interested in purchasing certified logs, tracking the certified logs throughout the process allows those consumers to be certain their logs were harvested sustainably. Pershing mentioned that tracking individual logs is also beneficial because 'it allows the mills to calculate exactly how much of the log is actually used and how much waste comes from each log' (Pershing Frechette, 22 October 2010). This process is a certified sustainable practice that Rick Wilson called "Chain of Custody" (Rick Wilson, 23 October 2010). Both MTE and Pukall Lumber Co. are chain-of-custody certified.

Pukall Lumber Co. has also recognized the benefits of chain-of-custody certification. Rick of Pukall Lumber Co. said 'that as a result of the economic downturn, the mill's certification has made them more competitive in new markets' (Rick Wilson, 23 October 2010). He noted that this is especially important as the demand for lumber varies within a fluctuating market. Though Pukall's certified logs cost 5-10 percent more as a result of tracking costs, it does make them competitive in a new market which can help increase the outlets for profitability (Rick Wilson, 23 October 2010).

Sustainable Sawmill Results: Mill By-products & Waste

The use of by-products economically and environmentally benefits sustainable sawmills. A sawmill by-product is not the primary product (i.e. the finished log) but rather, the excess of a log. Forms of by-products include things such as sawdust, bark, and woodchips. At sustainable sawmills such as MTE, Kretz Lumber Co., and Pukall Lumber Co. using as much of the log as

possible (as close to 100 percent) helps to create sustainable energy production as well as add to the new and growing by-product market. For example, MTE prides itself on utilizing every piece of the log. They have a device called a Bark Bin that catches the bark after the debarking process (. This bark is used for fuel and although carbon is still emitted when biofuels are burned, it is less harmful than the burning of fossil fuels (Bozbas 2008: 545). Biofuels are a renewable source of heat and energy so it is better for the environment to use those compared to fossil fuels. There is a sense of pride that comes with operating a sustainable sawmill and also a sense of community. This comes in the form of aid to the local families and workers where the extra scraps from the mill are given to them to use as firewood. For example, 'MTE workers make back-scratchers and cribbage boards from the scraps of the Millwork Division' (Pershing Frechette, 22 October 2010).

The by-product market has also expanded beyond the forestry business. Kretz Lumber Co. sells the extra chips collected after a log has been sawed to playgrounds and paper mill companies (Lloyd Godell, 22 October 2010). Sawdust is also a form of a by-product. Kretz Lumber Co. will sell the sawdust to meat packers where it is used for meat generation. Believe it or not, sawdust is smoked in combination with the meat and this creates the smoky taste in meats. 'Kretz has sold sawdust to companies such as Oscar Meyer and Hormel and occasionally the sawdust is sold for animal bedding' (Lloyd Godell, 22 October 2010). Pukall Lumber Co. also sells their non-rectangular sawn scrap chips to paper mills and the shavings and sawdust to animal barns as bedding. The sawdust by-product is also stored in silos to be eventually used as fuel feeding the boilers and dry kilns (Rick Wilson, 23 October 2010).

All three sawmills mentioned above take time to yield as much from one log as possible. The invention of technologies such as MTE's Bark Bin and others have made the transition to a

sustainable mill a more beneficial and easy one to make. With the creation of a by-product market, sustainable sawmills have incentives to make use of as much of the log as possible and waste the least amount. This is profitable for the sawmills and is now a well-known method of sustainability. By-products are an incentive for mills to become self-sustainable and are used as energy to power dry kilns, an important step in the sustainable milling process.

Sustainable Sawmill Results: Improving the Quality of Wood Products

By using dry kilns, sawmills can improve the quality of its wood products. Drying the boards after they have been sawed preserves the grade of the wood and is an extremely important step for the lifespan and quality of the wood. If the boards are not kiln-dried, there is a chance that the wood may warp and expand in the future, making the size of the wood unstable. Kiln drying also decreases the chance of attracting mold. These precautions add to the sustainability of the wood by ensuring the use and long lifespan of milled wood.

At MTE the lumber is prepared for the drying process after the log goes through the Trimmer. The higher grade boards are always kiln dried. The Kiln dryers can hold up to 40,000 board feet but the drying process varies depending on tree species (i.e. different lengths and moisture content across species). On average, the boards are dried at around 115 degrees Fahrenheit and it takes twelve to thirteen days (depending on species, moisture content, etc.) to dry. MTE stressed the importance of kiln drying hardwoods as it ‘adds to the value and quality of the boards’(Pershing Frechette, 22 October 2010).

Similar to MTE, Kretz Lumber Co. has thirteen drying kilns at their mill. Here, 60 percent of the logs that go through the mill are kiln dried (Lloyd Godell, 22 October 2010) and they do not kiln dry softwoods. Kretz stated that their ‘economy depends on the future

techniques and practices that mills can and hopefully will develop including economically sustainable kilns that waste less energy' (Lloyd Godell, 22 October 2010).

Finally, Pukall Lumber Co., which mainly mills softwoods, shared their concerns about the relationship between the quality of wood and kiln drying. They dry 100 percent of the lumber produced. There are eleven kilns at Pukall where twenty packs of boards can be kiln dried at once. The degree of the drying process at Pukall (like the other two sawmills) also depends on tree species. Pukall has drying standards that must be met. For example, if the wood must have a moisture content of nineteen percent or less otherwise the lumber is considered unusable (Rick Wilson, 23 October 2010).

After touring the three mills, it seems as though there is economic motivation to improve the sustainability of the dry kilns in the future. Using the kilns to dry the wood can waste energy at the mills therefore decreasing the amount of heat lost when the dry kilns are in use is something that each mill could benefit from. The creation of new technologies to better the processes of preserving energy seems inevitable in the near future to secure the economic success of the mills.

Sustainable Sawmill Results: Sustainability and the Economy

In addition to producing certified logs, the mills have taken other steps to increase their marketability as a result of the recent economic downturn. MTE implemented a Millworks Division in 2010. This branch of their company produces hand-crafted wood products, such as cabinets, caskets, and furniture. Pershing mentioned that the division has not taken off too much as a result of the current economy but he expects it to be very popular and successful once it does (Pershing Frechette, 22 October 2010). Kretz Lumber Co. and Pukall Lumber Co. have also

implemented value-added practices in addition to their respective Millworks Division. Though Pukall Lumber Co. has offered log home packages for years, they just recently began building a model log home to help market this service. The home is being built with FSC logs of various species to show their customers the multiple products available to them in a sustainable wood market.

When asked what motivates Pukall Lumber Co. to be sustainable, Rick Wilson said that there was no reason to clearcut the forests and deplete its resources (Rick Wilson, 23 October 2010). He noted that because 'the Northwoods are a valuable part of the northern Wisconsin economy, especially with regards to tourism, there is reason to sustain the resources so that Wisconsin can share its forests with everyone else' (Rick Wilson, 23 October 2010). Therefore, there is a sense of community. The sawmills and forests implement sustainable practices not only to sustain their industry but also to sustain the economy of the surrounding area.

Aerial Images Results

The analysis of aerial images of forestland is beneficial in helping set a standard for what well managed forests look like. Well managed forests, in the case of the MTE forestland, reflect sustainable practices and help ensure the timber supply needed to keep a sawmill in production.

The Menominee forest is shown in the GoogleMaps image below (See Figure 7). This land is densely forested and clearly marks the boundary between Menominee forestland and neighboring forestland. It also outlines a distinct boundary for Menominee County itself.

Before northern Wisconsin was settled and heavily logged during the nineteenth century, the majority of the land in northern Wisconsin looked much like the Menominee land looks in this image today. As other areas in northern Wisconsin quickly exploited the forest resources,

the Menominee people recognized the importance of sustaining the land they were limited to on the reservation. While maintaining healthy forests is part of the Menominee culture, the people also understood that their resources were exhaustive and well managed practices needed to be implemented to ensure the longevity of their forestland.

Figure 7: Menominee Tribal Enterprises Forest showing dense forest cover and Menominee County outline. *Retrieved from GoogleMaps (www.maps.google.com)*

Taking a look at the second image below, we can compare the Menominee land to surrounding areas. This image is a good example of what a well managed forest looks like (See Figure 8 below). For example we can see the surrounding areas have been partially deforested, developed, and are now used for agriculture. Roads have been developed on these neighboring lands to mark property lines which, in addition to agricultural use, fragments land outside the Menominee forestland. This fragmentation and agricultural land use may limit the implementation of sustainable practices in the patches of forest outside the Menominee land.

This also places different values on the land which influence decisions related to management and land use. The Menominee have also clearly minimized development on their land. This is due to social and cultural reasons but also due to concerns regarding forestry and maintaining sustainable forests.

Because of the successful management of the land, the Menominee forest is rich in species diversity including trees of all ages and sizes, and contains more standing timber today than ever before (Pershing Frechette, 22 October 2010). These practices make the Menominee forestland a leading model for sustainability that can ensure the long lifespan of forests. Despite consistent cutting to provide sawmills with logs, there is still a large quantity of quality trees in these forests. Not only is this good for environmental purposes, but also because it allows sawmill operations to continue to stay in business. The Menominee land can be used to provide motivation for sawmills to manufacture logs that are grown in sustainable forests because it ensures the survival of the sawmill industry.

Figure 8: Menominee Tribal Enterprise Forestland showing neighboring forest and agricultural land. *Retrieved from GoogleMaps (www.maps.google.com)*

Future Research

Though our research provided us with many results there were limits to the methods used. The sawmill interviewees provided a great deal of first-hand knowledge of practices that make their operation sustainable. The personal exposure through tours and interviews made this project valuable to addressing our research question. However, relying largely on interviews for the majority of our primary research has its limits. For example, we risk the influence of personal biases of the mill representatives. The practices mentioned during our interviews and the benefits they provide may be part of their natural inclination to portray the mills in a positive light. Hence, further critical evaluation of these practices is necessary.

To address this problem future research can be done to help quantify sustainable practices such as measuring carbon footprints, by-products/waste, and ecological impacts as well as measuring different levels of sustainability against a set standard or control level. With more time, future research could be helpful to ensure that the methods practiced by the mills provide the ecological benefits that the sawmill representatives mentioned.

Because of the limited time and extent of travel related to answering the presented research question, we were only able to interview three sawmills. If given the time, we would have liked to interview and tour more sawmills. A larger sample size would help identify more characteristics related to sustainability. Interviewing and touring mills that do not practice sustainability would have also enabled us to compare and contrast sustainable versus non-sustainable sawmill characteristics. This would ultimately provide a more comprehensive analysis of sustainable forestry and sawmill operations. After completing our research we came across sustainable characteristics that could warrant further exploration. Some characteristics worth researching further are renewable energy and mill technology.

Renewable energy has found its way into some aspects of the lumber industry but it still remains relatively untapped as a resource. All of the sawmills we toured make use of a portion of their by-products by burning them for heat and energy. However, while by-products are a renewable resource and a better alternative than fossil fuels, they still emit carbon when burned. A more sustainable approach could be incorporating solar, geothermal, or even wind energy into the mill operations. Implementing these types of renewable energies can be very expensive but the return on investments can be very good as they generally save a lot of money in the long run. It may take some time for these types of renewable energy to develop enough where they are effective as sawmills and dry kilns require a lot of energy. However, these types of energy sources could help a sawmill become more sustainable if properly used.

The technology involved with sawmills is constantly evolving as mills strive to become more efficient, increase production, and protect forest resources for present and future use. New technology is constantly coming out for sawmills to improve their operations. Unfortunately there wasn't enough time to fully explore this new technology but from the conversations with the mills it was apparent that they are always looking for the next breakthrough. The main areas where new technology can help mills are the sawing of the logs themselves, the cutting of lumber to length and width, keeping track of the lumber as it goes through the mill, and better drying techniques that require less energy. The faster a log can go through the mill the less energy that will be used. This makes it important to use new technologies to become more efficient and increase production.

Conclusion

At the start of our research, we broadly defined sustainability as a management practice that preserves a resource for present use while maintaining it for future use. As initially expected, this vague definition has transformed due to the research conducted. We have concluded that sustainability is a process that mimics the natural environment by ensuring species diversity, administers species-appropriate management techniques to avoid exhaustion of the tree species, maximizes the tree and the by-products of that tree, and implements techniques such as kiln drying to preserve the quality/lifespan of the wood for the future. Sustainability is a long-term process that will continuously change over time due to anthropogenic influences on the surrounding environment.

Aside from our developed definition of sustainability, we arrived at many other conclusions. Perhaps the most interesting revelation has been the realization that forestry is extremely important to the sustainability of a sawmill industry in addition to what is actually done at the mill. We predicted that forestry was a crucial aspect in a sustainable sawmill operation but have now realized that the origin of the logs and the maintenance of those logs largely affect the ability of the mills to be characterized as sustainable. If the mill does not saw sustainably harvested logs, then the mill cannot attain FSC and chain of custody certification, a primary characteristic of a sustainable sawmill operation.

Prior to our research, we assumed that sustainable sawmill characteristics would be primarily associated with how the mill is powered and the effects of that method (i.e. what type of fuel the mill uses, carbon emissions, etc.). While this is a crucial characteristic of sustainability, the mills appear to be more sustainable in terms of how they handle use of by-products and waste. Methods used to power the mills are important but are not as developed as

the methods used for the by-products of the log. Both aspects are obviously important but there seems to be more limitations with regards to methods of powering the mill than there are in terms of handling by-products and waste.

Perhaps the most surprising outcome of the research is related to our new perceptions of the forestry and sawmill industries. Before this project we were all unaware of just how much is actually done to implement sustainable practices and maintain forest resources. To an extent, we were under the impression that loggers, foresters, and the sawmill industry were predominantly focused on making a profit. While the mills are obviously concerned with making a profit, we did not realize how equally concerned they are with maintaining the forests. Our perceptions have now changed due to our visits with the sawmills. There is a large community of loggers, foresters, mill managers, etc. who genuinely care about maintaining the forests and its resources. Previously we were skeptical of clear cutting practices and now we realize that it is not a damaging practice. It instead ensures the stability of a diverse forest. The plans and management strategies in place ensure the survival of the valuable forest resources.

Sustainability goes beyond the actual manufacturing process of the tree to include cultural characteristics as well. Due to increasing environmental issues, sustainability has become a prevalent cultural concern and has ultimately changed public perspectives. The value placed on the land is more than monetary. It is cultural too. Loggers and mill employees feel connected to the land from which they survive. When asked the question 'what motivates you to be sustainable and project that value in your company?' Pershing Frechette of MTE replied 'we oughtta be who we are'. The concept of sustainability reflects our cultural values; who we are, how our environment echoes our identity, and our awareness of that relationship. We are the

long-term stability of healthy and diverse forests. This reflects the significance of sustainability within our culture and the desire to provide for future generations.

Appendix A
Historical Photographs

Image 1: Log transportation down river. *Log Jam on St. Croix River: Wisconsin. Wisconsin State Historical Society of Wisconsin-Division of Visual Archives: WHi-31451. (Last accessed 2 October, 2010)*

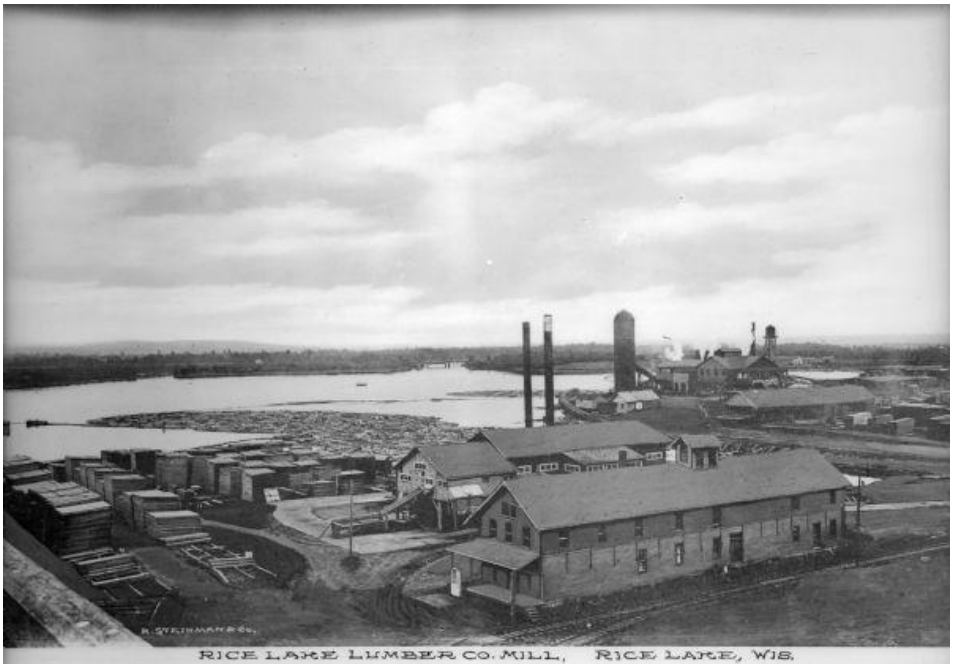

Image 2: See location of sawmill near water. *Rice Lake Lumber Company: Rice Lake, Wisconsin State Historical Society of Wisconsin- Division of Visual Archives: WHi-78293 (Last accessed 2 October, 2010)*

Appendix B
Interview Materials

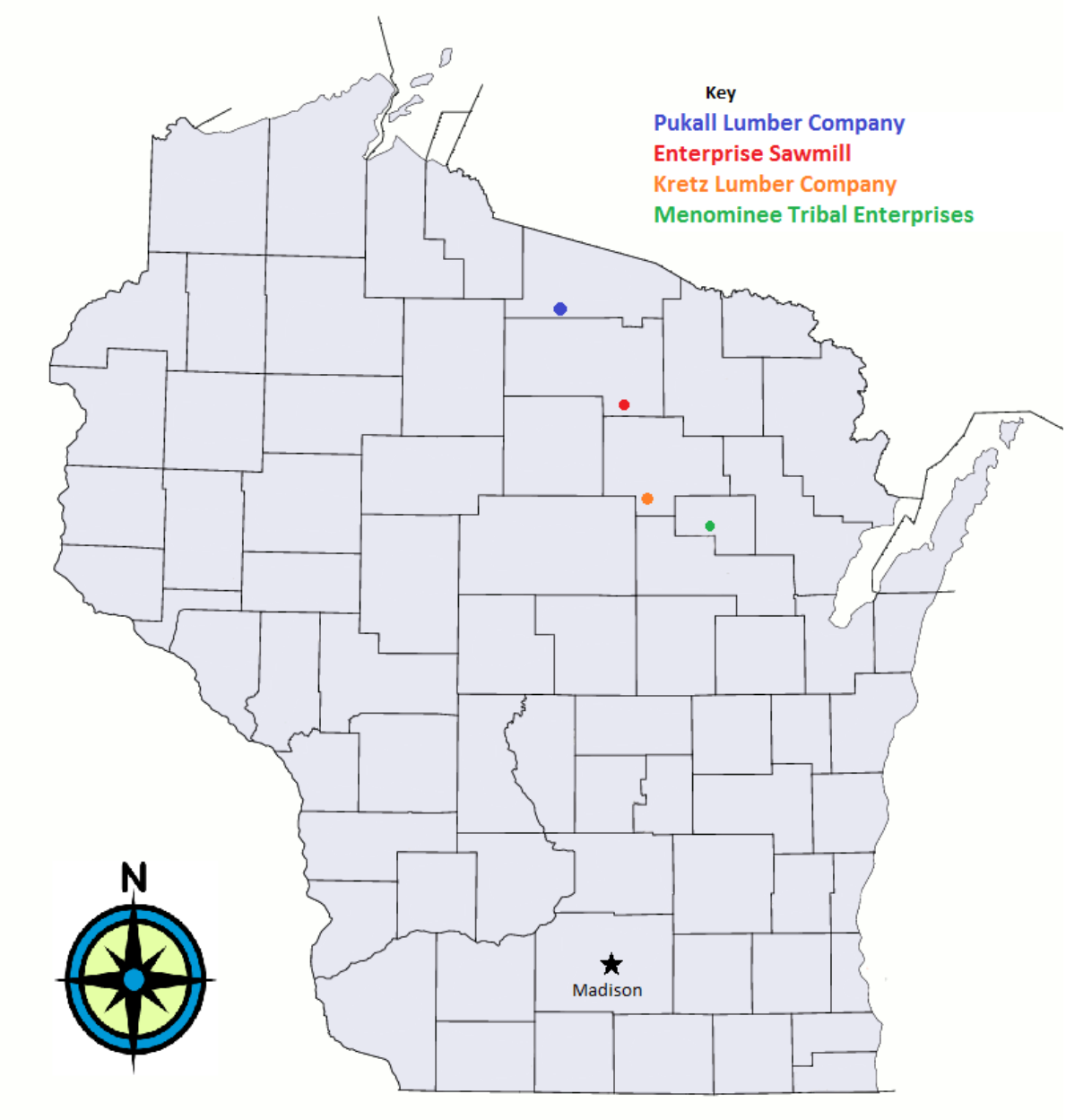

Figure 1: Map of Sawmill Locations showing Pukall Lumber Co. in Arbor Vitae, Enterprise Sawmill in Enterprise, Kretz Lumber Co. in Antigo, and Menominee Tribal Enterprises in Neopit, Wisconsin. *Wisconsin county map retrieved from the United States Department of Agriculture-National Agricultural Statistics Service (www.agcensus.usda.gov). Map generated by Tom Ory.*

Figure 2: Purpose and Privacy Statement, October 2010

The goal of our project, Milling the Future, is to document the characteristics associated with sustainable forestry and sawmill operations in Northern Wisconsin. Sustainable logging and milling are difficult to assess as there is no agreed-upon method or standard for measurement. We therefore seek to understand the process of logging and milling as a whole, explore connections, and document approaches to logging and milling that promote both long term sawmill stability and healthy, diverse forests.

We are conducting this interview in order to better understand the history of this forestry and/or milling operation as well as any strategies to promote sustainability. Your privacy is important to us. You may decline to answer any question you wish. You may request that we don't use your name/company in our report. These interviews will not be recorded and will not be used for any purpose outside of this project.

We will send you an electronic copy of our report when it is completed. We invite you to attend our class presentation in December. We will contact you in December to provide you with details regarding the presentation.

Thank You,

Tom Ory -ory@wisc.edu
Holly Powell- hpowell@wisc.edu
Valerie Poulos- vpoulos@wisc.edu
Anna Berberet- aberberet@wisc.edu

Figure 3: Sawmill Interview Questions

1) How long has the mill been in operation?
2) How long have you been employed at this mill?
3) What type of sawmill do you use?
4) How is your sawmill powered?
5) Where are your forests located?
6) What criteria do you have when purchasing logs?
7) What are the main species that you saw?
8) What do you do with wood byproducts?
9) What are the benefits of certification?
10) Has the current economic downturn necessitated any changes to your operation?
11) What role do you see sustainability playing in the future of milling?

Appendix C
Results Images

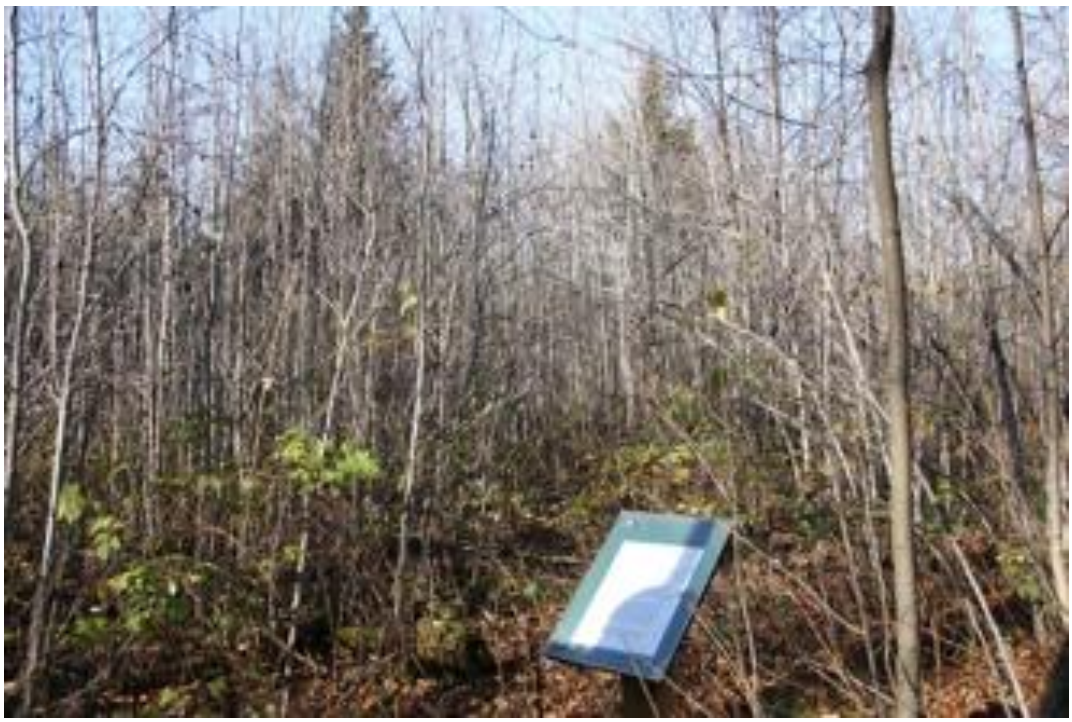

Image 1: Aspen Stand in Ray Kretz Industrial Forest showing. Taken 22 October 2010 by Anna Berberet

Image 2: Cheery veneer tree in Ray Kretz Industrial Forest showing markings used to assess harvest time. Taken 22 October 2010 by Anna Berberet

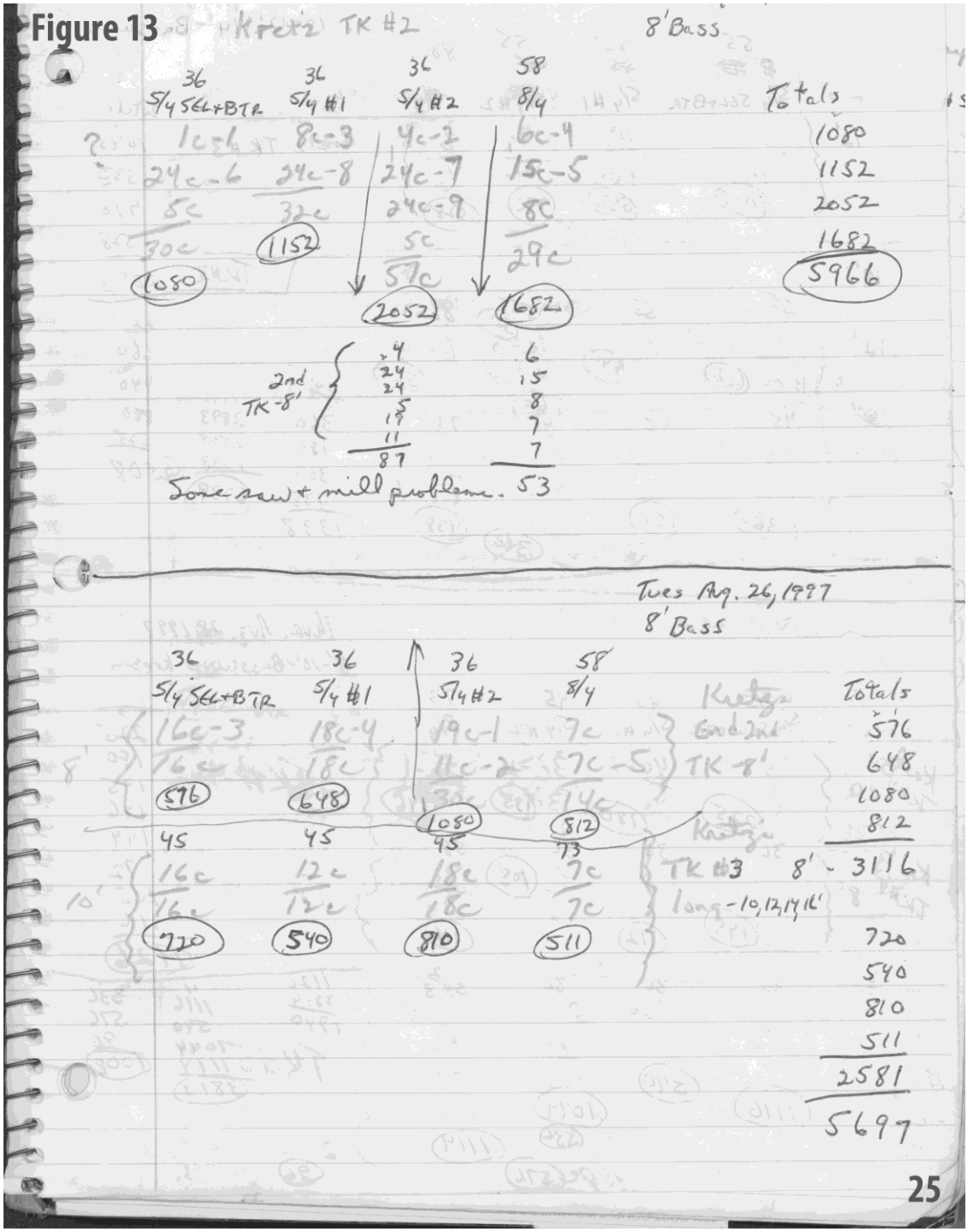

Image 3: Example of Logging Records Page from Enterprise Sawmill. *Courtesy of Steve Ory, owner of Enterprise Sawmill*

	Lumber Species Milled at Enterprise Sawmill, 1992-2001 (measured in board feet)								
Year	Aspen	Basswood	Beechwood	Butternut	Cedar	Cherry	Custom Order	Elm	Hard Maple
1992	564,400	171,481	0	0	1,410	33,438	81,807	0	276,331
1993	406,554	290,657	333	184	1,099	18,136	1,263	280	521,253
1994	594,190	124,124	0	0	0	19,911	105,018	0	310,363
1995	244,204	73,006	0	0	7,587	17,714	65,612	0	76,167
1996	11,486	93,461	0	0	5,492	1,549	0	53,211	30,548
1997	220,097	355,618	0	0	1,354	14,327	1,174	0	225,566
1998	288,867	283,705	0	0	0	946	16,971	0	786,884
1999	8,604	218,809	8,030	1,304	0	28,532	184	250	655,370
2000	1,060	310,368	0	0	731	16,753	7,269	0	910,748
2001	13,263	177,356	0	0	78	26,522	0	0	596,671
Totals	2,352,725	2,098,585	8,363	1,488	17,751	177,828	279,298	53,741	4,389,901
	Hemlock	Pine	Red Oak	Sugar Maple	Spruce	Tamarack	Miscellaneous	White	Yellow Birch
1992	118,982	35,332	119,411	10,960	0	0	0	14,459	55,305
1993	1,925	119,970	78,105	114,422	123	0	0	47,666	62,347
1994	0	54,599	86,620	233,210	0	0	30,109	36,687	
1995	3,520	109,408	131,323	147,796	0	0	0	36,302	21,192
1996	0	0	33,318	8,571	0	0	0	9,215	4,715
1997	0	43,386	30,716	81,288	0	0	0	16,099	42,655
1998	0	39,960	62,395	285,577	0	0	0	37,884	71,245
1999	0	37,325	179,286	269,847	0	0	0	39,259	62,176
2000	0	16,866	109,546	182,271	0	0	0	20,168	85,633
2001	0	5,154	171,438	198,079	0	9,694	0	39,103	227,356
Totals	124,427	462,000	1,002,158	1,532,021	123	9,694	30,109	296,842	632,624

Image 4: Lumber Species Milled at Enterprise Sawmill, 1992-2001 (measured in board feet)

Image 5: Bar code stickers on logs at Menominee Tribal Enterprises. Taken 22 October 2010 by Anna Berberet

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