

Summary Report

GHG Inventory for Forests and Trees Outside Forests, 2001 to 2016 Milwaukee County, Wisconsin

Summary

Forests and trees play a key role in mitigating climate change, yet they are often not included in local greenhouse gas (GHG) inventories or climate action plans. Milwaukee County, Wisconsin has taken the first step towards understanding how local changes in land use and tree canopy have contributed to the county's net greenhouse gas profile. Unlike other sectors, land use (in this case, forests and trees) not only emit GHGs, they also remove CO₂ from the atmosphere through photosynthesis, and play a critical role in regulating the planet's climate. The information contained in this summary report can be useful when designing climate actions that reduce GHG emissions and/or increase removals of GHGs from the atmosphere.

Key findings:

- Over the period 2001 to 2016, emissions from forests and trees were 11,215 t CO₂e per year.
- Over the period 2001 to 2016, the Net GHG balance of forests and trees was -57,667 t CO₂e per year.
- Roughly 11% of Milwaukee County's total land base of 62,813 hectares (155,214 acres) is forest. Many areas outside of forests are also covered by trees, including an average of nearly 9.9 percent tree canopy on lands outside of forest areas
- Over the same period, annual CO₂ removals from forests and trees were -68,881 t CO₂e per year. (Carbon removals are represented by negative values.)
- Total GHG emissions for Milwaukee County across all sectors could be reduced if additional forests/trees were added to its land base, and/or if losses of trees were reduced further.

Table 1. Milwaukee county's GHG fluxes from forests and trees for inventory period 2001 – 2016, all values reported in t CO₂e per year

	Removals(t CO ₂ e/yr)	Emissions(t CO ₂ e/yr)
Undisturbed Forest	-12,238	
Forest Disturbances		9,299
Non-Forest to Forest	-755	
Forest to Settlement		1,664
Forest to Grassland		33
Forest to other non-forest lands		375
Trees outside of forests	-55,889	32
Harvested Wood Products	0	
TOTAL	-68,881	11,215
Net GHG balance	-57,667	

Data Inputs

Data used as inputs into the GHG emission and removal calculations are described below.

Land and Forest Cover

GHG inventories for lands are reported in six “land use” categories which were defined by data on land cover—forest land, grassland, cropland, wetland, settlement and other land (barren, snow, ice). Milwaukee County’s total land base is approximately 62,813 hectares (155,214 acres), with nearly 78.2% Settlement (i.e. developed areas of varying intensity), around 10.8% forest, 4.2% Grassland (which includes hay/pasture, shrub/scrub and other herbaceous cover), 4.9% cropland, 1.3% wetland and 0.6% other land.

Figure 1. Land cover in Milwaukee from the National Land Cover Database, 2016

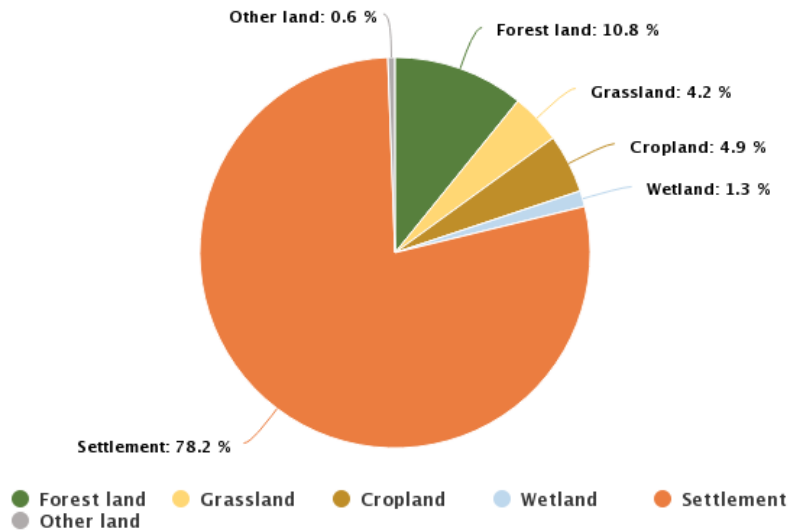
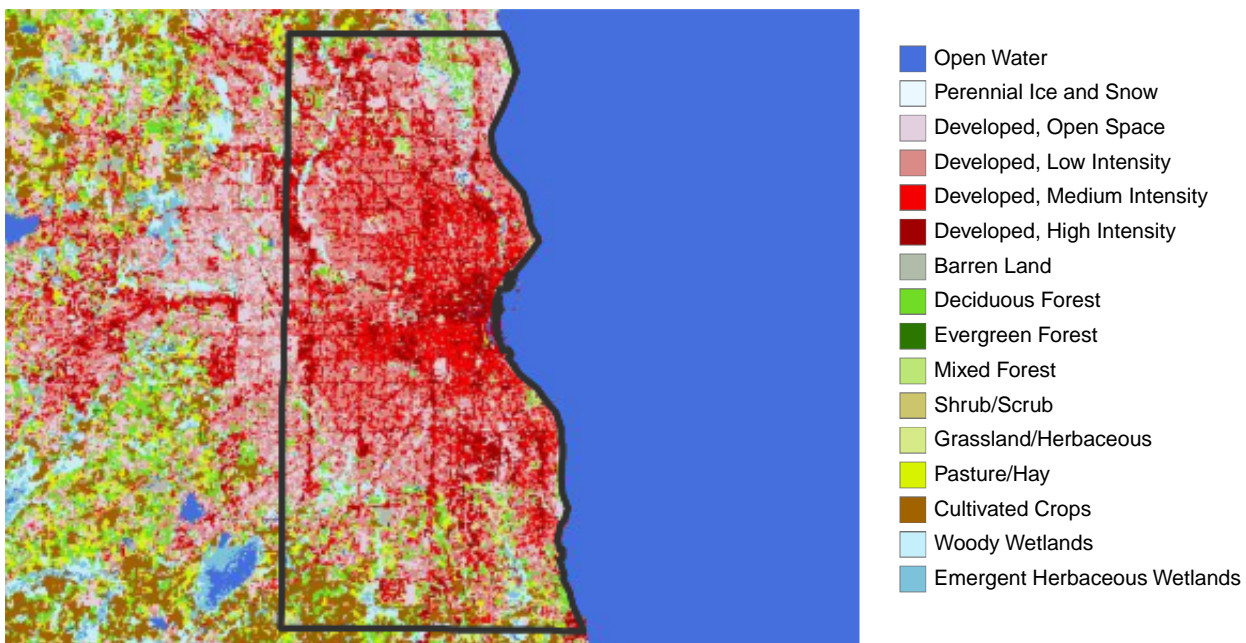
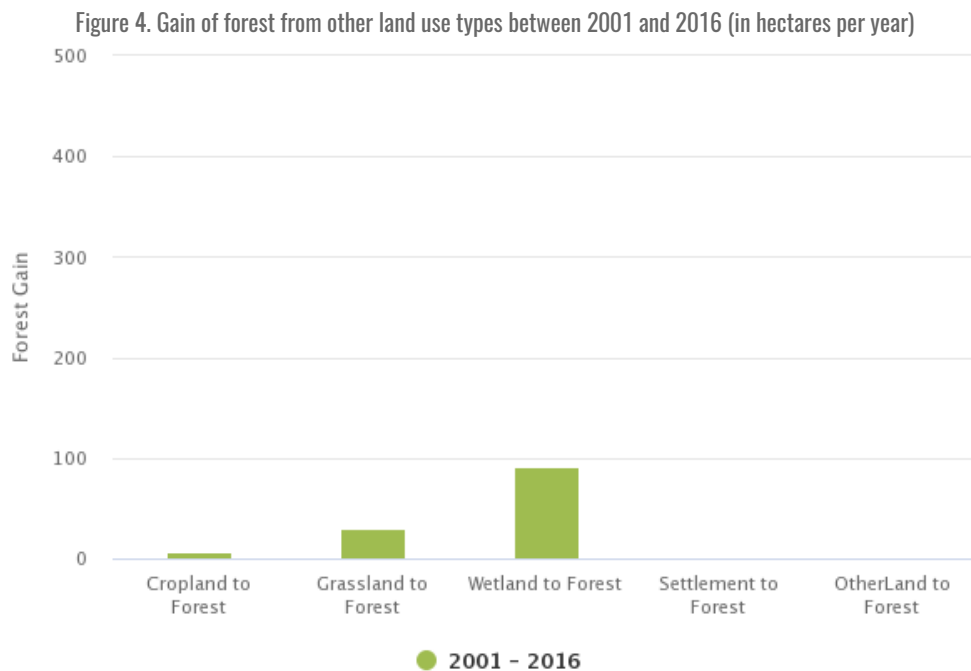
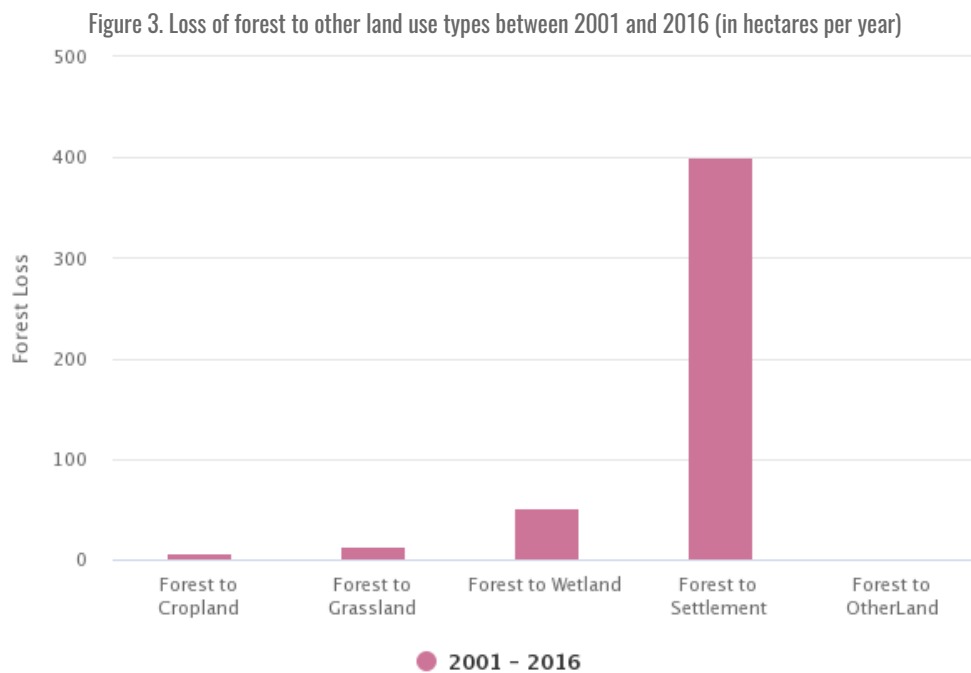


Figure 2. Land cover in Milwaukee from the National Land Cover Database, 2016



Forest Cover Change

Generating GHG estimates requires data not just on areas of land use, but also data on how land use has changed over time. Between 2001 and 2016, the county lost around 473 hectares (1,169 acres) of forest land per year, largely conversion to Wetland. Over the same period, the county gained around 128 hectares (316 acres) of forest land, largely from Wetland.



Forest Disturbances

Over the inventory period 2001 to 2016, forest disturbance from insects was the most significant in Milwaukee County, affecting an average of 4527.9 hectares (11,189 acres) per year, followed by harvests, which affected 3.6 hectares (9 acres) per year and fires, which affected 0 hectares (0 acres) per year.

Trees Outside Forests

Figure 5 shows tree canopy captured by the NLCD tree canopy data. (Note that some areas with high tree canopy in Figure 5 overlap with the NLCD forest class shown in Figure 2.)

These data are available only for the years 2011 and 2016. Over this time period, Montgomery County had an average of 9,629 hectares (23,795 acres) of tree canopy outside forests. Between 2011 and 2016, 1 hectares per year of tree canopy were lost, for a total of 16 hectares (39 acres) of tree canopy loss over the 5 year period. Most of this loss occurred within the ForestLand class.

Figure 5. Tree canopy 2016 (Source: National Land Cover Database)

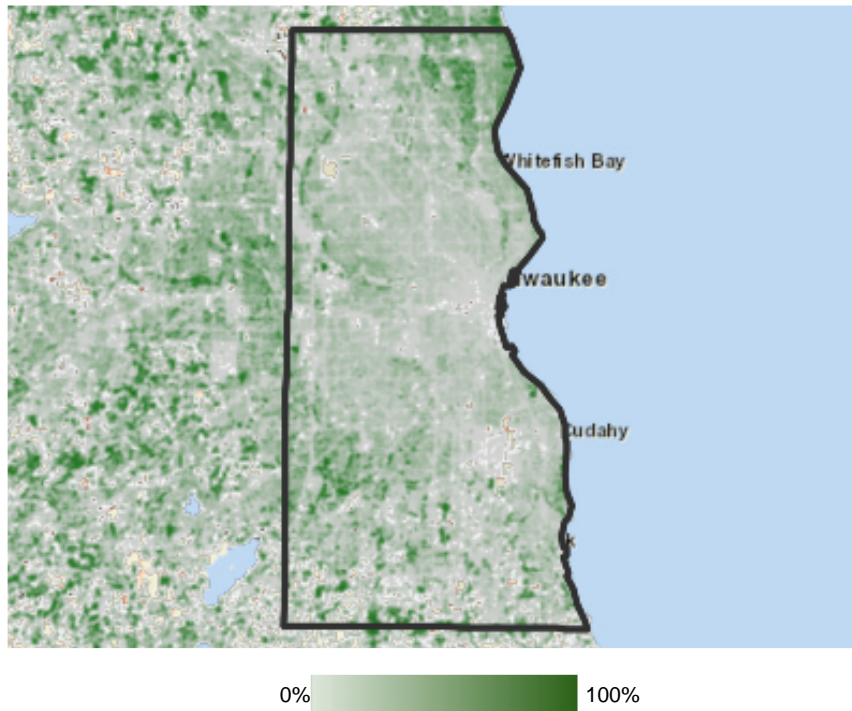


Figure 6: Average tree canopy (in hectares) and % tree canopy in different non-forest land use categories in Milwaukee County for the period 2011-2016. Note: bars relate to tree canopy area (left vertical-axis, hectares) and orange dots are the % tree cover per land use category (right vertical-axis). "Other" category not shown due to very low area.

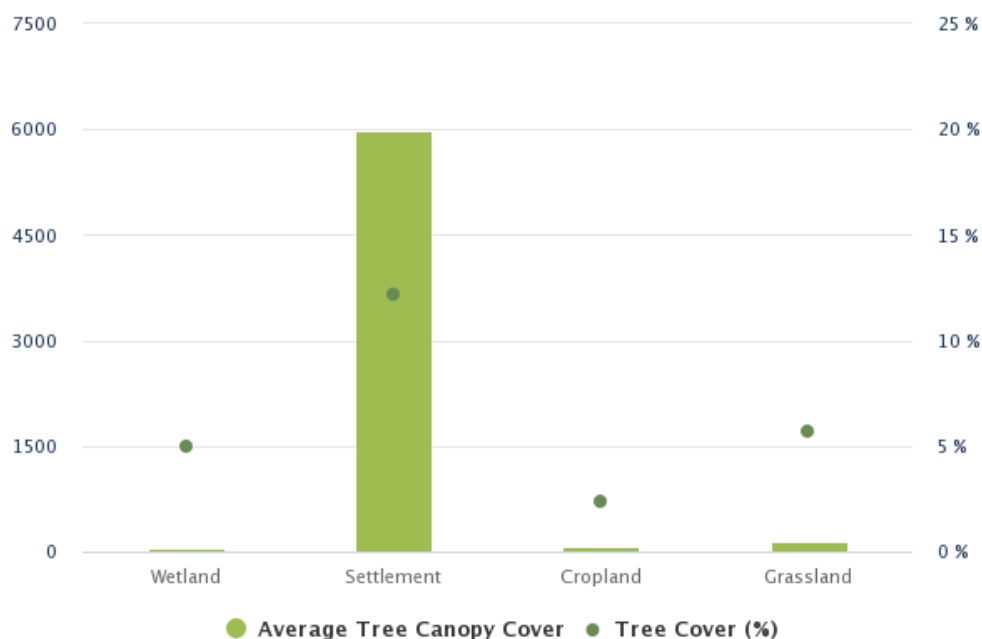
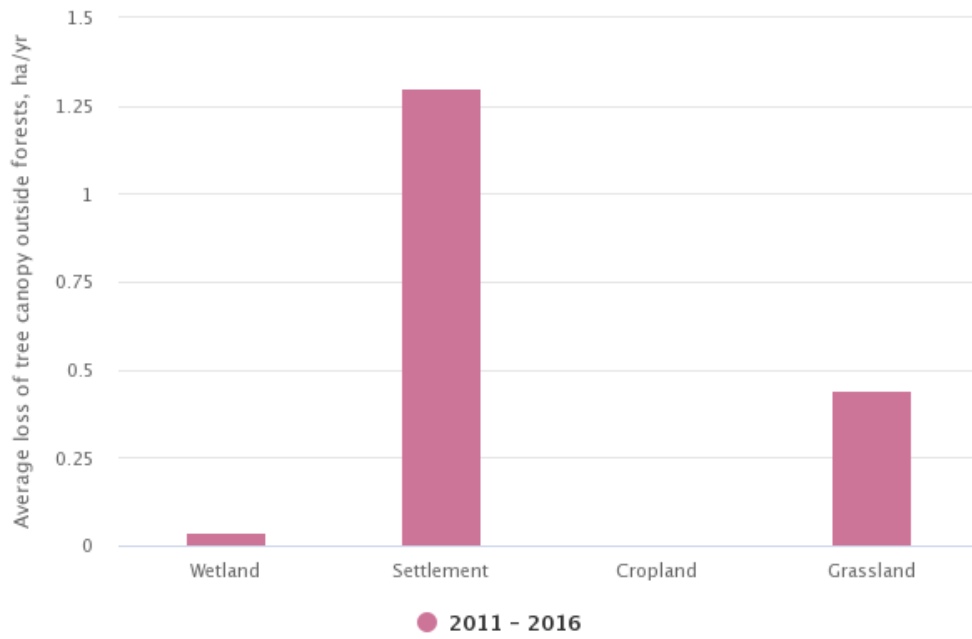


Figure 7: Average area of tree canopy loss in different non-forest land use categories in Milwaukee County over the period 2011 to 2016 (hectares per year). Note: other category not shown due to very low area.



Land Cover Change Matrix

Table 2. Full NLCD land cover change matrix for 2001 to 2016. All areas are in hectares.

2016: Top 2001: Left	Deciduous Forest	Evergreen Forest	Mixed Forest	Woody Wetlands	Cultivated Crops	Pasture/Hay	Grassland/Herbaceous	Shrub/Scrub	Open Water	Emergent Herbaceous Wetlands	Developed, Open Space	Developed, Low Intensity	Developed, Medium Intensity	Developed, High Intensity	Barren Land	Perennial Ice/Snow	Total
Deciduous Forest	3,558	0	0	0.4	5	1	3	8	0.5	2	133	80	69	47	0.2	0	3,907
Evergreen Forest	0	8	0	0	0	0	0	0	0	0	0.4	0.3	0	0	0	0	9
Mixed Forest	0.5	0	383	0	0.1	0.2	0	0.1	0	0	6	2	2	0.6	0	0	394
Woody Wetlands	0.7	0	0	2,736	2	0.5	0.3	0.2	3	46	36	14	8	5	0	0	2,850
Cultivated Crops	5	0	0.3	1	2,978	10	12	0.4	2	6	130	134	129	56	0.5	0	3,464
Pasture/Hay	0	0	0	0.5	17	1,062	3	0	1	4	51	36	31	24	2	0	1,230
Grassland/Herbaceous	26	2	0.4	0.1	45	11	1,314	8	2	2	136	120	126	81	0.1	0	1,872
Shrub/Scrub	0.2	0	0	0.7	2	0.2	0.1	182	0	0.5	16	20	16	7	0	0	245
Open Water	0	0	0	3	0.2	0	1	0	316	5	2	1	4	5	4	0	340
Emergent Herbaceous Wetlands	1	0	0.1	88	7	3	2	0.5	5	428	19	9	3	1	0.1	0	566
Developed, Open Space	0	0	0	0	0	0	0	0	0	0	7,523	66	289	126	0	0	8,003
Developed, Low Intensity	0	0	0	0	0	0	0	0	0	0	0	18,618	131	223	0	0	18,972
Developed, Medium Intensity	0	0	0	0	0	0	0	0	0	0	0	0	14,489	41	0	0	14,529
Developed, High Intensity	0	0	0	0	0	0	0	0	0	0	0	0	0	6,040	0	0	6,040
Barren Land	0.1	0	0	0	3	2	0	0	2	0	1	1	6	16	361	0	393
Perennial Ice/Snow	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	3,591	10	384	2,830	3,059	1,089	1,335	199	332	493	8,051	19,100	15,301	6,671	369	0	0

Table 3. Simplified land cover change matrix for 2001 to 2016. All areas are in hectares.

2016: Top 2001: Left	Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	Total
Forest Land	6,686	7	14	51	401	0.2	7,159
Cropland	6	2,978	22	8	448	0.5	3,464
Grassland	29	64	2,579	10	663	2	3,347
Wetland	92	7	6	753	44	4	906
Settlement	0	0	0	0	47,544	0	47,544
Other Land	0.1	3	2	2	24	361	393
Total	6,814	3,059	2,624	825	49,124	369	0

Emission and Removal Factors

A summary of the emission and removal factors used in the calculations is provided in Table 4.

	Emission Factor (t CO ₂ e/ha)	Removal Factor (t CO ₂ /ha/yr)
Forest Change		
Deforestation		
To Cropland	18.1	
To Grassland	9.9	
To Settlement	17.0	
To Wetland	12.6	
To Other	13.2	
Reforestation (Non-Forest to Forest)		
		-1.6
Forest Remaining Forest		
Undisturbed		
		-0.5
Disturbed		
Fire	0	
Insect/Disease	8.3	
Harvest/Other	59.2	
Trees Outside Forest		
Tree canopy loss	4.8	
Canopy maintained/gained	-2.5	

Harvested Wood Products

Harvested wood products (HWP) temporarily store carbon from the forest ecosystem as the wood goes through a series of production processes and end-uses, with eventual disposal (and emission to the atmosphere). The delay represents a net benefit to the atmosphere. The period of storage varies from long-lived solid wood products that remain in use for long periods of time to products that are quickly disposed of in landfills.

In the web tool, the HWP Calculator tracks carbon in harvested wood through four different "fates," from harvest to timber products to primary wood products to end-use to disposal, applying best estimates for product ratios and half-lives at each stage. Based on user inputs entered about annual harvest volumes in Milwaukee County, the change in the harvested wood pool over the inventory period 2001 to 2016 is estimated as 0 t CO₂e per year.

Caveats

Information presented here represents a snapshot in time of the net GHG balance and many of the factors contributing to that balance. The estimates can help identify where policies may be designed to reduce net GHG emissions. This inventory currently uses a simplifying assumption that a loss of forest or trees results in immediate emissions to the atmosphere (rather than delayed emissions in the case of various use cases from long-term storage to shorter decay timelines if sent to landfills). In general, it is important to consider that these estimates represent a relatively short period of time compared with the long-term consequences of policy decisions and land management actions. For example, a forest converted to settlement represents a permanent loss of removal capacity. Over the long term, maintaining forests will sustain a higher rate of carbon removal, depending on age-related growth rates and occurrence of disturbances.

There are significant uncertainties in the estimates. Although not quantified here, typical greenhouse gas inventories of forests using similar approaches, including the national GHG inventory, report uncertainties in the net GHG balance that can be as high as $\pm 45\%$ (with 95% confidence). In the results presented here, the most uncertain estimates involve emissions from land-use change which are based on well-documented remote-sensing products, but relatively few field observations from a statistical sampling of county forests. While uncertainties can be high, the estimates can still provide useful information on the relative magnitude and importance of such GHGs; subsequent analyses can also provide information on the directionality of emissions and removals from land management.

Finally, it is recommended that additional analyses be done using models that project impacts of alternatives over coming decades. Such models are available and have been used in other studies at county scale. The GHG inventory presented here is only the first step to providing science-based information to support policy decisions. To more fully explore the potential impacts of alternate policies, projection models can be used to compare long-term results among the alternatives which typically include a "business as usual" (i.e. no change in policy) alternative. This feature may be added into the web tool in the future.