COLORADO STATE FOREST SERVICE
COLORADO STATE UNIVERSITY

Woody Biomass in Colorado:
Quantification, Assessment and Opportunities

Section 1 - Project Overview

1.1 Introduction

Colorado has approximately 24 million acres of forests that provide multiple benefits to the residents of and visitors to the state. While many enjoy the forests for their aesthetic value and outdoor experiences, the forests of Colorado also provide necessities like clean air and water. Managing forests to conserve and promote these and other values can create forest products and provide economic opportunities in the state.

Decades of fire suppression and a changing climate have disrupted Colorado's natural wildfire cycles and threaten the resilience of forests. Active management can ensure forests are more resilient to wildfire by reducing the potential intensity and spread of wildfire. Low-severity fires help manage forest density and composition, especially in dry ponderosa pine forests. Intense fires can destroy plants, damage soil and put watersheds, communities and ecosystems at risk. Wildfires have received significant attention in the past decade due to the increasing occurrence of uncharacteristic wildfire and serious impacts in Colorado. With the increasing importance of wildfire risk reduction to communities, more fuel is being removed across large landscapes in the state, resulting in more woody biomass production.

Derived from trees and other woody flora, woody biomass is a renewable resource that can be incorporated into a circular economy. The potential benefits of sustainable woody biomass utilization are numerous: It can support job creation (particularly in rural economies), promote adaptive forest management and offer an alternative to fossil fuels. Challenges with increased woody biomass utilization include supply chain logistics, market conditions, and potential environmental and social impacts.

In 2001 Lynch and Mackes published *Wood use in Colorado at the turn of the twenty-first century* (RMRS-RP-32). More than 20 years later, the Colorado State Forest Service has updated these data and expanded the analysis to provide a more accurate description of the current status of woody biomass and utilization in the state. This assessment contributes to the ongoing discourse concerning sustainable solutions to the environmental challenges in Colorado forests including uncharacteristic wildfires; increased mortality from insects, disease and drought; and reduced productivity and regeneration.

1.2 Purpose

`This statewide biomass assessment is a comprehensive review of woody biomass and technologies for its utilization. It is intended to provide context for the multiple stakeholders with interests in managing forests and utilizing biomass and to provide a basis for assessing green energy and supporting economic development. Furthermore, it connects to the Colorado Carbon Accounting Framework, initiated by HB 22-1012, to facilitate efforts in promoting carbon sequestration in natural and working lands.

1.3 Project goals and objectives

The goal of the assessment is to inform interested parties about the woody biomass resources available in the state and to provide a scientific basis for decision-making around biomass utilization while providing an example for states pursuing similar efforts. Objectives to that end are to describe the amount of woody biomass present, determine the current and potential uses, identify costs and benefits of woody biomass utilization, characterize the woody biomass supply chain (harvest to end use), identify barriers to utilization and propose solutions.

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COVER: *The basal scars on these ponderosa pines in Fishers Peak State Park show a history of surface fire in the stand.* ***Credit: Steve Rudolph, CSFS***

1.4 Project description and scope of work

The Statewide Biomass Assessment Includes the following topics and analyses:

- **Research recent scientific literature as the foundation for the biomass assessment**
  - Reference state and federal statutes
  - Reference biomass assessments from other states and some municipalities
  - Reference biomass work conducted by federal agencies
- **Discuss forest conditions in Colorado**
  - Include historic background and specific information from the past 10 years of wildfire impacts and cost
  - Tie in 2020 Colorado Forest Action Plan
  - Provide an overview of Colorado's forests and their role in the carbon cycle
- **Characterize the benefits associated with biomass removal and utilization**
- **Identify and quantify woody biomass resources**
  - Create tables and graphs of woody material volumes across Colorado's forested landscapes by
    - Analyzing Forest Inventory and Analysis data
    - Using existing USDA Forest Service and CSFS tools
- **Describe current biomass harvesting, transportation and delivery systems**
  - Outline major aspects of the woody biomass procurement system
- **Provide information on equipment and harvesting costs**
- **Describe uses of and markets for woody biomass**
  - Generate narratives and tables of consumption of existing wood products in Colorado
  - Present narratives and tables of products processed (sawlogs, products other than logs, non-merchantable material)
- **Characterize biomass utilization technologies**
  - Detail accepted technologies and production requirements
  - Create tables and other visualizations to compare biomass utilization technologies
  - Discuss options for practical applications of biomass energy including which industries may benefit and how to determine suitable sites
- **Address social, economic and environmental considerations associated with woody biomass**
  - Research current issues around community and social challenges to biomass harvesting and utilization
  - Create a list of potential economic benefits to increased biomass utilization
  - Examine current policy incentives regarding biomass utilization
  - Describe varying scales of possible environmental impacts of proposed uses
  - Highlight findings of Colorado Carbon Accounting Framework
- **Recommend next steps**
  - Compile potential project opportunities
  - Propose actions to enhance biomass utilization
  - Outline a process for collaborative next steps

1.5 Study area description

Included in this study is the area within the jurisdictional boundaries of the state of Colorado. Broad areas sharing geographic or economic similarities will be grouped as Eastern prairie, the Front Range and Western forests. The Front Range within Colorado includes counties along the I-25 corridor from Pueblo to Fort Collins (Ward et al., 2004). This collection of counties shares a similar geography and urban infrastructure.

Beyond that, specific locations will be referred to by named geographic units, such as counties, towns and cities. The CSFS breaks the state into four areas for organizational purposes, referred to by directional quadrants as seen in **Figure 1.**

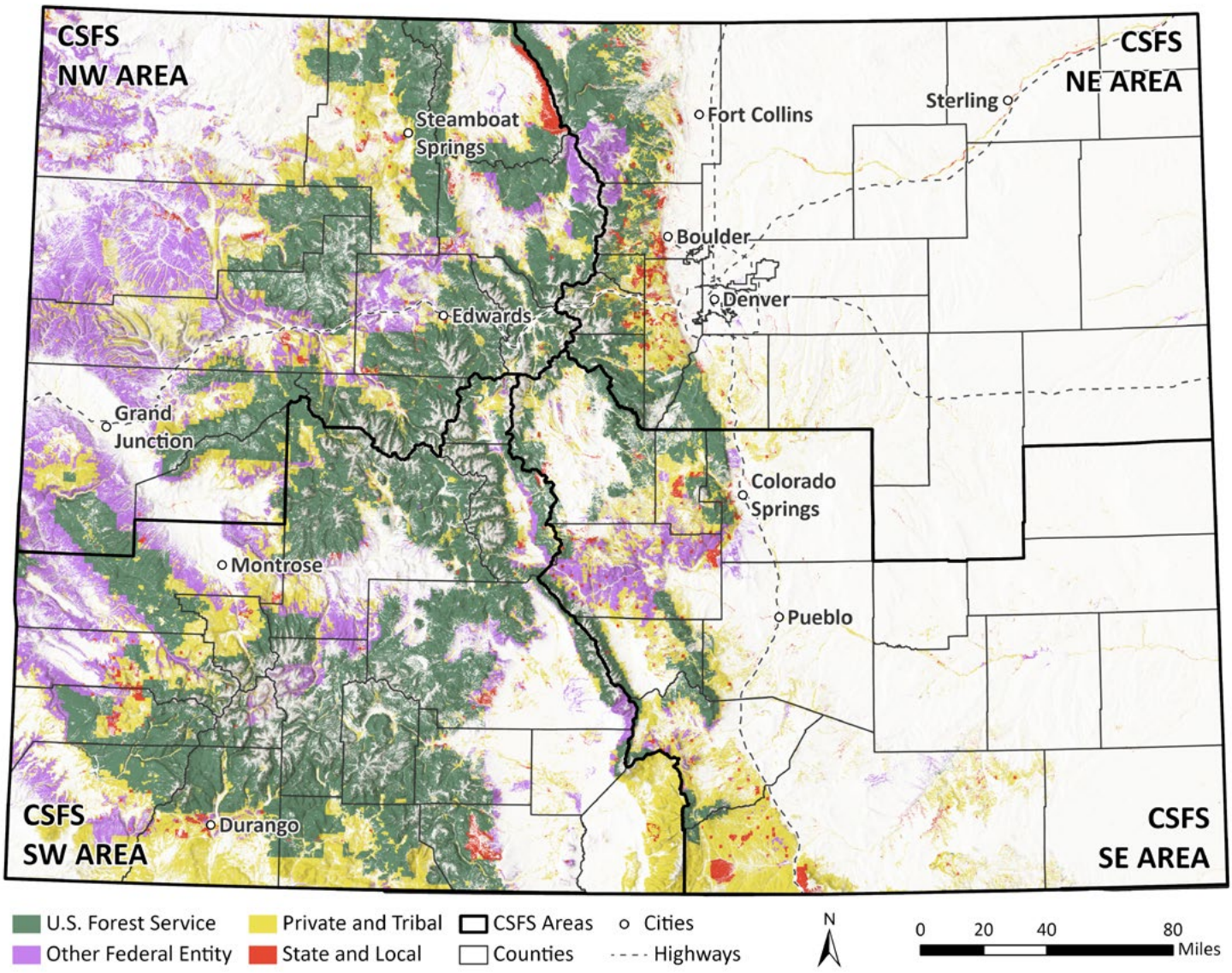

Figure 1. *Land ownership map of forested lands in Colorado. The Colorado State Forest Service divides the state into four geographic areas: Northwest, Northeast, Southwest and Southeast (Colorado Natural Heritage Program, 2021; Colorado State Forest Service, 2023).*

1.6 Biomass resource definition

1.6.1 Biomass definition

The Colorado Revised Statutes (2022) provide an umbrella definition of biomass: (A) Non-toxic plant matter consisting of agricultural crops or their by-products, urban wood waste, mill residue, slash or brush; (B) Animal wastes and products of animal wastes; or (C) Methane produced at landfills or as a by-product of the treatment of wastewater residuals.

This definition captures the heterogeneity of available biomass resources present in the state; however, it does not comprehensively capture potential feedstocks associated with wood and woody material. A more complete definition includes woody material derived from trees, as described by numerous state and federal agencies. Examples of more exhaustive biomass definitions are included in **Table 1.**

Agency/Affiliation	Definition
DOE/USDA	In addition to … existing uses, forestlands have considerable potential to provide biomass from two primary sources: residues associated with the harvesting and management of commercial timberlands for the extraction of sawlogs, pulpwood, veneer logs and other conventional products; and currently non-merchantable biomass associated with the standing forest inventory (Perlack et al., 2005).
BIA/DOI	Any by-product of management, restoration and vegetation management treatments, as well as the product of natural disasters, including trees and woody plants (limbs, tops, needles, leaves and other woody parts; grown in a forest, woodland or rangeland environment) (U.S. Department of the Interior, 2023).
University of California	Woody biomass comprises residues of the wood processing industry, post-consumer woody waste materials and agricultural residues in addition to material arising from forest management or fuels reduction activities. Forest biomass includes small-diameter woody material, damaged or low-valued trees, the branches and tops (slash), and diseased or insect-infested wood (University of California Agriculture and Natural Resources, 2025).
Texas State Forest Service	… forest wood waste includes residual tops and limbs of trees, unused cull trees, pre-commercial thinnings, and wood or debris from noncommercial tree species, slash or brush (Xu et al., 2008).
USFS	… all parts of the tree (i.e., stem, bark, branches, leaves, needles, shavings, chips, stumps and roots) that are generated from forest management and processing activities. Forest biomass also includes residues that remain after harvesting forest products, fuelwood from forestlands, residues from forest products processing mills and forest residues from silvicultural treatments aimed to decrease the amount of hazardous fuel to reduce wildfire risk and improve forest health (Page-Dumroese et al., 2022).
Joint Research Centre (JRC), the European Commission's science and knowledge service	The stock of wood in forests and other wooded land consists of living biomass and deadwood. In living biomass, above-ground biomass is defined as all biomass of living vegetation, both woody and herbaceous, above the soil including stems, stumps, branches, bark, seeds and foliage whereas below-ground biomass corresponds to all biomass of live roots except fine roots of less than 2 mm diameter. Deadwood denominates all non-living woody biomass not contained in the litter, either standing, lying on the ground or in the soil. Deadwood includes wood lying on the surface, dead roots and stumps larger than or equal to 10 cm in diameter or any other diameter used by the country (Camia et al., 2021).

The shared characteristic of these definitions is that they include trees in situ with descriptive and limiting language. For this assessment we propose modifying section "A" of the Colorado Revised Statutes to read as follows: Non-toxic plant matter consisting of agricultural crops or their by-products, urban wood waste, forest products residue, woody material derived from trees and tree-like shrubs removed for forest health improvement and wildfire mitigation, and timber harvest residues including low-value trees and tree parts.

1.6.2 General terminology

The following terms are used throughout the Statewide Biomass Assessment.

- ***Sawtimber:*** Hardwood and softwood trees that are widely used to produce lumber products, typically having a diameter at breast height (DBH) greater than 9" and being free of damage that would prevent cutting of sellable sawn pieces.
- ***Other log:*** Sometimes called Product Other Than Logs (POL), this material is too small or contains too much damage to be generally used to produce sawtimber. It may be used for posts, poles or other products like firewood.
- ***Non-log:*** Material that may not be readily used for conventional wood products. Material may have low value or not be economically viable in existing markets. May include forest residue.
- ***Forest residue:*** Non-merchantable material from commercial logging operations that includes non-log tree parts such as bark, cones, tops, branches, foliage, stumps and roots (Titus et al., 2021).
- ***Cull:*** Part of a tree that has damage or other undesirable variability preventing its use in timber.
- ***Reserved land:*** An administrative designation referring to forested land that produces timber that has been excluded from harvest operations.
- ***Municipal solid waste:*** Items that are commonly disposed of by households and collected by a city or town, such as yard waste. Wood captured as part of this stream includes furniture and wood packaging such as pallets (U.S. Environmental Protection Agency [EPA], 2019).
- ***Construction and demolition debris:*** Waste material generated by "construction, renovation and demolition activities for buildings, roads and bridges, and other structures" (EPA, 2016).
- ***Urban tree residue:*** Woody material generated by urban forestry programs, private tree firms, utilities operating in a municipality and disaster cleanup that occur outside the municipal solid waste stream (Milbrandt, 2005).
- ***Management activity residue:*** Woody material removed from treed areas as part of efforts to improve forest health, prevent wildfires, protect wildlife habitat, improve watersheds or attain other conservation or cultural objectives. Examples include removal of pest-killed trees, fuel treatments, road construction and developing recreation areas.
- ***Primary and secondary wood processing residues:*** Primary processing includes the conversion of felled trees to timber, lumber and composite panel products; residue types include bark, sawmill slabs and edging, sawdust and peeler log cores (Ward et al., 2004). Secondary processing takes the outputs from primary processing and further assembles them into products; waste types include sawdust, shavings, wood chips, sander dust and solid wood residues (Indiana DNR, 2008, p. 27; Ward et al., 2004).

1.7 Summary

Colorado's forests are plentiful, life-sustaining and scenic — and they are under serious threats from wildfire. But if managed efficiently and used judiciously, the forests will continue to be a significant and sustainable contribution to Colorado's economy and overall well-being.

Successful management of Colorado's forests requires accurate, detailed data about the state of biomass and its utilization. The next sections of the Statewide Biomass Assessment use the definitions and areas outlined here to build a comprehensive picture of the condition and availability of biomass in Colorado.

1.8 References

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