

Technical Appendix. Documentation of GHG Reduction Assumptions

Our greenhouse gas emissions calculations for the Missoula Tree Revitalization for Energy and the Environment (MissoulaTREE) project focuses on two main activities. Our first calculations (Waste Diversion) focus on the diversion of biomass from 136 removed trees to our city-owned Garden City Compost facility instead of the landfill. Our second set of calculations (Afforestation) focuses on the replanting of 157 trees to replace the removed trees as well as expand the urban forest.

Waste Diversion

From the MissoulaTREE project, the 136 removed trees will result in an estimated 2,686 board feet that will be milled into kiln-dried lumber. The carbon captured in the removed trees will be retained to the maximum extent possible. Although it varies slightly by species, wood is roughly 50% carbon by weight and will be stored for the lifetime of the wood product. Milled lumber resulting from this program will be used locally by City departments for construction projects.

The remaining biomass resulting from MissoulaTREE will be composted at the Garden City Compost facility. Composting yields significant greenhouse gas emissions reductions when compared to landfilling the same material. The finished compost material will be utilized in the soils mixture for backfill into the suspended pavement systems for new tree plantings. Overall, 109,890 pounds or 54.9 tons of mulch will be created from the 136 removed trees. The City of Missoula used the International Council for Local Environmental Initiatives (ICLEI) ClearPath software to calculate the avoided emissions from directing this mulch to Garden City Compost instead of the landfill. According to the ClearPath software, we will save 7.57 metric tons of CO₂.

Afforestation

The City of Missoula contracted with the Davey Resource Group (“DRG”) to forecast the avoided emissions and sequestered emissions from the 157 newly planted trees through MissoulaTREE. used i-Tree tools to develop a methodology for determining the Greenhouse Gas (“GHG”) emission reductions and other eco benefits for the following:

- Trees slated for removal (136) in the project area that Missoula is planning on replacing through this grant.
- New trees (157) to be planted by grant funds for the time periods of 2025-2030 and 2025-2050.

Additionally, DRG identified research that pertained to tree growth changes that came from planting the trees in suspended pavement systems. This research was considered when determining if GHG emissions reductions would be increased due to the use of the suspended pavement systems.

Methodology

DRG utilized i-Tree Planting, a web-based tool used to estimate the long-term benefits from a tree planting project, to accurately estimate the potential GHG emission reductions and other eco benefits for the proposed planting of 157 trees in Missoula MT:

- The 157 proposed trees were run through i-Tree Planting in two scenarios: to forecast benefits 5 years out (2025-2030) and to forecast benefits 25 years out (2025-2050). Each time the 157 proposed plantings were run through i-Tree planting they were assumed to be 2” Diameter Breast Height (“DBH”) and in “Excellent” condition. Excellent condition was assumed because

most trees would be planted in better growing conditions (suspended pavements) and with scheduled irrigation and maintenance. Missoula provided the number of each species to be planted as follows:

- 42 Sienna Glen maples
- 42 American lindens
- 42 New Horizon elms
- 10 Gladiator crabapples
- 10 Amur chokecherries
- 11 Apollo maples
- All other inputs remained the same for all scenarios: 3% mortality rate assumed each year, distance from building assumed to be 20-39 ft (trees will be planted along streets in the Downtown area), side of building planted assumed to be East (assuming the East side gave a conservative estimate of the benefits with planting on the North side of the building giving the most benefits and planting on the South side giving the least benefits), buildings assumed to be built before 1950 and have heating and cooling, and trees assumed to have access to full sunlight.
- To forecast the benefits 5 years out from planting (2025-2030), DRG made the following assumptions:
 - **Location:** Missoula, Montana 59801
 - **Total number of trees planted in this project:** 157
 - **Electricity Emissions Factor:** 1,438.67 pounds CO2 equivalent/MWh
 - **Fuel Emissions Factor:** 208.60 pounds CO2 equivalent/MMBtu
 - **Timeframe:** 5 years
 - **Annual Tree Mortality:** 3%
- To forecast the benefits 25 years out from planting (2025-2050), DRG made the following assumptions:
 - **Location:** Missoula, Montana 59801
 - **Total number of trees planted in this project:** 157
 - **Electricity Emissions Factor:** 652.57 kilograms CO2 equivalent/MWh
 - **Fuel Emissions Factor:** 94.62 kilograms CO2 equivalent/MMBtu
 - **Timeframe:** 25 years
 - **Annual Tree Mortality:** 3%

- **157 Proposed Plantings 5 Years Out:**

- 22,779.7 kg of CO₂ avoided
- 3,264.2 kg of CO₂ sequestered above ground
- 1,305.7 kg of CO₂ sequestered under ground
- 5,381.8 kWh of electricity saved
- 192.7 MMBtu of fuel saved
- 43.9 cubic meters of avoided runoff
- 6.25 kg of O₃ removed
- 5.16 kg of NO₂ avoided
- 1.10 kg of NO₂ removed
- 40.98 kg of SO₂ avoided
- 0.03 kg of SO₃ removed
- 0.56 kg of VOC avoided
- 1.5 kg of PM_{2.5} avoided
- 0.2 kg of PM_{2.5} removed

- **157 Proposed Plantings 25 Years Out:**

- 121,874.50 kg of CO₂ avoided
- 28,003.40 kg of CO₂ sequestered above ground
- 11,201.40 kg of CO₂ sequestered below ground
- 49,341.10 kWh of electricity saved
- 847.70 MMBtu of fuel saved
- 245.50 cubic meters of avoided runoff
- 45.21 kg of O₃ removed
- 27.65 kg of NO₂ avoided
- 7.85 kg of NO₂ removed
- 219.28 kg of SO₂ avoided
- 0.22 kg of SO₃ removed
- 2.89 kg of VOC avoided
- 13.54 kg of PM_{2.5} avoided
- 1.71 kg of PM_{2.5} removed

- Overall, the total amount of CO₂ avoided and sequestered through 2030 is 34,918.58 kilograms, or 34.92 metric tons, of CO₂. The total amount of CO₂ avoided and sequestered through 2050 is 168,648.3 kilograms, or 168.65 metric tons of CO₂. The MissoulaTREE project will also contribute to the successful execution of the Downtown SAM project by funding the investment in the required street trees. By supporting successful implementation of the Downtown SAM, this project would contribute to avoiding an additional 2,596 metric tons of CO₂ from 2025 through 2050, though we do not include these indirect benefits in our greenhouse gas emissions numbers as part.
- To calculate the below ground carbon sequestration, the City of Missoula drew on recent research by Dr. Simone Webber (["How do Trees Store Carbon?" 2024](#)) which demonstrates that, compared to the above ground sequestration, the roots of trees sequester approximately 40% additional CO₂ emissions.

- Additional eco benefits, with the financial values for each ecosystem service, can be found in the separate GHG Emissions Reduction Calculations excel spreadsheet.

Sources

- i-Tree Planting. i-Tree Software Suite v2.7.0(n.d.). Web. Accessed 21 March. 2024. <http://www.itreetools.org>
- Smiley, E. Thomas, et al. 2006. Comparison of Structural and Noncompacted Soils for Trees Surrounded by Pavement. Arboriculture & Urban Forestry.
- Bartens, Julia, et al. 2010. Stability of Landscape Trees in Engineered and Conventional Urban Soil Mixes. Urban Forestry & Urban Greening.
- Webber, Simone. 2024. How do Trees Store Carbon? <https://www.creatingtomorrowforests.co.uk/blog/technical-note-how-do-trees-store-carbon>