Biochar-Urban Forestry Strategy

BOULDER, COLORADO BIOCHAR FEEDSTOCK ASSESSMENT

June 2022

Prepared for:
City of Boulder

Prepared by:
Cambium Carbon

With support from:
Carbon Neutral Cities Alliance
Nature-Based Climate Solutions

Table of Contents

Introduction

This report aims to estimate the potential to use urban forest biomass as a feedstock for biochar production and application within and around the City of Boulder, Colorado. This analysis is one of four municipal case studies completed in coordination with Nature-Based Climate Solutions (NCS) and supported by the Carbon Neutral Cities Alliance (CNCA). Peer assessments from the cities of Helsinki, Minneapolis, and Stockholm will also be available at the culmination of the project.

This analysis draws upon several sources of urban forest data – considering both top-down and bottom-up approaches – in order to quantify potential feedstock availability of urban forest residues. Subsequent reports will further explore local application opportunities, as well as estimated environmental impacts from biochar use.

Why Biochar?

Biochar is a carbon-rich solid obtained from pyrolysis of organic matter in a low-oxygen environment. Classified as a negative emissions technology by the IPCC, biochar's long-term carbon sequestration potential has yielded growing awareness as a natural climate solution, with production further incentivized by a burgeoning carbon offsets market. The application of biochar in soil poses several benefits to vegetative growth[1] and plant health, including increased water holding capacity[2] and disease resistance.[3] Additionally, biochar has shown proven efficacy in contaminant remediation and water management.

Critically, biochar presents an opportunity to derive a high-value and environmentally beneficial product from low-value or traditionally wasted material. Biochar can be produced from a variety of feedstocks, including green/yard waste, food scraps, sewage sludge, and wood. Feedstock, along with pyrolysis conditions, plays an important role in determining the quality, pore structure, nutrient content, and characteristics of resulting biochar.

[1] Scharenbroch, B.C. et al. 2013. Journal of Environmental Quality 42 1372-1385 "Biochar and Biosolids Increase Tree Growth and Improve Soil Quality for Urban Landscapes"
[2] Omondi, M et al. 2016. Geoderma 274 28-34 "Quantification of biochar effects on soil hydrological properties using meta-analysis of literature data"
[3] Zwart, D.C. and Kim, S-H. 2012. Hort Science 47 1736-40 "Biochar Amendment Increases Resistance to Stem Lesions Caused by Phytophthora spp. in Tree Seedlings"

Urban Forest Biomass Estimates

The goal of this analysis is to understand the scale of potential production and application of biochar within the City of Boulder's urban forest system; as a result, urban forest biomass was chosen as our feedstock of focus. Urban forest biomass – or fresh cut wood residues resulting from tree removal and maintenance work – presents an exciting opportunity for biochar production, given both proximity to centralized infrastructure (relative to traditional harvested wood), and the current cost burden tree care companies face to dispose of their waste stream. A demand for this material by biochar producers could help **1.) cut disposal costs**, **2.) reduce waste**, and 3.) **sequester tree carbon** in a semi-permanent product, rather than release greenhouse gasses into the atmosphere.

In order to size the potential volume of wood debris resulting from tree work, two methods were used to estimate annual availability: a top-down and bottom-up approach.

Top Down: Approximating Yield from Total Canopy Loss

Tree inventory data served as a basis for quantifying total biomass resulting from forest management activity within the City of Boulder. A 2019 study by Nowak et al[4] estimated that a 2 to 7% annual mortality rate would be typical of urban forests in the United States. Using this range as a foundation, we assume a total 5% urban forest biomass availability from combined tree removal, pruning, and hazard management activity. The City's Tree Inventory data[5] (Table 1) was used to summarize the demographics of Boulder's public trees, including most prevalent species, average size, and total biomass.[6]

Table 1. Summary of City of Boulder Public Tree Inventory

Species	Count	Average DBH	% Total	Dry weight above ground biomass (kg/tree)	Total Biomass (MT)
Maple	5,835	10.6	11.7%	361	2106.4
Pine	4,860	9.1	9.7%	66.1	321.3
Elm	4,645	10.4	9.3%	655.0	3,042.5
Ash	4,130	12.0	8.3%	650.0	2,684.5
Honeylocust	3,652	10.0	7.3%	416.0	1,519.2

[4] Nowak, David J.; Greenfield, Eric J.; Ash, Ryan M. 2019. Annual biomass loss and potential value of urban tree waste in the United States. Urban Forestry & Urban Greening. 46: 126469. 9 p. https://doi.org/10.1016/j.ufug.2019.126469.
[5] https://open-data.bouldercolorado.gov/datasets/dbbae8bdb0a44d17934243b88e85ef2b_0/explore
[6] Biomass calculations were derived using the USDA Forest Service's CUFR Tree Carbon Calculator. https://www.fs.usda.gov/ccrc/tool/cufr-tree-carbon-calculator-ctcc

Species	Count	Average DBH	% Total	Dry weight above ground biomass (kg/tree)	Total Biomass (MT)
Cottonwood	3,453	15.5	6.9%	712.5	2,460.3
Oak	3,434	6.7	6.9%	122.0	419.0
Crabapple	3,029	7.2	6.1%	93.8	284.1
Spruce	2,133	10.2	4.3%	218.8	466.7
Linden	1,816	8.5	3.6%	156.0	283.3
Other	12,901	6.4	25.9%	88.0	1,135.3
Total/Average	**49,888**	**9.7**	**100%**	**321.7**	**14,723.0**
				% city canopy on public land	**10%**
				Estimated total city biomass (public & private)	**147,230**
				Estimated annual biomass loss %	**5%**
				Total annual biomass loss (MT)	**7,362**

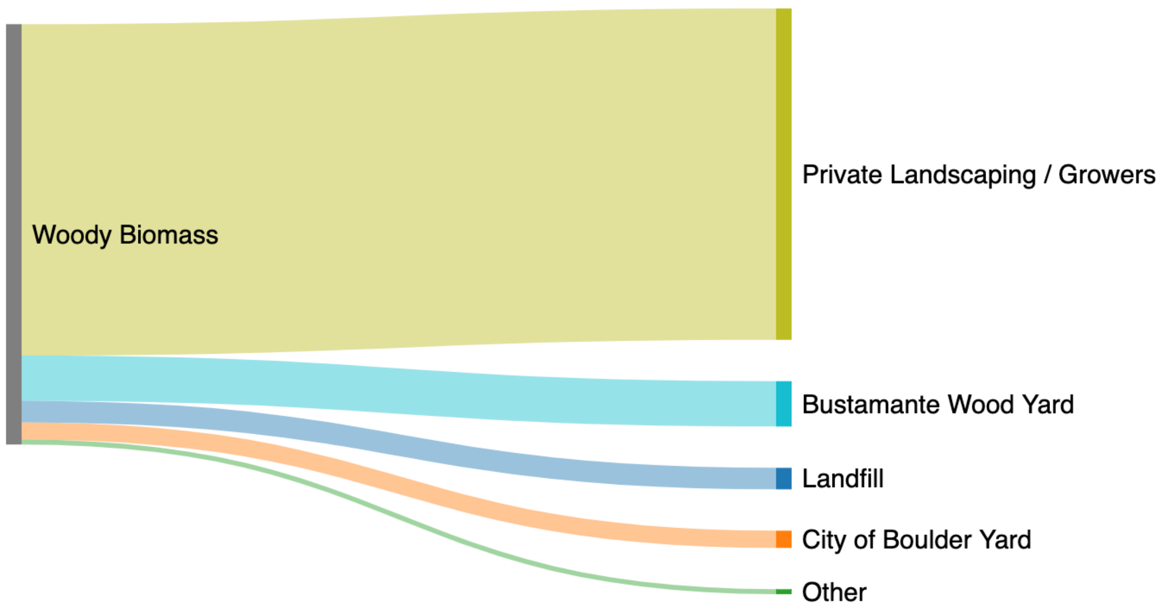
The City of Boulder's public tree inventory contains an estimated 14,723 metric tons of wood biomass; however, it is believed that this inventory represents only 10% of the City's total canopy, with 90% of trees situated on privately managed lands. As a result, it is estimated that there are more than 147,000 tons of biomass in the city's urban forest. With an annual biomass loss of 5%, this would result in approximately **7,362** metric tons of biomass availability across public and private landscapes.

It should additionally be noted that severe weather events, targeted forest health management campaigns (such as preventative tree removals aimed at mitigating spread of Emerald Ash Borer), and large urban development initiatives could all significantly increase the volume of urban biomass availability in a given year.

Bottom-Up: Aggregating Arborist Sample Data

A second approach was used to approximate urban forest biomass loss from the perspective of the tree care industry responsible for this activity. Eight of Boulder's largest tree care companies provided estimates of their annual wood waste generation, as well as the typical disposal pathways for resulting material (Figure 1). The companies averaged roughly 1,005 tons of annual wood waste generation each, a total of **8,039 tons** of biomass. At present, the majority of this debris is chipped and dropped at soil, landscaping, and nursery operations. Excess chips and whole logs – which can prove difficult to dispose of – are often sent to secondary disposal outlets, including landfill.

Figure 1: Typical Disposal Pathways for Woody Biomass in Boulder, CO



Assuming that the 8 companies surveyed represent 75% of all tree work in the City of Boulder, it can be estimated that a total of **10,719** tons of urban forest biomass would be generated annually.

Supplemental Biomass Sources

Averaging the top-down and bottom-up projections, a total **9,041 tons of urban forest biomass** could be fed into biochar production systems. The City of Boulder is currently piloting a community-scale bioenergy-biochar unit that can process roughly 200 tons of biomass into 30 tons of biochar annually, with an additional 200,000 Btu of heat cogenerated hourly.[7] Using this technology, as many as 45 such units could be powered annually by the city's tree waste, resulting in roughly **1,356 tons of biochar.**

While there is certainly great potential for biochar production from urban forest biomass, it should be noted that there are unique challenges to utilizing this wood waste stream. These challenges include:

- the heterogeneous species and quality of city trees, making for an inconsistent feedstock

[7] Annual figures are calculated based on an operating schedule of 8 hours/day, and 240 days/year.

- seasonal fluctuations in tree work and the associated variation in material flow – requiring either storage capacity or an ability to modify processing volumes by season
- potential contamination of wood (eg. with metal, concrete, and other objects resulting from growth in an urban environment)
- a lack of coordinated collection & processing infrastructure, with individual tree care companies handling their wood waste independently from one another

To address feedstock consistency and/or supply constraints, other sources of biomass may be considered as biochar demand and production infrastructure grow. Clean dimensional lumber resulting from construction and demolition waste streams, as well as household and commercial yard wastes (including leaves and grass) could serve as supplementary inputs to the pyrolysis system. Table 2 highlights several potential sources of regional green and wood waste.

Additionally, expanding the geographic scope of biomass collection could open larger regional funnels for viable waste material. A 2005 feasibility study analyzing a potential biomass facility in Jefferson County estimated that a total 18,300 bone dry tons of wood biomass were generated annually in Boulder County, across urban wood waste and surrounding county public and private forests.[8] Given that many tree care companies and waste handlers operate at a regional scale and handle additional non-city wood waste, it was noted that allowing wood waste from adjacent communities would allow for more streamlined disposal and increased material capture.

Table 2. Potential Biochar Feedstocks

Source	Tons	Notes
Urban Forest Biomass	9,041	Average of top-down and bottom-up estimates
Dimensional Lumber (Construction Waste)	1,505	Data from Western Disposal (2021)
Yard Waste	11,363	Data from Western Disposal (2021)
Boulder County	18,300	Jefferson County Biomass Facility Feasibility Study (2005)

Ultimately while pilots may begin with a small portion of the wood waste stream, successful implementation of large-scale biochar production and application systems could enable dramatic growth in the quantities and varieties of waste materials utilized.

[8] McNeil Technologies, Inc. "Jefferson County Biomass Facility Feasibility Study." January 21, 2005.