Journal of Forestry, 2020, 1–8
doi:10.1093/jofore/fvaa027
Brief Communication - geospatial technologies
Received December 29, 2019; Accepted May 11, 2020
Advance Access publication June 23, 2020

Brief Communication - geospatial technologies

Forest Ownership Patterns in the Western Upper Peninsula of Michigan, USA

Robert Zupko

Robert Zupko (rzupko@mtu.edu), Department of Social Sciences, Michigan Technological University, Houghton, MI 49931; Center for Infectious Disease Dynamics, Pennsylvania State University, State College, PA 16801.

Abstract

In heavily forested rural areas, tax-incentivization programs are commonly employed to encourage timber production and harvesting activities. Because of growing interest in developing woody-biomass-based biofuels in the Western Upper Peninsula of Michigan, USA, we analyzed property records to determine who the regional actors are along with what role tax-incentivization programs may play. We found that a minority of entities collectively control 77 percent of the land in the region; however, family forest owners collectively own 23 percent of the land. Although tax-incentive programs are commonly used by commercial forests, the requirements of the primary program in Michigan program appear to preclude most family forests in the region. Accordingly, this study suggests that a greater understanding of reluctance of family forests to enroll in secondary programs is needed, or a lowering of forestland requirements to permit more family forests to enroll.

Study Implications: In heavily forested rural areas, the development of local forest resources has been suggested as a means of developing the local economy. One means of using the forest resources is through the development of woody-biomass-based biofuel or bioenergy programs. As these programs are dependent upon harvesting to supply the relevant feedstocks, tax-incentivization programs, such as Michigan's Commercial Forest Land (CFL), may be used to encourage commercial timber production and overcome resistance to harvesting by nonindustrial private forest (NIPF) owners. These findings suggest such programs are likely to be well to fully subscribed by commercial forests. However, the implementation of these programs (ex., minimum of 40 ac. of forestland) may preclude a significant number of family forests from being able to enroll, which may be a contributing factor to low subscription rates. As a result, policymakers wishing to encourage enrollment by family forests in tax-incentivization programs should consider the practical realities of regional family ownership (i.e., average forestland acreage) in developing the programs.

Keywords: family forests, geographic information systems, ownership patterns, tax incentives.

The development of forest resources has been proposed as one means of developing rural economies (Saul et al. 2018), and tax-incentivization programs are frequently employed to encourage forest owners to supply timber for industrial purposes (Hibbard et al. 2003). These programs are of note to the development of woody-biomass-based biofuel or bioenergy facilities, as such facilities are highly dependent upon harvesting activities to supply the relevant feedstocks (Alian and Maclean 2015, Springer et al. 2017). Recently, the

development of woody-biomass-based biofuels has been proposed for the Western Upper Peninsula (WUP) region of Michigan, USA (Woods 2013, Western Upper Peninsula Planning and Development Region (WUPPDR) 2017) with Ontonagon, Michigan being selected as a candidate site for a woody-biomass-based biorefinery (Zupko 2019). The WUP contains approximately 16,000 km^2 of heavily forestland, which could supply a woody-biomass biorefinery, and although commercial forests are present in the region, the regional economy is depressed with tourism being the primary sector (WUPPDR 2017).

There have been several studies conducted in the region to evaluate its potential for woody-biomass-based biofuels (see Zhang et al. 2011, Alian and Maclean 2015, Brunner et al. 2015), and family forests (i.e., forest ownership by individuals and families) are highlighted as one potential barrier to development because of reluctance to harvest (see Schubert and Mayer 2012, Lind-Riehl et al. 2015, Rouleau et al. 2016). However, whereas family forests, and more broadly non-industrial private forests (NIPFs) (i.e., private forest lacking woody processing facilities), appear to control approximately one-third of the forestland in the region (Lind-Riehl et al. 2015, Butler et al. 2016a), the precise inventory in the region is unknown. Potentially mitigating reluctance to harvest by landowners are tax-incentivization programs through the State of Michigan that require harvesting as part of a documented forest management plan. The most commonly known one is the Commercial Forest Lands (CFL) program, which offers significantly reduced property taxes for owners of at least 40 contiguous acres (161,874 m^2) of forest who also permit public access to their land (Michigan Department of Natural Resources (DNR) 2018). A lesser-known program enacted in 2006 is the Qualified Forest Program (QFP), which offers reduced or capped property taxes, but also has an annual enrollment fee (Lowe et al. 2017, Michigan Department of Agriculture and Rural Development 2019). Although the QFP tax savings are not as significant as the CFL program, the parcel size and stocking requirements are significantly lower, and public access to the land is not a requirement. Although there is a developing understanding of what may motivate family forests to enroll (or not) in these programs, it remains unclear if regional enrollment may be approaching a potential maximum because of a combination of ownership type and land use.

Also driven by the interest in developing woody-biomass-based biofuels in the WUP region, agent-based modeling (ABM) has been applied to assess their potential regional impact (Rouleau and Zupko 2019). Agent-based modeling is a computer modeling technique in which software "agents" are used to simulate the various actors in a system and how they interact with a landscape, allowing for projections to be made about timber harvesting and the impacts on the landscape. However, the validity of an ABM is highly dependent upon the accuracy of the underlying data, necessitating a comprehensive inventory of the ownership in the region as well as land-cover data. The National Land Cover Database (NLCD) is one possible source of these data, with both the NLCD 2011 (Homer et al. 2015) and NLCD 2016 (Yang et al. 2018) data sets being possible sources of land-cover data. However, in releasing NLCD 2016, Yang et al. (2018) note that corrections were made to the methods that impacted forest and wetlands classifications, which may impact the results of models using the legacy NLCD 2011 data set.

Accordingly, this brief communication has two goals: first, determine what enrollment is possible in tax-incentivization programs, given the ownership and land cover data for the WUP. Second, quantify the possible error in studies previously conducted using the legacy NLCD 2011 data set compared to the NLCD 2016 product suite.

Methods

Parcel maps were collected from WUP counties (i.e., Baraga, Gogebic, Houghton, Iron, Keweenaw, and Ontonagon) and aggregated into a single map using ArcGIS 10.6.1 (ESRI 2017) resulting in 65,461 parcels containing 15,724 km^2 of land. Ownership records were extracted, and parcel references to towns and physical features (e.g., lakes) were discarded. Each property owner was assigned a unique id and exact duplicates (e.g., same name, address, etc.), where all assigned the same unique id value. A Python script was then written using ArcGIS's ArcPy extensions to look for additional duplication based upon differences in county entireties (e.g., "John and Jane Doe" versus "John Doe et ux").[1] The Levenshtein Distance (Levenshtein 1966), or similarity score, between names was calculated when matching owner addresses were found, and records with a similarity score exceeding the statistical threshold of approximately 0.55 were assumed to be matches. Once the matches were identified, the records were updated with the relevant parent record and source of match (e.g., name or address records).

Upon consolidation of ownership records, parcels smaller than 1 acre were removed, since they cannot meet the minimum area to qualify as forest (Butler et al. 2016a). Labels were then programmatically assigned based upon the scheme outlined in Table 1. First, the CFL registry (DNR Open Data 2017) was used to identify commercial forests based upon centroid intersection between the registry parcels and the consolidated parcel map. Other labels were programmatically applied based upon pattern matching of the owner record, and specific labels were not assigned if a pattern was not matched.

Upon completion of parcel labeling, the land-cover characteristics were calculated using both legacy NLCD 2011 and NLCD 2016 data sets. Although the NLCD 2016 data set was used for primary data analysis, for both data sets the ArcGIS Tabulate Area tool was used to calculate the area of each parcel by NLCD code, and the results were aggregated into forest (NLCD codes 41, 42, and 43 for deciduous, evergreen, and mixed forest, respectively) and woody wetlands (NLCD code 90). Once the total forested area was calculated, parcels with less than 1 acre of forest were removed per the minimum threshold requirement. Any remaining unlabeled parcels with at least 1 acre of forestland were manually reviewed to determine whether they fit into any of the categories. If so, an appropriate label was applied, otherwise they were left uncategorized. Finally, parcels were clipped to ensure they were bound to the county lines (Michigan Center for Geographic Information 2005).

Results

Upon completion of the analysis, a total of 39,119 parcels remained, containing 10,648 km^2 of forests and 3,112 km^2 of woody wetlands (see Table 2, Figure 1). These parcels also account for approximately 15,367 km^2 of land or 98 percent of the total area in the region. The discrepancy in total area is attributable to the parcels that fell outside the minimum size thresholds used in the analysis. Land-cover classification showed a minor decrease in forestland from NLCD 2011 to NLCD 2016, whereas the quantity of wetlands increased significantly by a total of 432 km^2. This increase is likely attributable to changes in the preparation of NLCD 2016, specifically improvements to wetland classifications (see Yang et al. 2018).

Land ownership is approximately 30 percent federal, 23 percent family forests, and 28 percent registered as commercial forest independent of any other attributes. Federal land ownership is primarily limited to Isle Royale National Park and Ottawa National Forest, whereas the state of Michigan manages parks such as Porcupine Mountains Wilderness. Excluding parcels controlled by government entities, and parcels listed in the CFL registry as "Forest Industry," a total of 31,080 parcels with 3,712 km^2 of forest and 5,695 km^2 of total land may be classified as NIPFs (see Figure 2). Furthermore, analysis of the ownership records indicates that a minority of 624 private entities (i.e., corporations, trusts, and private individuals) own in excess of 1 km^2 of forest with a mean ownership of about 9.5 km^2 of land under their control. However, this list is dominated by timber companies, the top 10 of which control 2,687 km^2 of land in the region.

Family forests are common in the region, and a total of 18,123 were identified with an average forested area of approximately 30 ac (131,406 m^2) (see Table 3). Family-forest ownership patterns break with

Table 1. Labels assigned to parcels during analysis along with characteristics of the parcel.

Label	Description
Native American	Parcel owner is a local Native American community (ex., "Keweenaw Bay Indian Community"), or records indicated land held in trust by the government for Native Americans
Federal	Parcel ownership is associated with the "US Government" or a federal agency
State	Parcel ownership is associated with the "state of Michigan" or a state agency
Municipal	Parcel ownership is associated with the county (e.g., "Houghton County"), local community (e.g., "Houghton Township"), or local community services (e.g., "Houghton-Portage Twp Schools")
Commercial	Parcel appears in Commercial Forest Land data set (Michigan DNR Open Data 2017)
Family forest	Parcel has at least 1 ac (4,046.86 m^2) of forest, and the owner appears to be an individual or family
Trust	Parcel ownership record clearly indicates association with a trust (ex., "Doe Family Trust"), the owner is listed as a trustee, or the organization is a 501(c)(3) registered nonprofit

Table 2. Summary of labels along with percentage changes from NLCD 2011 to 2016 data.

			NLCD 2011		NLCD 2016		Percentage change	
	Count (parcels)	Total (km²)	Forest (km²)	Wetlands (km²)	Forest (km²)	Wetlands (km²)	Forest	Wetlands
Native American	120	23	18	3	18	3	–1.3	23.1
Federal	2,546	4,620	3,418	857	3,286	996	–4.0	14.0
State	1,911	1,249	868	256	855	293	–1.6	12.6
Municipal	790	325	203	79	188	93	–7.9	15.0
Commercial forest	4,776	4,336	3,332	706	3,243	827	–2.7	14.6
Family forest	24,498	3,553	2,280	563	2,288	658	0.4	14.4
Trust	1,796	369	242	69	239	77	–1.2	10.8
Mixed/corporate	2,682	892	549	147	530	164	–3.6	10.1
Totals	39,119	15,367	10,910	2,680	10,648	3,112	–2.7	14.3

Note: "Commercial forest" represents properties that are solely registered as such.

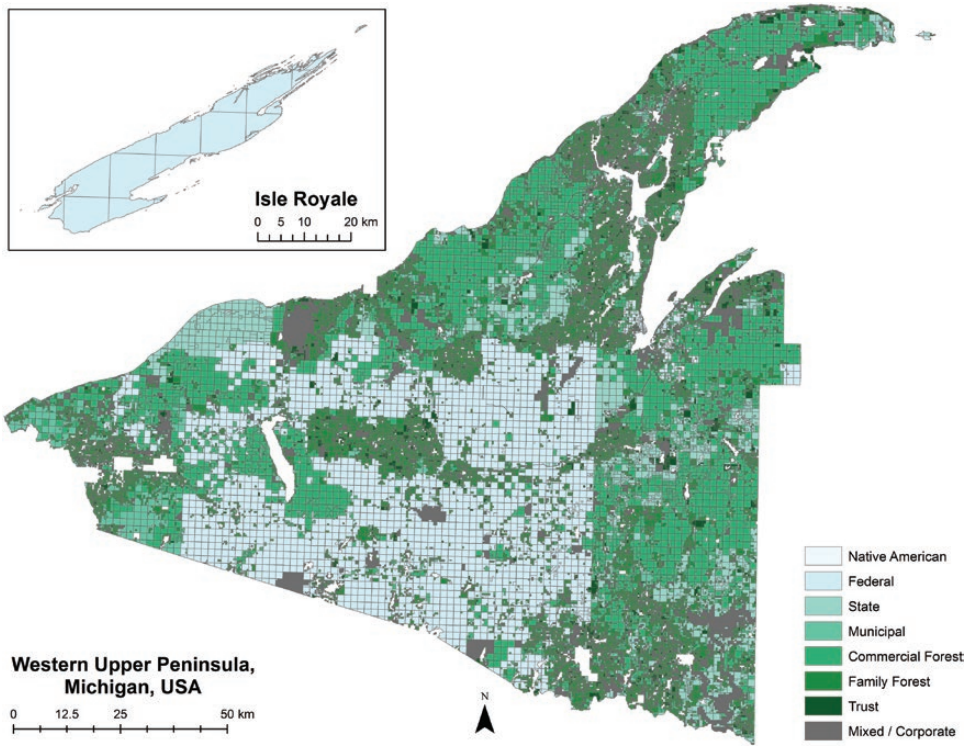

Figure 1. Comprehensive map of the Western Upper Peninsula region along with the labels that were assigned to the parcels. Note that Isle Royale consists entirely of Isle Royale National Park.

the national averages found in Family Forest Owners of the United States 2013 (Butler et al. 2016b) and National Woodland Owner Survey (NWOS) (Butler et al. 2016a), which found that the majority would have between 1 and 9 ac of forest. The rates are like those found in the NWOS breakout for the state of Michigan (Butler et al. 2016a), although ownership is more concentrated in the "20 to less than 50 acres" range at about 31 percent versus the state rate of 26.2 percent.

Across all private ownership types, 6,103 parcels and 3,583 km² of forests were found to be registered in the CFL program, of which 1,166 parcels consisting of 290 km² are family forests (see Table 3). Approximately 72 percent of the 4,953 km² of eligible forests are enrolled in the program. Furthermore, approximately 30

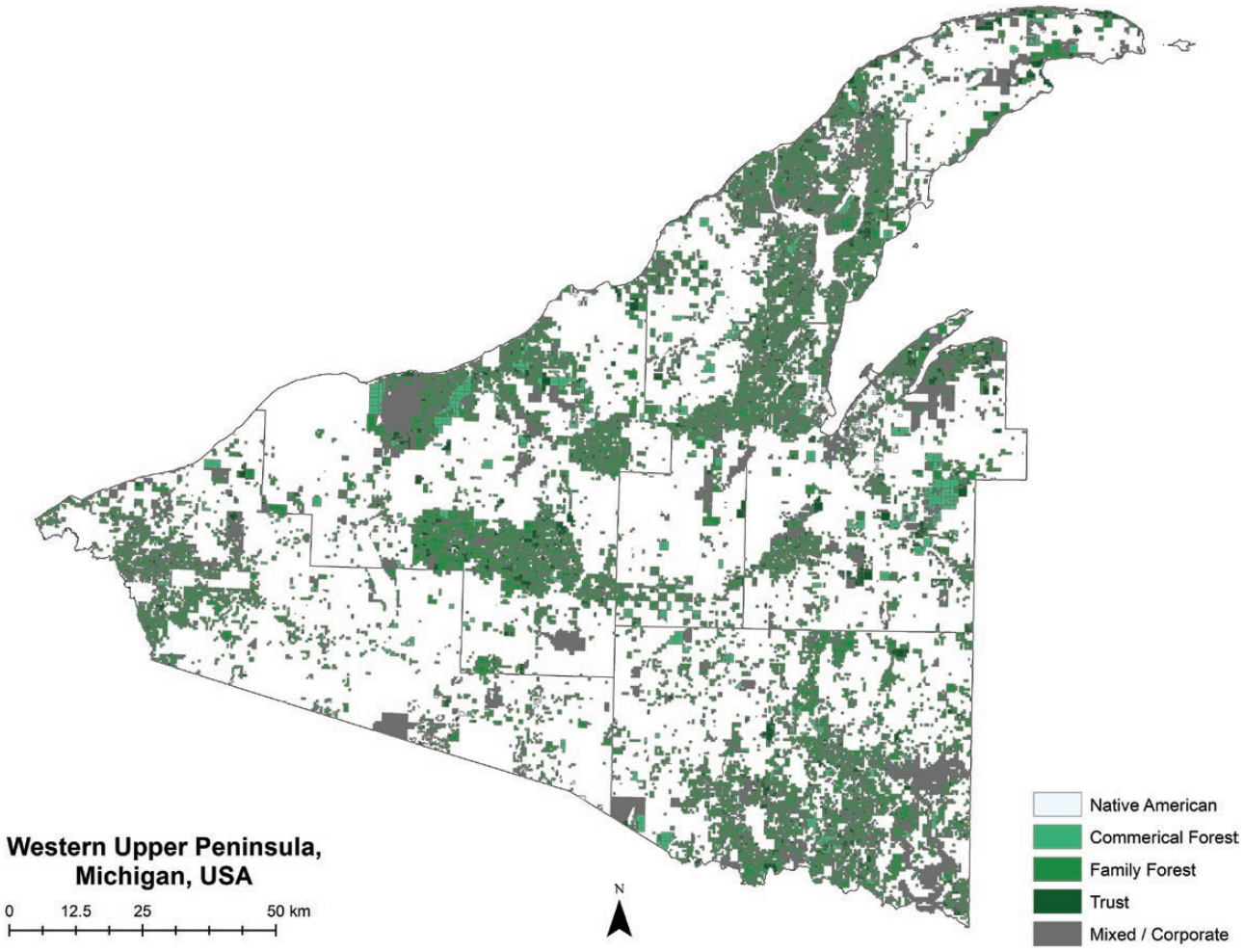

Figure 2. Likely NIPF parcels in the WUP, "Commercial Forests" indicates enrollment in the program. Note that Isle Royale is excluded because of being solely federally owned.

Table 3. Family forest holdings based upon NCLD 2016.

	Count (parcels)	Forest area (ac)	Wetlands area (ac)	Total area (ac)	Percentage of total
1 to <10	6,863	32,256	28,180	83,941	5.71
10 to <20	3,319	49,024	24,165	92,948	8.67
20 to <50	5,072	164,904	39,233	243,689	29.18
50 to <100	1,912	132,580	26,671	190,546	23.46
100 to <200	731	99,192	18,666	137,716	17.55
200 to <500	185	52,635	12,762	74,164	9.31
500 to <1,000	30	19,156	4,177	26,522	3.39
1,000 to <5,000	11	15,451	5,527	23,074	2.73

Note: Breaks follow the pattern used by Butler et al. (2016a).

percent of eligible family-forest parcels are enrolled in the program, whereas about 34 percent of trust-owned parcels are enrolled. For parcels not registered with the program, 3,842 containing about 1,370 km^2 of forest met the minimum requirements for participation (see Figure 3). A total of 2,731 of the eligible parcels containing 826 km^2 of forestland appear to be family-owned. One complicating factor in evaluating eligible parcels is the presence of parcels, annotated as "Mixed/Corporate," whose ownership indicated an

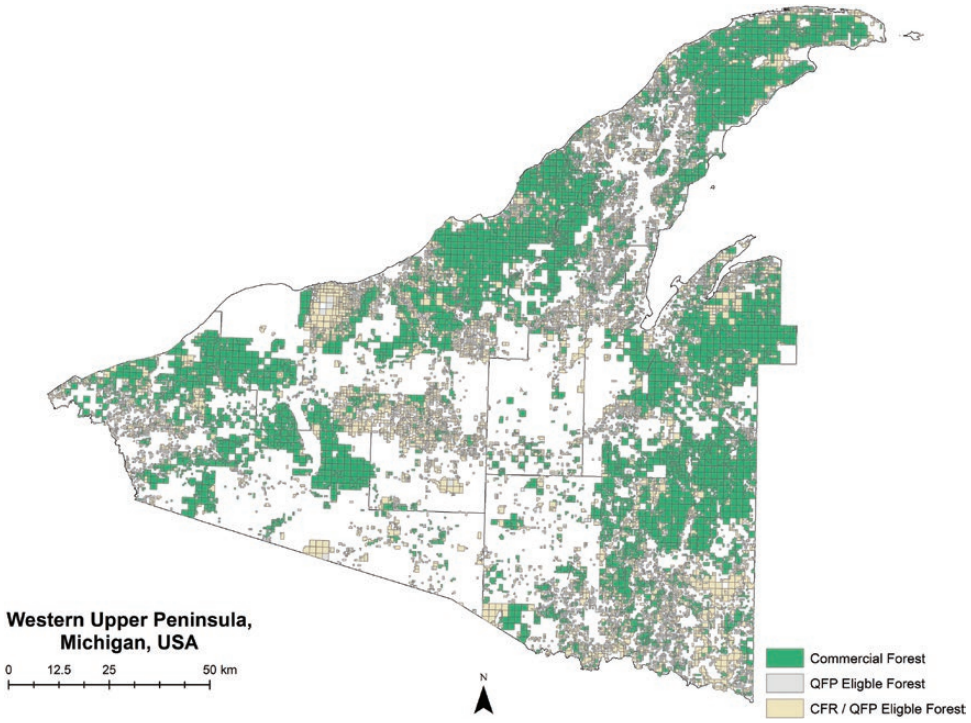

Figure 3. Parcels registered in the Michigan Commercial Forest Land program with the remaining eligible parcels, based upon NLCD 2016 land-cover data.

affiliation with the forest industry but were not enrolled. This may be attributable to a delay in updating maps by the state of Michigan or site factors that preclude registration. However, this complicating factor implies that the total number of eligible parcels may need to be revised down by as much as 15 percent.

Discussion

One outcome of this study is the quantification of the deviation in wetlands between the NLCD 2011 and NLCD 2016 data sets, which is significant enough to have modeling implications. A review of the results (see Table 2) suggests that the primary source of this deviation is the reclassification of pixel data from forest (i.e., deciduous, evergreen, and mixed forest) to woody wetlands. Although it is possible that this deviation is skewed by the nature of the WUP region, other heavily forested parts of the United States might notice results. Accordingly, studies that were dependent upon the legacy NLCD 2011 data set, and concern wetlands, may have underestimated projected impacts.

Next, the results of the current enrollment remaining eligible properties for the Michigan CFL program bears some consideration. Given the parameters of the program; namely, 40 contiguous acres of forest, a forest management plan that incorporates timber harvesting, and public access to the land, the program appears to be quite successful at enrolling eligible parcels. The regional forest industry appears to be taking advantage of the program, with the data suggesting that they might be fully enrolled on a regional basis. The remaining 3,842 eligible parcels warrant careful consideration, since the property records indicate that some are owned by the forest industry. Other large tracts of eligible parcels indicate ownership by the mining industry, being held as conservation lands, or possible use as research forests by universities that would preclude enrollment in the CFL program. This supports claims that family forests may be the last major reserve of unenrolled CFL eligible parcels in the region.

One potential barrier to increasing enrollment in the CFL is the requirement that landowners have a minimum of 40 contiguous acres of forest (Table 4). Although family forests in the WUP region are larger than the national average (Butler et al. 2016b), a mean of 30 ac indicates that CFL acreage requirements may exclude a significant number of interested landowners. An alternative to the CFL is the Qualified Forest Program (QFP) program, and statewide the program reports 483,368 ac (1,956 km^2) enrolled as of fiscal year 2018 (Harlow 2018), although an inventory of parcels is not available to the public. However, it is still

Table 4. Enrollments in the Michigan Commercial Forests Program compared to possible enrollment based upon a minimum of 40 contiguous acres of forest using NLCD 2016 land use labels.

	CFL registered forests				CFL eligible forests			
	Count (parcels)	Forest (km^2)	Wetlands (km^2)	Total (km^2)	Count (parcels)	Forest (km^2)	Wetlands (km^2)	Total (km^2)
Commercial forest	4,775	3,243	827	4,336				
Mixed/corporate	5	1	1	2	772	422	97	653
Family forest	1,166	290	99	420	2,731	826	133	1,103
Trust	156	49	11	65	300	108	23	147
Native American	1	0	0	0	39	13	2	16
Totals	6,103	3,583	938	4,823	3,842	1,370	255	1,919

Table 5. Summary of parcels eligible for enrollment in the Qualified Forest Program with at least 20 ac of forest and less than 40 ac.

	QFP eligible forests (20–40 ac)			
	Count (parcels)	Forest (km^2)	Wetlands (km^2)	Total (km^2)
Family forest	5,805	720	128	990
Trust	448	56	14	81
Native American	27	4	0	4
Mixed/corporate	549	68	25	123
Totals	6,280	779	142	1,076

possible to identify parcels in the lower 20–40 ac range offered by the QFP (see Figure 3, Table 5). Although it is unlikely that none of the family forests eligible for the QFP are enrolled, it is quite likely that family forests are again the major reserve of eligible forest in the region that can be enrolled in the QFP. This suggests that family forests in the WUP region may offer a maximum of 1,546 km^2 of forestland across 8,536 parcels for enrollment in either the CFL or QFP.

Recalling that both the CFL and QFP programs require a forest-management plan, one implication of these findings is that it suggested that management plans by family forests in the region are quite uncommon. For family forests with 10 or more acres, the findings support a minimum of only 13 percent of forestland being under a management plan because of CFL requirements, significantly below the national rate reported by Butler et al. (2016). Interviews with NIFPs in the region support this as the concept of "[letting] nature take its course" (Lind-Riehl et al. 2015, p. 99) and may conflict with a formal management plan.

The data that are presented here represent an improved understanding of the forest-ownership patterns in the WUP region. Although ownership is largely dominated by a minority of entities such as the federal government and industrial forests, family forests are quite common. Furthermore, ownership records strongly suggest that commercial forests are likely fully enrolled in the CFL, whereas family forests are predominately unenrolled in tax-incentivization programs. Understanding why family forests do not participate in tax-incentivization programs will be of interest to policymakers seeking to support the timber industry or when attempting to evaluate regional potential for woody-biomass-based biofuels.

Acknowledgments

The author would like to thank Mark Rouleau and Audrey Mayer of Michigan Technological University for their assistance in preparing this manuscript.

Endnote

1. Source code is available on GitHub at https://github.com/rjzupkoii/cabals/tree/master/gis

Literature Cited

Alian, S., and A. Maclean. 2015. Assessing site availability of aspen and northern hardwoods for potential feedstock

development in Michigan: A case study. *Land* 4(2). doi: 10.3390/land4020413.

Brunner, A., W.S. Currie, and S. Miller. 2015. Cellulosic ethanol production: Landscape scale net carbon strongly affected by forest decision making. *Biomass Bioenerg.* 83:32–41.

Butler, B.J., J.H. Hewes, B.J. Dickinson, K. Andrejczyk, S.M. Butler, and M. Markowski-Lindsay. 2016a. Family forest ownerships of the United States, 2013: Findings from the USDA Forest Service's National Woodland Owner Survey. *J. For.* 114(6):638–647.

Butler, B.J., J.H. Hewes, B.J. Dickinson, K. Andrejczyk, S.M. Butler, and M. Markowski-Lindsay. 2016b. USDA Forest Service National Woodland Owner Survey: National, regional, and state statistics for family forest and woodland ownerships with 10+ acres, 2011–2013 (Research Bulletin NRS-99; p. 39 p.). USDA Forest Service, Northern Research Station. doi:10.2737/NRS-RB-99.

Harlow, R. 2018. Qualified Forest Program [MDARD Annual Report | 2017–2018]. Michigan Department of Agriculture and Rural Development. Available online at https://www.michigan.gov/documents/mdard/FY2018_Qualified_Forest_Annual_Report_653518_7.pdf; last accessed February 11, 2020.

Hibbard, C.M., M.A. Kilgore, and P.V. Ellefson. 2003. Property taxation of private forests in the United States: A national review. *J. For.* 101(3):44–49.

Homer, C.G., J.A. Dewitz, L. Yang, S. Jin, P. Danielson, G. Xian, J. Coulston, N.D. Herold, J.D. Wickham, and K. Megown. 2015. Completion of the 2011 National Land Cover Database for the conterminous United States-representing a decade of land cover change information. *Photogramm. Eng. Remote Sens.* 81(5):345–354.

Lind-Riehl, J., S. Jeltema, M. Morrison, G. Shirkey, A.L. Mayer, M. Rouleau, and R. Winkler. 2015. Family legacies and community networks shape private forest management in the western Upper Peninsula of Michigan (USA). *Land Use Policy* 45:95–102.

Lowe, S., B. Baker, E. Pratt, and J. Sefton. 2017. Senate bills 651, 652, and 653 (as enacted) (p. 10) [Bill Analysis]. Senate Fiscal Agency. Available online at https://www.legislature.mi.gov/documents/2015–2016/billanalysis/Senate/pdf/2015-SFA-0651-N.pdf; last accessed February 11, 2020.

Michigan Center for Geographic Information. 2005. Michigan counties V17 (5a ed.) [Map]. Available online at http://gis-michigan.opendata.arcgis.com/datasets/counties-v17a; last accessed April 1, 2019.

Michigan Department of Agriculture and Rural Development. 2019. Qualified Forest Program (QFP) frequently asked questions. Available online at https://www.michigan.gov/documents/mdard/FAQ_QFP_6_27_13_425908_7.pdf; last accessed February 11, 2020.

Michigan Department of Natural Resources. 2018. Commercial forests summary (No. IC4171; p. 1–2). Michigan Department of Natural Resources (DNR). Available online at https://www.michigan.gov/documents/dnr/IC4171_CommercialForestSummary_185969_7.pdf; last accessed July 10, 2018.

Michigan Department of Natural Resources Open Data. 2017. Michigan commercial forest land (Private Land Tax Incentive/Public Hunting and Fishing) [Map]. Available online at http://gis-michigan.opendata.arcgis.com/datasets/0e78979ab94648b8b5e34759bbdc8cf2_5; last accessed July 11, 2018.

Rouleau, M., J. Lind-Riehl, M. Smith, and A. Mayer. 2016. Failure to communicate: Inefficiencies in voluntary incentive programs for private forest owners in Michigan. *Forests* 7(9). doi: 10.3390/f7090199.

Rouleau, M., and R. Zupko. 2019. Agent-based modeling for bioenergy sustainability assessment. *Landscape Urban Plan.* 188:54–63.

Saul, D., S. Newman, S. Peterson, E. Kosse, R. Jacobson, R. Keefe, S. Devadoss, T. Laninga, and J. Moroney. 2018. Evaluation of three forest-based bioenergy development strategies in the Inland Northwest, United States. *J. For.* 116(6):497–504.

Schubert, J.R., and A.L. Mayer. 2012. Peer influence of nonindustrial private forest owners in the Western Upper Peninsula of Michigan. *Open J. For.* 2(3):150–158.

Springer, N., N. Kaliyan, B. Bobick, and J. Hill. 2017. Seeing the forest for the trees: How much woody biomass can the Midwest United States sustainably produce? *Biomass Bioenerg.* 105:266–277.

Western Upper Peninsula Planning & Development Region. 2017. Comprehensive economic development strategy (p. 84). Western Upper Peninsula Planning & Development Region (WUPPDR). Available online at http://www.wuppdr.org/wp-content/uploads/2017/04/CEDS16_FINAL.pdf; last accessed May 29, 2017.

Woods, R. 2013. *U.P. biofuels cooperative strategy*. Michigan Technological University.

Yang, L., S. Jin, P. Danielson, C. Homer, L. Gass, S.M. Bender, A. Case, et al. 2018. A new generation of the United States National Land Cover Database: Requirements, research priorities, design, and implementation strategies. *ISPRS J. Photogramm. Remote Sens.* 146:108–123.

Zhang, F., D.M. Johnson, and J.W. Sutherland. 2011. A GIS-based method for identifying the optimal location for a facility to convert forest biomass to biofuel. *Biomass Bioenerg.* 35(9):3951–3961.

Zupko, R. 2019. Life cycle assessment of the production of gasoline and diesel from forest residues using integrated hydropyrolysis and hydroconversion. *Int. J. Life Cycle Ass.* 24(10):1793–1804.