A Snapshot of New Woody Biomass Production Potential in Michigan

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Executive Summary

Over half of Michigan is covered by forests that produce a variety of goods and services to the benefit of its citizens. The state has a thriving wood products sector but also provides a wide variety of recreational opportunities that depend on these forests. Beyond quantifiable services, the forests of Michigan provide valuable ecological services, not the least of which is to protect the quality of the waters in the Great Lakes.

Michigan's forests and the trees in them are getting bigger every year. This growing resource, together with other potential renewable sources of wood, represents an undertapped potential for the sustainable development of an expanded bioeconomy in the state. A growing bioeconomy promises to create local jobs and prosperity, develop valuable intellectual capital, reduce dependence on polluting fossil fuels, and improve the health and productivity of the state's forested ecosystems.

Michigan's future tree-based bioeconomy will depend on and be limited by the amount of woody biomass available for markets. This snapshot examines the potential ***availability*** of ***presently unused*** woody biomass in Michigan as summarized in Table 1 below.

The thriving wood products industries of Michigan presently use about 4.6 MMg (million dry metric tons) of wood each year. It is often and erroneously assumed that today's mills leave piles of waste that can be obtained free-of-charge by an expanding bioeconomy. This is simply not true. Mill wastes are already converted into other products or being otherwise used by the producers. Additional supplies of new woody biomass for an expanded bioeconomy are available (1) in Michigan's natural forests (about 3.40 MMg/yr), (2) in new biomass plantations on idle, underused, non-agricultural land (about 2.42 MMg/yr), and (3) from urban wood waste streams (about 2.20 MMg/yr). Together, these potential new resources could provide over 8 million dry metric tons of biomass – enough to almost triple the size of Michigan's current wood products industry. This report describes how these estimates were derived.

Table 1:
Potential new sources of woody biomass for an expanded bioeconomy in Michigan.

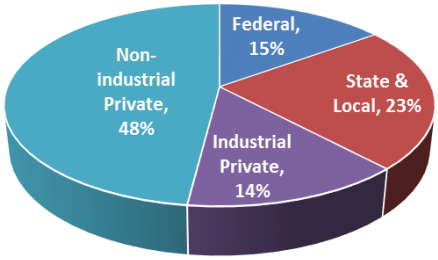
Source of Woody Biomass	***Additional Biomass Availability Estimate (million dry Mg/yr)***	
Current Harvests of bolewood (4.60 MMg/yr)	*0.00*	
Recovered Logging Residues (topwood & culls) from Current Harvests	*0.95*	
Recovered Mortality from Timberlands (bolewood & topwood)	*1.52*	
Recovered Unused Growth (bolewood & topwood)	*0.93*	
New Biomass From Michigan's Natural Forests		**3.40**
Mill Residues	*0.01*	
Short Rotation Wood Crop Plantation Potential	***2.42***	
Recovered Wood from Urban Tree Mortality	*1.20*	
Recovered Urban Wood Waste	*1.00*	
New biomass From Non-forest Sources in Michigan		**4.63**
TOTAL UNTAPPED MICHIGAN WOODY BIOMASS	**8.03**	

Introduction

Raw material (*i.e.* biomass) to expand the wood-based bioeconomy of Michigan can be sustainably obtained from existing timberlands, new short rotation plantations, and from urban tree and wood waste streams. Determining how much biomass is actually present and how much increase or decrease takes place annually in each of these three main sources is difficult enough. Establishing the availability of that biomass (after considering existing uses, accessibility, and the owner's willingness to sell) is more difficult still. However, understanding the availability and distribution of biomass is important for expanding the bioeconomy in Michigan, especially when locating and developing new facilities. Here we use recent studies and data sets to estimate the availability from each of these three major sources of woody biomass in Michigan.

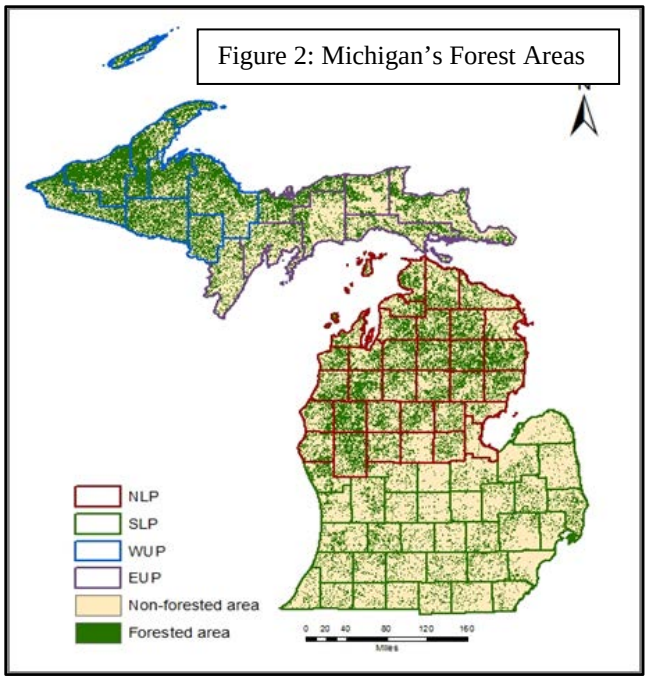
Michigan Timberlands

Figure 1: Proportion of MI forestlands by ownership (Forest Resources of the US 2012)

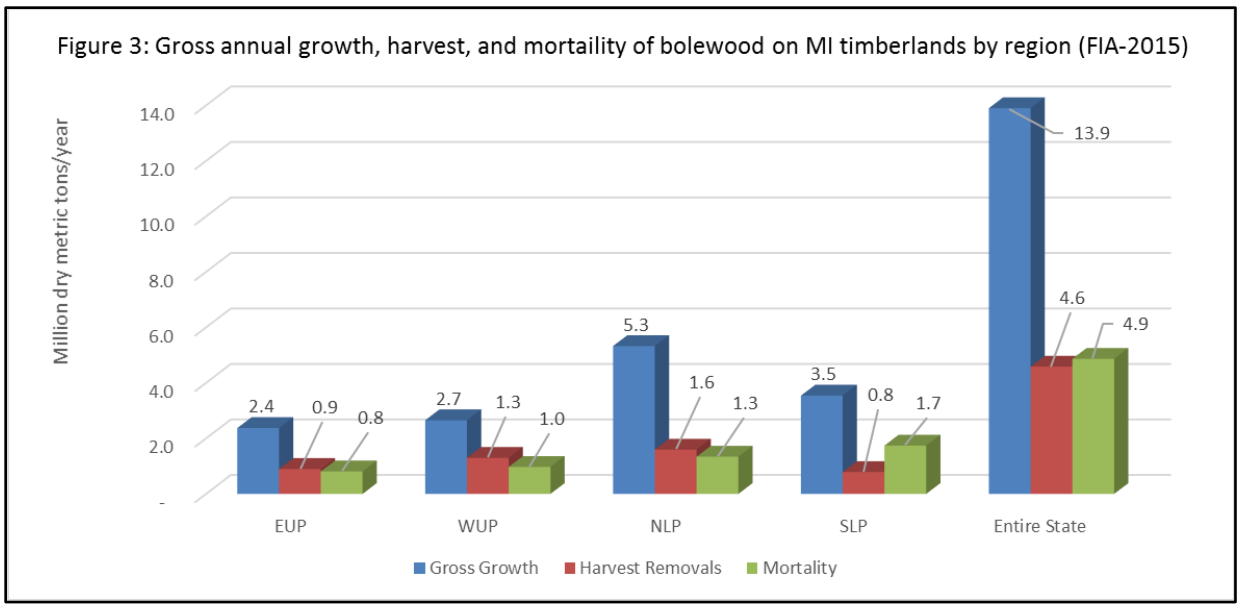


Michigan's forests are vast; the seventh largest in the nation. Forests cover 8.2 million hectares of Michigan, which is approximately 54% of the state's land area. Out of this, 7.8 million hectares are capable of producing more than 0.25 dry Mg/ha·yr of industrial wood and are thus defined as "*timberlands.*" Non-industrial private individuals own the largest share of forestlands in Michigan (48%) followed by the State of Michigan and local governments (23%), the Federal Government (15%), and private corporations (14%) (Figure 1). While the Forest Inventory and Analysis (FIA) unit of the US Forest Service maintains excellent forest ***inventory*** information for all timberlands, each ownership group uses their forests differently. This makes predicting future biomass harvests, and consequently wood ***availability***, difficult.

Figure 2: Michigan's Forest Areas



To further complicate matters, the timberlands of the state are distributed in four geographic sub-regions. The Western Upper Peninsula (WUP) contains 23%, the Eastern Upper Peninsula (EUP) contains 20%, the Northern Lower Peninsula (NLP) contains 38%, and the Southern Lower Peninsula (SLP) contains 18% of the timberland (Figure 2). The productivity, utilization, and ownership of timberland varies within and among these four sub-regions. This further complicates estimating wood availability at specific places in the state, which is a problem for bioeconomy facility developers.



Current Patterns of Growth, Removals, Mortality, and Accumulation

According to 2015 data from FIA, Michigan's forests grow 13.9 dry MMg of new bolewood (sometimes referred to as roundwood) each year. Of this, approximately one third is harvested and used, another third dies and is left to rot in the woods, and the remaining third accumulates; making the forests larger and the trees bigger each year. The wood that is accumulating and/or rotting (2/3 of annual growth) represents a potential source of additional biomass for a developing bioeconomy. Annual growth, removal, and mortality varies by region (Figure 3). These patterns must be understood to avoid siting new facilities in places where insufficient resources exist to support them. For example, 77% and 57% of annual net growth is already used in the WUP the EUP, respectively, because this is where the primary forest products industries are concentrated. There is certainly room for future development in the Upper Peninsula but consider that only 40% of annual net growth is harvested in the NLP. This, combined with the vast forests and impressive annual growth rate in the NLP, suggests where bioeconomy development activities might be concentrated without unduly interfering with existing forest products industries.

Approximately 74% of the wood harvested each year in Michigan comes from deciduous species; the remainder comes from conifers. An in-depth analysis of species distribution is not included here but should be done in the future. The diversity and distribution of feedstocks will determine the types of bioeconomy facility that could be supported in different parts of the state.

Potential Logging Residue Recovery from Current Harvests

It was assumed that none of Michigan's currently harvested biomass would be available to expand the bioeconomy. Additional sources must be found to avoid interfering with the existing forest products industry. One such source might be *logging residues*. These materials are generated in the forest when bolewood is harvested. The tops of merchantable trees (topwood) and the entirety of un-merchantable trees (cull) are usually left behind. Some of these materials have historically been used when fossil fuel prices were high but that is not the case now. It is possible to estimate the amount of topwood that is generated when different types of trees are

harvested. In this case, formulas for hardwoods and softwoods were derived from FIA's 2015 data and used to make this estimate:

$$Hardwood\ Topwood = 0.2682 \times hardwood\ bolewood\ removals$$
$$Softwood\ Topwood = 0.1768 \times softwood\ bolewood\ removals$$

It was assumed that only 75% of this topwood would be available to markets. This was done for both operational considerations and to comply with Michigan Woody Biomass Harvesting Guidance. These guidelines suggest leaving 17% to 33% of residues on-site to maintain ecosystems services and fertility of harvested forest sites.

Total topwood residues from current removals was estimated to be about 1.13 MMg/yr, and three quarters of that (0.85 MMg/yr) might be available. Using FIA removals data, it was determined that approximately 0.2 MMg/yr of cull wood was left behind after current logging operations. If half of this cull biomass was recovered, it could add another 0.1 MMg/yr of useful biomass in the future. Thus, a total of 0.95 MMg/yr of logging residues from current harvests might be available in Michigan.

Potential Recovery of Mortality

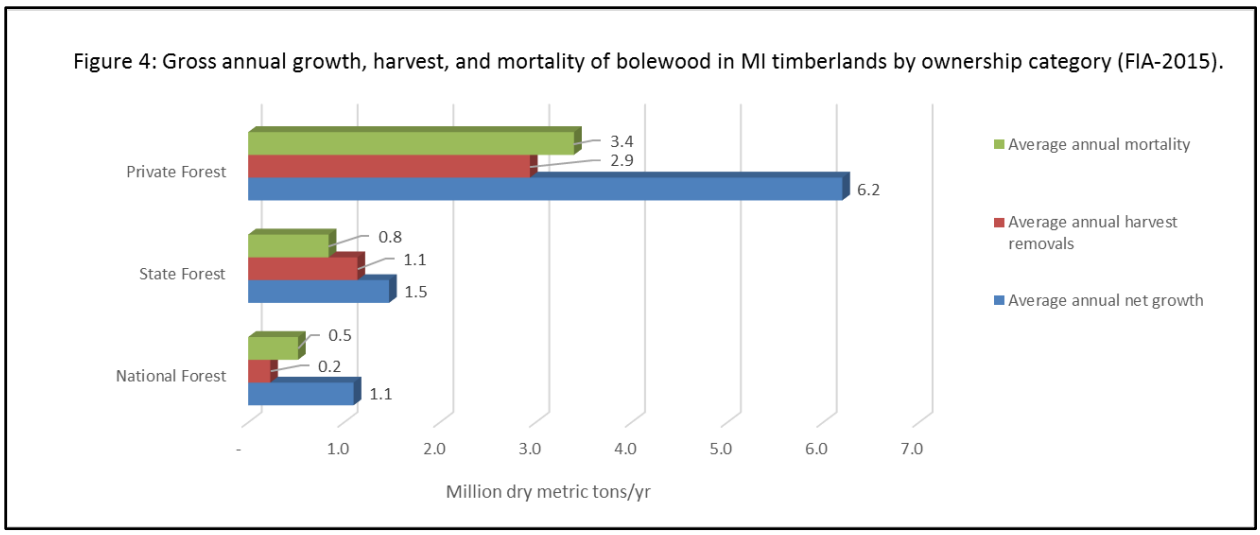
Currently about 6.08 MMg of biomass dies in Michigan timberlands every year (4.87 MMg of bolewood and 1.21 MMg of topwood). This is considerably more than the biomass that is harvested and used (4.60 MMg). The region with the greatest mortality is the SLP (Figure 3). Aging forests, insects, diseases, and natural disasters are the prime reasons for mortality of trees in Michigan's forests. Species groups suffering the greatest mortality include ash, cottonwood, aspen, spruce, and balsam fir (FIA 2015).

Some of the major forest pests that pose threats to Michigan's forests include the emerald ash borer, Asian longhorned beetle, beech bark disease, balsam and hemlock wooly adelgid, diplodia shoot blight, eastern larch beetle, jack pine budworm, spruce budworm, and oak wilt. According to the US forest service health mapping data, the total area damaged by pests in Michigan more than doubled, from approximately 142 to 328 kha between 2013 and 2015, and this trend of increasing mortality is expected to continue in the future (USDA Forest Service, 2017).

Even though this mortality represents a vast untapped source of biomass, the dead trees are scattered throughout the landscape so they are more difficult and expensive to recover than if they were found in large groups. For this reason it was assumed here that only 25% of this mortality (1.52 MMg/year) might be available for recovery and use by the future bioeconomy.

Potential Expanded Use of Unharvested Annual Growth

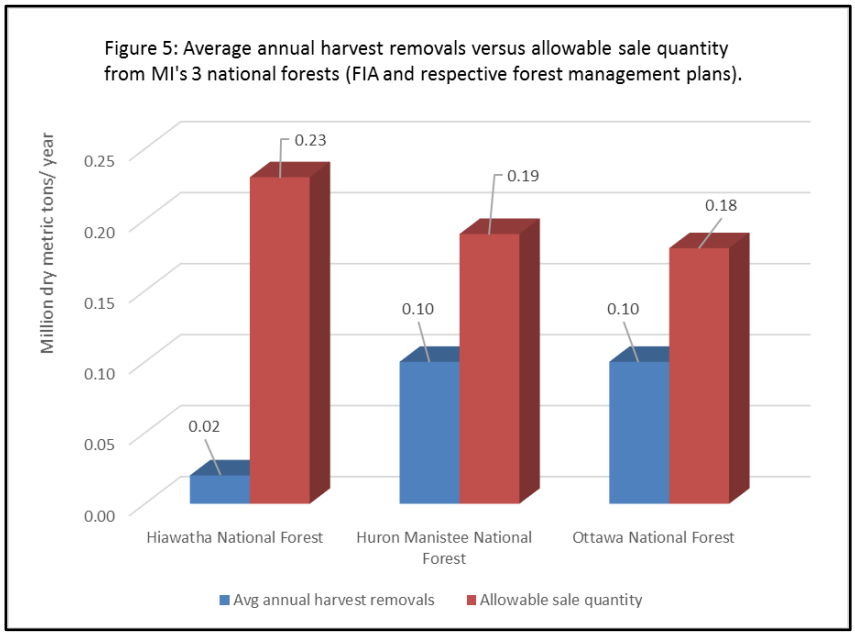
Roughly 1/3 of the wood that grows each year in Michigan is not harvested and does not die, but remains unused and accumulates in the forests. Understanding what might happen to this unused growth in the future is tricky. Approximately 19% of the state's unused annual growth is on national forests, 10% is on forests owned by state, 9% is on industrial private forests, and 62% is on non-industrial private forests (NIPF) (Figure 4). Here we employ a variety of methods and estimate that 0.93 MMg/yr of bolewood and topwood from this unused annual growth might find its way into the expanding bioeconomy of Michigan.



Wood removals are determined in part by written management plans, by international timber products markets, and often by the whim of the landowner. National and state forests utilize written management plans which specify removal targets as well as limits to removals. Industrial private timberlands are owned by timber management organizations (TIMOs), real estate investment trusts (REITs), or other corporations and they usually follow formal plans that are certified by third parties. Some non-industrial private forest owners (NIPF) follow written professional management plans (and obtain property tax benefits for doing so) but many more are disinclined to harvest trees on a regular basis or at all. Private forest owners are usually not required to share their management plans with the public, so it is difficult to project future harvest patterns in nearly 2/3 of Michigan's forests.

National Forests

Approximately 0.24 MMg of timber is being harvested from Michigan's national forests annually. This is only about 22% of the net growth – well below the state average of 51%. Allowable annual harvests in the forest management plans are more than double current harvest levels (Figure 5). An additional 0.52 MMg/yr of bolewood and topwood might be harvested from the national forests in the future if they were able to follow existing management plans.



State Forests

Approximately 1.28 MMg of timber is being harvested from Michigan's state forests annually which is 74% of the net annual growth. These forests are being intensively managed today. The Michigan Department of Natural Resources estimates that approximately 61,000 acres/year of timberland will be harvested in each of the next five years and that the average acre will yield approximately 15 cords. According to this estimate, future average annual removals from State Forests might be 1.00 MMg/yr, which is 22% less than historic harvest levels. This projection is imprecise and it is probable that future harvests will be similar to past harvests. Here we assumed that future state forest harvests will continue at a rate that will be slightly higher than those of the past, adding 0.05 MMg/yr of bolewood and topwood from unused annual growth in an attempt to expand the bioeconomy.

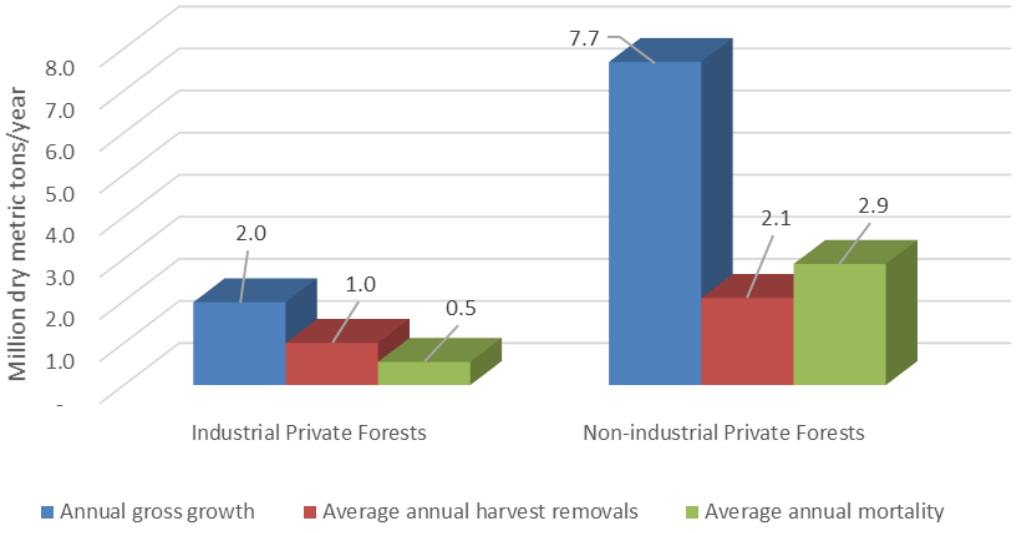
Industrial Private Forests

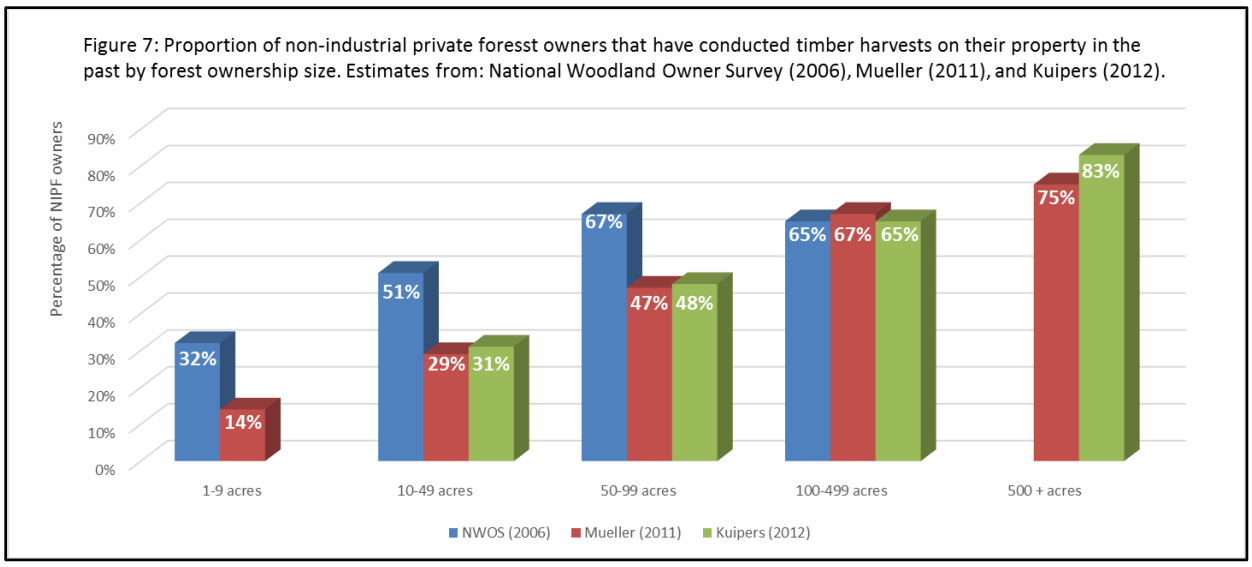
Approximately 1.01 MMg of timber is being harvested from Michigan's industrial private forests annually, which is 71% of net annual growth (Figure 6). These forests are already being managed intensively to produce forest products. The management plans are not public, but it was assumed here that these owners would continue to follow their previous behavior and might be encouraged to moderately increase their harvests by about 0.05 MMg/yr of unused bolewood and topwood.

Non-Industrial Private Forests

Approximately 2.07 MMg of timber is being harvested from Michigan's non-industrial private forests annually (Figure 6). This is about 43% of net annual growth. Judging by this metric, these forests are being managed less intensively than the state and industrial forests but much more intensively than federal forests. However, management intensity varies greatly among owners.

Figure 6: Gross annual growth, harvest, and mortality of bolewood in MI's private timberlands (FIA 2015).





The majority of non-industrial owners cite non-financial factors as the most important reasons for forest ownership. Despite this fact, more than 40% of non-industrial private forest landowners have harvested timber in the past. Review of three recent surveys suggests a significant positive relationship between NIPF landowners' propensity to harvest timber and the size of the forests they own. Figure 7 shows this relationship based upon surveys of NIPF owners conducted by Michigan State University in 2003 and 2010 (Mueller 2011 and Kuipers 2012, respectively) and data obtained between 2002 and 2006 from the US Forest Service National Woodland Owners Survey web application (NWOS). Note that NWOS data in Fig 7 represents all NIPF landowners in Michigan, while Mueller's and Kuipers' data include only survey respondents.

According to NWOS, more than half of NIPF owners in Michigan (53%) own less than 10 acres of forest area. Their ownership is equivalent to 8% of all non-industrial private forest area in the state. Harvesting timber from small forest areas is likely to be less financially viable compared to larger forest tract size and so here we assume that no new biomass will come from this land. Forty three percent of the landowners own forests between 10 to 99 acres in size, which is equivalent to 55% of the total forest area under NIPF ownership. These owners may have a slight inclination to contribute feedstock to the bioeconomy. The remaining 4% of landowners own more than 100 acres and approximately 27% of NIPF forest area in Michigan. This is the group among the NIPF owners most likely to become more active in supplying an expanding bioeconomy.

After considering the probable actions of various NIPF owners and the amount of unused annual growth on their forests, here we estimate that approximately 0.31 MMg/yr of bolewood and topwood could be expected to come from these forests.

Potential use of Mill Residues

According to the most recent Timber Products Output Report (2010) conducted by the State of Michigan, 1.3 MMg of *mill residues* were produced. All but 0.012 MMg (or less than 1 %) remained unused. This suggests that only a negligible amount of mill residue is currently

available for other purposes. However, it does not negate the possibility of increased availability of this resource if markets shift in the future.

Potential for Short Rotation Plantations on Open Land in Michigan

No short rotation woody crop (SRWC) plantations exist in Michigan today, but there is abundant unused open land that is suitable for this type of biomass production. According to the National Land Cover Database of 2011, the total grassland area in Michigan is approximately 553,707 ha. Additionally, the total shrub land area is 311,316 ha. The actual availability of these 865,000 ha for energy plantation will be influenced by multiple factors including property owner objectives, productivity of the site, access to the roads, and distance from markets. It was assumed here that one third of this land (288,341 ha) could eventually be brought into SRWC biomass production.

Based on SRWC biomass production trials conducted throughout Michigan, normal annual yields have ranged from 7.85 to 8.97 dry Mg/ha-yr and averaged about 8.41 Mg/ha-yr. When these yield assumptions are combined with land availability assumptions, SRWC plantations could be expected to contribute about 2.42 MMg/yr.

Potential Recovery of Wood from Urban Trees

The total urban area in Michigan ranges from approximately 1.4 to 1.6 Mha, based upon the 2010 adjusted census urban boundary data layer available from the Michigan Geographic Data Library, the 2011 National Land Cover database and 2014 Cropscape-cropland data layer from USDA National Agricultural Statistics Service database. In his study conducted in 2009, Dave MacFarlane from Michigan State University reported the mean urban biomass (wood + bark + leaves) in 13 Southeastern Michigan counties of 33.6 – 47.4 Mg/ha (MacFarlane 2009). When applied across the total urban area of Michigan, this suggests a total standing biomass of 47.0 - 75.8 MMg. MacFarlane estimated that about 2% of this biomass (0.94 – 1.52 MMg/yr) will die each year and that approximately 0.3 MMg of that would be suitable for producing sawn roundwood products. The remainder would be available for other biomass markets. The optimistic assumption made here was that 1.20 MMg/yr would be available to support new bioeconomy markets.

Potential Recovery of Urban Wood Waste Streams

Urban wood wastes such as yard trimmings, site clearing wastes, pallets, wood packaging, other miscellaneous commercial and household wood wastes as well as wood wastes generated from construction and demolition processes can potentially be used for bioenergy purposes if markets develop for such products in the future. A study conducted by Walsh et al. 1999, reported that approximately 0.82 MMg of urban wood wastes are available on an annual basis in Michigan at a price less than $30/Mg. A study of urban wood waste in the 14 southeastern counties in Michigan was conducted by Sherrill and MacFarlane 2007. The authors' surveyed 1500 randomly selected businesses thought to be potential generators or users of wood residue. They reported that approximately 2.8 MMg of wood residue was generated in southeastern Michigan alone. Out of this, 1.6 MMg was discarded and just over 0.8 MMg were sent to landfills. Recent state-wide studies are lacking, but in their absence, and based on the previous studies, it was assumed here that at least 1.0 MMg of urban wood waste might be available for use in the bioeconomy throughout all Michigan cities.

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