COLORADO STATE
FOREST SERVICE
COLORADO STATE UNIVERSITY

Woody Biomass in Colorado:
Quantification, Assessment and Opportunities

Section 3 - Characterizing and Quantifying Forest Resources in Colorado

3.1 Acknowledgements ·······································

3.2 Introduction ·······································

Colorado's forests face a range of ecological, social and economic challenges, underscoring the need for timely, informed forest management (Colorado State Forest Service [CSFS], 2020). Quantifying the amount, condition and distribution of Colorado's forest resources is a critical step in addressing these challenges. This section presents standardized estimates of live and salvageable standing dead trees across the state's forests, categorized by geographic region, forest type and ownership categories.

Volume estimates are derived from the USDA Forest Service's (USFS) Forest Inventory and Analysis (FIA) program, the nation's primary forest census. FIA uses a scientifically designed, systematic sampling framework to collect consistent measurements on public and private forestlands across all 50 states. Its standardized methodology, national scope and rigorous quality control make FIA the most reliable and widely accepted data source for statewide forest resource assessments.

Quantifying the volume of wood across Colorado's forests is important for understanding potential industry opportunities while also assessing changes through time. Previous efforts to estimate Colorado's forest volume include the 1987 Benson and Green report, which reflected 1983 data and estimated approximately 17 billion cubic feet in growing-stock volume on "timberland," a classification that excluded woodland forest types. A more comprehensive analysis was conducted by Thompson et al. (2017), which used FIA data from 2004 to 2013 to estimate 35.2 billion cubic feet in net live volume on all forestland, explicitly including woodlands and unproductive forests. Differences in definitions, scope and sampling design among the studies limit direct comparisons, but they demonstrate an evolving understanding of Colorado's forest resources and underscore the importance of consistent, replicable methods for estimating volume over time. These investigations are important to characterize the geographic distribution of woody volume across various ownerships, forest types and locations to provide up-to-date estimates that enable regional digestion and interpretation for new and emerging initiatives across scales (i.e., local to regional to statewide).

This assessment reflects the most recent 10 years of FIA data (2012 to 2021) to characterize standing woody volume at statewide, regional and county levels. Estimates are reported for five volume categories: *Gross live, Sawtimber, Other log, Non-log* and *Salvageable,* and they are broken out by forest type and ownership. This analysis includes trees that meet specific diameter thresholds on both public and private lands, excluding wilderness areas, national parks and urban forests. Volume is reported in cubic feet to represent the complete amount of woody material, regardless of size class or merchantability.

The purpose of this section is to provide a scientific accounting to characterize, describe and quantify standing volume across Colorado's forests. While this study does not evaluate management priorities or market potential, the results are intended to inform decisions by clearly demonstrating the scale and distribution of available resources. Ultimately, this analysis aims to support data-driven decision-making for forest industry professionals, government agencies, energy producers and policymakers.

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COVER: *Forest Inventory and Analysis staff member using stem-mapping to determine the next tree in the sample.* **Credit: Jim Jones, CSFS**

3.3 Methods ·······································

3.3.1 Forest Inventory and Analysis

The core dataset used for this section comes from the USFS FIA program, the nation's primary inventory of all U.S. forestlands. The FIA program assesses the status and trends of forests across all land ownerships and forest types. FIA defines forestland as land that has at least 10% canopy cover of live tally tree species of any size, or land formerly having such tree cover, and not currently developed for a nonforest use. The minimum area required for classification as forestland is one acre. Roadside, streamside and shelterbelt strips of trees must be at least 120 feet wide to qualify as forestland (USDA Forest Service [USFS], 2023).

The FIA program uses a network of permanent, geographically unbiased field plots at a density of approximately one per 6,000 acres (Bechtold & Patterson, 2005). These plots are systematically measured over a 10-year cycle in Colorado, with one-tenth of the plots measured each year. This approach, known as the annualized FIA inventory system (Gillespie, 1999), ensures consistency and prevents spatial bias.

All FIA plots follow a nationally standardized, fixed-area, mapped-plot design, with four nonoverlapping, 24-ft-radius circular subplots, each covering about 1/24 acre. Each subplot area meeting FIA's definition of forestland is designated as a "forest condition." On each forest condition, a variety of tree, stand and site variables are recorded, including forest type, species identity, diameter, height and status (live or dead) of every measured tree. Additional details on inventory design and forestland definitions are provided in Bechtold and Patterson (2005) and on the [Colorado State Forest Service FIA webpage.](#)

3.3.2 Data and analysis

The data used in this analysis were downloaded from the [FIA DataMart](#), as an SQLite database. We used the most recent FIA inventory cycle available for Colorado, covering plot measurements from 2012 to 2021.

The FIA program calculates tree volume by applying species- and region-specific equations to field measurements, converting them into estimates of volume. Tree diameter and height are key predictors of volume because they reflect a tree's size and structural form. FIA distinguishes between "timber" and "woodland" species based on differences in growth form and typical utilization, which in turn determine

where diameter is measured on the stem. Timber species are typically straight stemmed, commonly used for industrial wood products, and measured for diameter at breast height (DBH). This group includes all conifers except piñons and junipers. Woodland species, in contrast, have more irregular forms, are not usually converted into industrial wood products, and are measured for diameter at root collar (DRC). Appendix Table A.1 lists the species included in this analysis and their classification as timber or woodland species. More information on calculating volume from diameter and height is provided in Appendix K of the FIA Database User Guide (Burrill et al., 2024). Our estimates incorporate the FIA's National Scale Volume and Biomass (NSVB) update (Westfall et al., 2024), implemented in October 2023, which introduced revised volume and biomass models, primarily for timber species.

This analysis used five FIA volume variables: VOLCFGRS, VOLCFGRS_TOP, VOLTSGRS, VOLCFNET and VOLCSNET, individually or in combination to calculate woody material relevant to Colorado's markets (Table 1; see detailed FIA variable definitions in Appendix B). Volume estimates were classified into five woody material categories: Gross live, sawtimber, other log, non-log and salvageable dead (Table 1; see detailed definitions in Appendix C). Definitions, species groupings and volume calculations for these categories are provided in detail in Appendix A.2. Volume is generally reported in hundred cubic feet (CCF, where 1 CCF = 100 cubic feet) or million cubic feet (MMCF, where 1 MMCF = 1,000,000 cubic feet) depending on the context.

All volume estimates were generated using R (R Core Team, 2024) and the Forest Inventory ESTimation and Analysis (FIESTA) package (Frescino et al., 2023), an open-source tool designed for analyzing FIA data. FIESTA was selected for its ability to efficiently query, summarize and estimate FIA plot data with corresponding sampling errors.

Estimates were produced using FIESTA's Green-Book (GB) functions, which follow the standard methods described in Bechtold and Patterson (2005) and are consistent with FIA's other tools such as EVALIDator. Estimates were cross-checked with the USFS EVALIDator tool for accuracy. The FIESTA GB functions support post-stratification, adjust for nonsampled conditions and generate estimates at various geographic levels (Frescino et al., 2023). Since this analysis used county boundaries, state-level population data could be used directly without additional spatial processing.

■ = shaded area indicates parts of the tree included in each classification.

GROSS LIVE VOLUME

- For timber species, the total stem volume from a 1-foot stump to the top in live trees at least 5" diameter at breast height (DBH).
- For woodland species, the total wood and bark in live trees at least 1.5" diameter at root collar (DRC), up to a 1.5" top, including limbs.
- Reflects total standing live volume, regardless of quality, such as rotten or misshapen portions.
- The sum of sawtimber, other log, and non-log.
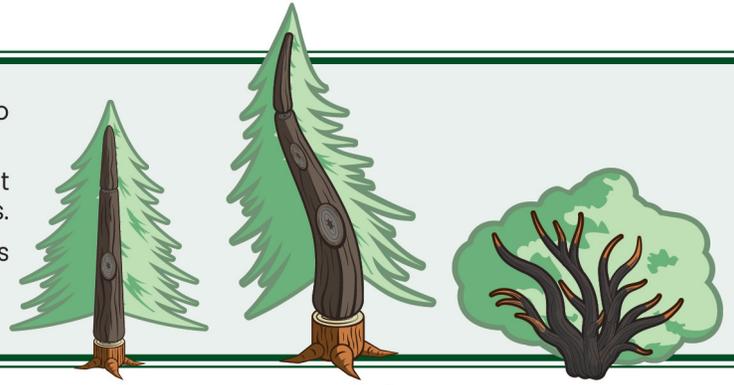
SAWTIMBER VOLUME

- Central stem live volume of softwoods at least 9" DBH and hardwoods at least 11" DBH, from a 1-foot stump to a 7" top (softwoods) or 9" top (hardwoods).
- Trees must contain at least one solid 8-foot log and have minimal defects, meeting merchantability standards.
- For timber species only; not applicable to woodland species.
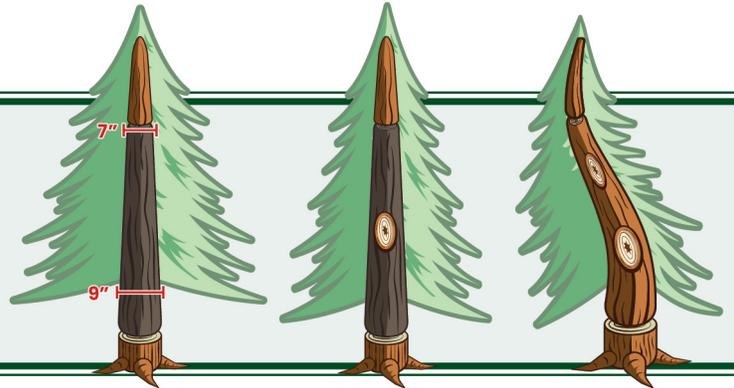
OTHER LOG VOLUME

- Usable log material from live trees that does not qualify as sawtimber. Includes central stem volume of softwoods 5–9" DBH and hardwoods 5–11" DBH, from a 1-foot stump to a 4–7" top (softwoods) or 4–9" top (hardwoods).
- Defects deducted.
- For timber species only; not applicable to woodland species
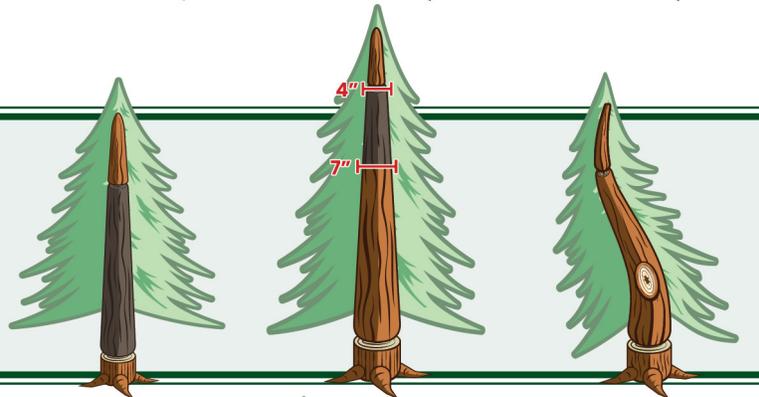
NON-LOG VOLUME

- Wood from live trees that does not qualify as sawtimber or other log.
- Includes remaining central stem volume of timber species at least 5" DBH, from a one-foot stump to the top, including defects.
- Includes the total wood and bark of woodland species at least 1.5" DRC, to a 1.5" top, including limbs above the minimum size.
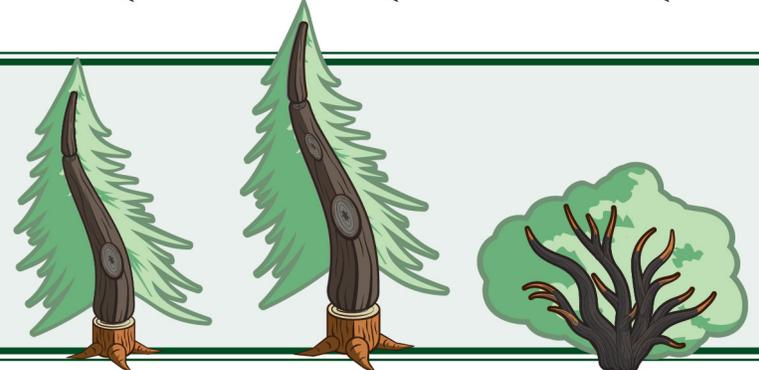
SALVAGEABLE VOLUME

- Wood from dead trees that are still mostly sound, qualifying if no more than 2/3 of the volume is lost to rot or decay.
- Includes central stem volume of dead timber species at least 1" DBH and all wood and bark of dead woodland species at least 1.5" DRC to a 1.5" top, including limbs.
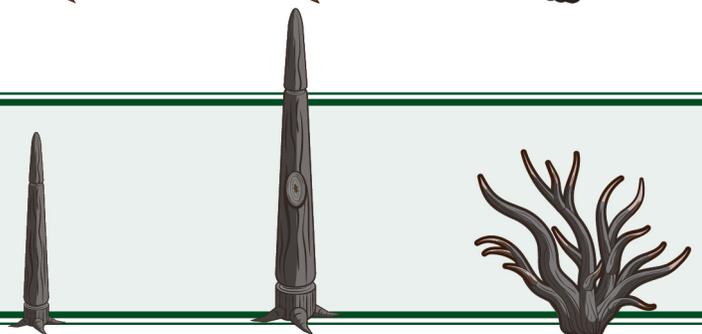
Illustration: Brian Sathe, CSFS

Table 1 — Classification and calculation of woody material categories based on FIA variables

Woody material category	Calculation from FIA variables
Gross live	Timber species: VOLCFGRS + VOLCFGRS_TOP Woodland species: VOLTSGRS
Sawtimber	Timber species, where TREECLCD = 2* AND STATUSCD = 1 (live trees): VOLCSNET
Other log	Timber species, where TREECLCD = 2 AND STATUSCD = 1: VOLCFNET − VOLCSNET
Non-log	Where TREECLCD = 3** or 4*** AND STATUSCD = 1, Timber species: (VOLCFGRS + VOLCFGRS_TOP)− VOLCFNET Woodland species: VOLTSGRS
Salvageable dead	If TREECLCD_RMRS**** = 5: VOLTSGRS

*TREECLCD = 2: Growing stock; All live trees of commercial species that meet minimum merchantability standards. In general, these trees have at least one solid 8-foot section, are reasonably free of form defect on the merchantable bole, and at least 34% or more of the volume is merchantable.

**TREECLCD = 3: Rough cull; All live trees that do not now, or prospectively, have at least one solid 8-foot section, reasonably free of form defect on the merchantable bole, or have 67% or more of the merchantable volume cull. More than half of this cull is due to sound dead wood cubic-foot loss or severe form defect volume less.

***TREECLCD = 4: Rotten cull; All live trees with 67% or more of the merchantable volume cull, and more than half of this cull is due to rotten or missing cubic-foot volume loss.

****TREECLCD_RMRS = 5: Hard (salvageable) dead; Dead trees that have less than 67% of the volume cull due to rotten or missing cubic-foot volume loss.

Further methodological details, including specific FIA variable definitions and volume estimation procedures, are documented in Appendix K of the FIA Database User Guide (Burrill et al., 2024).

3.3.3 County, ownership and forest type

The smallest spatial scale used for this analysis is the county, consistent with FIA's standard population tables and reflecting the resolution at which FIA data are most appropriately summarized. This analysis began with all Colorado counties and was narrowed down to 42 based on forest cover and data quality. Counties in the Eastern Plains and urban Front Range were excluded due to limited forested land and insufficient FIA plot data (i.e., Broomfield, Cheyenne, Crowley, Denver, Kiowa, Kit Carson, Lincoln, Morgan, Phillips, Prowers, Sedgwick, Washington and Weld counties). Additional counties with some forest cover were excluded if their percent standard error for gross cubic-foot volume was 25% or higher, reflecting low plot density and reduced reliability of estimates. These included Adams, Alamosa, Arapahoe, Baca, Bent, Elbert, Logan, Otero and Yuma counties.

The four CSFS areas (Northwest, Northeast, Southwest and Southeast) were used to clump counties together for visual purposes. The CSFS areas follow Colorado county lines except Park County, which is divided between the Southeast and Northeast areas. More than
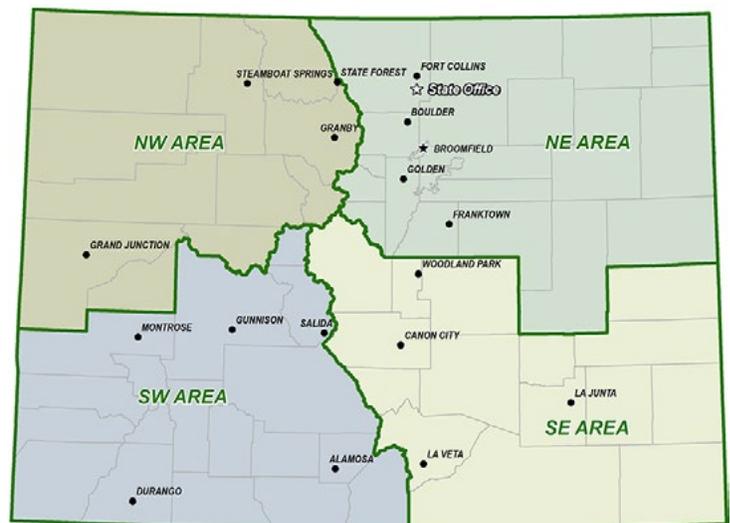
The Colorado State Forest Service divides Colorado into four geographic areas. Credit: CSFS

50% of Park County's geographic area is in the Southeast area, so it was placed in that area for the purpose of this analysis.

Next, volume estimates were assessed by land ownership. We used the four FIA ownership groups, which are made up of similar owner classes (Table 2). The FIA program further distinguishes land ownership by reserved status. Reserved land is land withdrawn

Table 2— *FIA land ownership groupings and associated descriptions, detailing specific owner classes within each group and reserved status distinctions.*

FIA ownership group (OWNGRPCD)	FIA owner classes (OWNCD)	Owner classes used in this assessment
Forest Service	National Forest (11); National Grassland and/or Prairie (12); Other Forest Service land (13)	National Forest (11, 12, 13), where non-reserved (RESERVCD = 0))
Other Federal	National Park Service (21); Bureau of Land Management (22); Fish and Wildlife Service (23); Departments of Defense/Energy (24); Other Federal (25)	Bureau of Land Management (22) and Departments of Defense/Energy (24), where non-reserved
State and local government	State including State public universities (31); Local (County, Municipality, etc.) (32); Other Non-Federal public (33)	State (reserved and non-reserved) and local (reserved); other non-federal public (non-reserved)
Private and Native American	Undifferentiated Private and Native American (46)	Private and Native American (non-reserved)

from management for the production of wood products through statute or administrative designation. Examples of this include designated federal wilderness areas, national parks and monuments, and most state parks (USFS, 2023). This assessment only considered land that is non-reserved among each owner class except for state land. In Colorado, only the Bureau of Land Management, Department of Defense and Department of Energy contain non-reserved land in the Other Federal ownership group; land owned by the National Park Service, U.S. Fish and Wildlife Service and other federal agencies were excluded in this assessment.

Reserved land was included for state land because FIA designates all state land in Colorado as reserved, except for state forests. The Colorado State Forest in Jackson and Larimer counties is categorized as a state park, which makes it "reserved" although it has a multi-use land management framework that includes management for production of wood products (Colorado Parks and Wildlife, 2019). In addition, there are other areas in Colorado owned by the Colorado State Land Board that are not classified as a state forest, where management for production of wood products does occur. Conservation easements and tribal protected areas within the *Private and Native American* grouping are classified as non-reserved by FIA. Appendix L of the FIA Database Manual (Burrill et al., 2024) contains further information on reserved status by ownership and land designation.

The amount of standing volume in the state was further estimated by forest type. We used the FIA Species Group Code (SPGRPCD) to classify the number of species-based categories. Each tree species in Colorado is assigned to a species group. For example, white fir (*Abies concolor*), subalpine fir (*Abies lasiocarpa*) and corkbark fir (*Abies lasiocarpa var. arizonica*) are in the *True fir* species group. There were 29 tree species and 10 tree species groups used in this assessment. The 10 species groups in this assessment include *Douglas-fir*, Ponderosa and Jeffrey pines (hereafter referred to as *Ponderosa pine*), *True fir, Engelmann and other spruces, Lodgepole pine*, Woodland softwoods (hereafter referred to as *Piñon-juniper*), *Other western softwoods, Cottonwood and aspen, Other western hardwoods* and *Woodland hardwoods*. Refer to Appendix Table A.1 for individual tree species assignments to species group codes.

The accuracy of estimates depends on the ratio of total forest area and the number of plots measured. Counties with fewer forested FIA plots tend to have higher associated errors, and these errors increase as the data are broken down into smaller categories. As such, we did not generate estimates for every combination of forest type and ownership within each county.

3.4 Results

The following sections provide summaries of standing wood volume across Colorado's non-reserved forests, categorized by material category, ownership and forest type. Statewide, the *Gross live* volume on non-reserved lands totals 26,064 ± 455 million cubic feet (MMCF) or 260,644,744 CCF ± 4,554,935 hundred cubic feet (CCF) (Figure 1). More than half (51%) of the *Gross live* volume is considered suitable for *Sawtimber* (13,205 ± 349 MMCF; 132,046,781 ± 3,486,738 CCF). The remaining *Gross live* is split nearly evenly between *Other log* (20%) and *Non-log* (19%) volume. The *Other log* volume totals 6,649 ± 162 MMCF (66,485,589 ± 1618987 CCF). The *Non-log* volume totals 6,211 ± 142 MMCF (62,112,375 ± 1,415,218 CCF). *Salvageable* standing dead trees, reflecting recent tree mortality events, constitute a significant portion of standing volume in Colorado, totaling 7,458 ± 240 MMCF (74,579,792 ± 2,403,580 CCF), more than either the *Other log* or *Non-log* categories. These statewide totals are illustrated in Figure 1.

Statewide estimates of standing wood volume vary notably by ownership group and material category (Figure 2). The *Forest Service* holds the largest share of standing volume in three of the categories: *Sawtimber* (74%), *Salvageable* (77%) and *Other log* (75%). *Non-log* is more evenly distributed across ownerships, with *Other Federal* lands (e.g., BLM, DOD and DOE) showing the largest share in this category (44%). *Private and Native American* lands contain the second highest
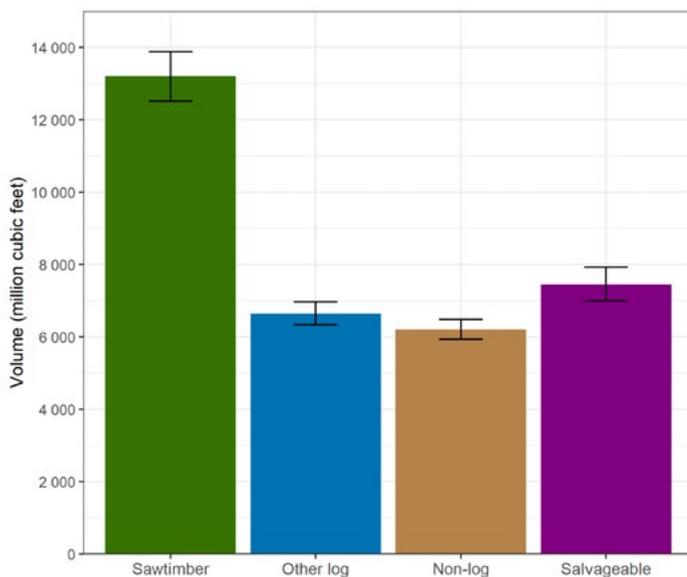
Figure 1. Statewide estimates of standing wood volume in Colorado's non-reserved forests by volume category for 2012–2021. Categories reflect portions of either live trees (Sawtimber, Other log, Non-log) or salvageable standing dead trees (Salvageable). Volumes are reported in million cubic feet, and error bars represent 95% confidence intervals.

volumes of each category. *State and local government* lands consistently account for the smallest proportion of standing wood volume across all categories. These differences reflect both land area and forest composition among ownership types.

Standing wood volume varies widely across forest types and material categories (Figure 3). *Engelmann and other spruces* dominate (34%) statewide *Sawtimber* volume. Similarly, *Cottonwood and aspen* lead the *Other log* category (38%), and *Piñon-juniper* account for the majority of *Non-log* volume (73%). In contrast, *Salvageable* standing dead volume is more evenly distributed across multiple forest types, including *Engelmann and other spruces* (30%), *Lodgepole pine* (21%), *Cottonwood and aspen* (17%) and *True fir* (17%), indicating that recent mortality events have affected a broad range of forest types across the state.

3.4.1 Access complete results

Complete results from this analysis are available in the [supplemental Excel workbook](#). For a broader view of volume patterns across the state, users can explore the [biomass dashboard](#), which also provides estimates by material category, ownership and forest type.
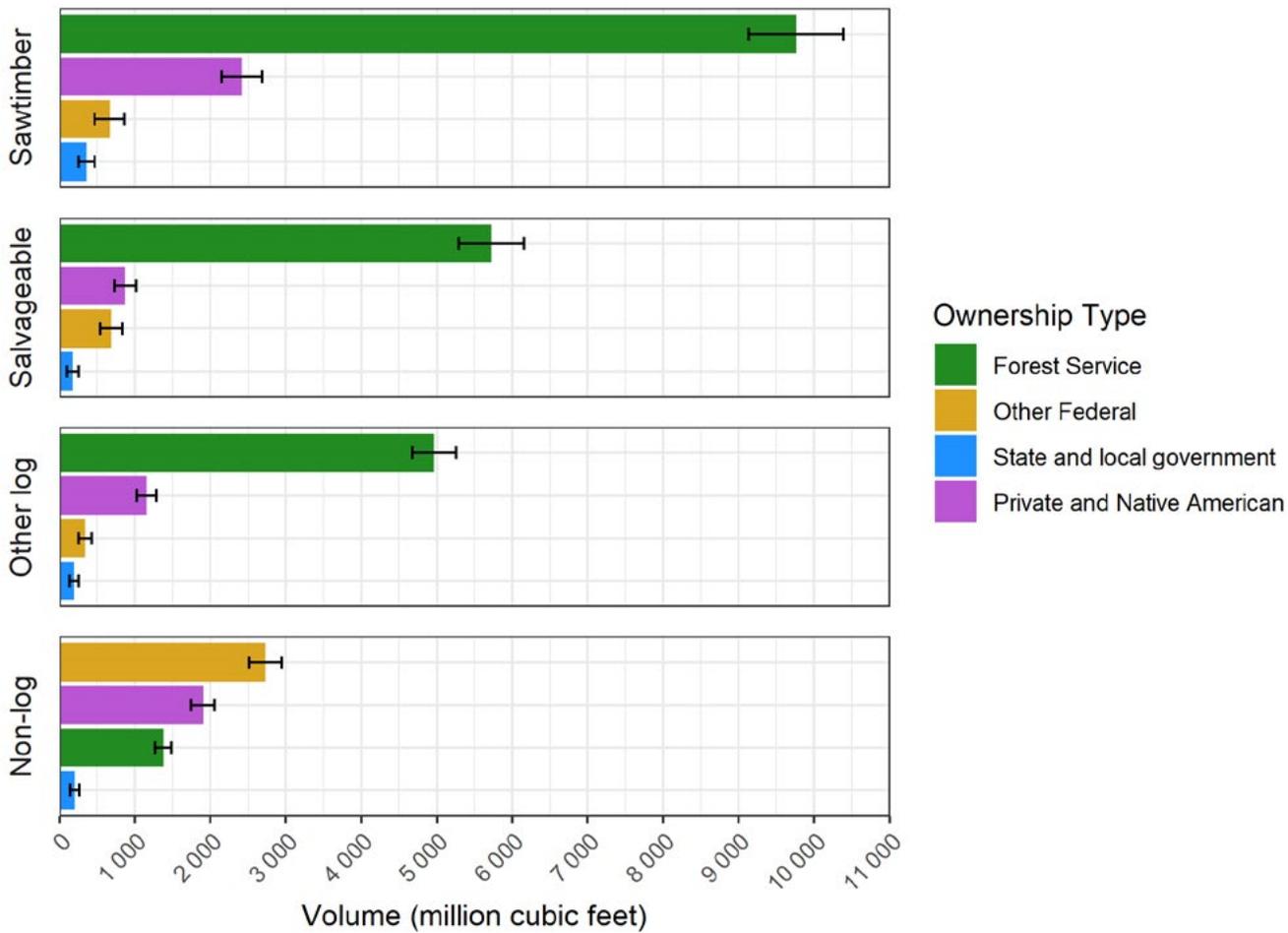
3.4.2 Sawtimber volume

3.4.2.1 Statewide
The estimated volume of *Sawtimber* in Colorado's non-reserved forests is 13,205 ± 349 MMCF (132,046,781 ± 3,486,738 CCF; Figure 1, Table S1 of Supplemental Workbook). Much of this material is located on *Forest Service* lands (74%), 18% on *Private and Native American* lands, 5% on *Other Federal* lands, and 2% on *State and local government* lands (Figure 2, Table S2). *Engelmann and other spruces* comprise 34% of this material, followed by *Ponderosa pine* (15%), *True fir* (15%), *Douglas-fir* (14%), *Cottonwood and aspen* (13%), *Lodgepole pine* (7%), *Other western softwoods* (2%) and *Other western hardwoods* (<1%) (Figure 3, Table S3).

3.4.2.2 County
Gunnison, Archuleta and La Plata counties in the Southwest Area contain the highest volumes of *Sawtimber*, with 1,330 ± 131 MMCF, 680 ± 66 MMCF and 644 ± 91 MMCF, respectively. Routt and Mesa counties, each in the Northwest Area, also contain significant amounts of *Sawtimber*, with 625 ± 79 MMCF and 581 ± 89 MMCF, respectively. Pueblo and Gilpin counties have the lowest *Sawtimber* volumes in the state at 52 ± 25 MMCF and 67 ± 16 MMCF respectively, likely a reflection of both county size and forested acreage (Table S4).

Figure 2. Statewide estimates of standing wood volume in Colorado's non-reserved forests by volume category and ownership group for 2012–2021. Categories reflect portions of either live trees (Sawtimber, Other log, Non-log) or salvageable standing dead trees (Salvageable). Volumes are reported in million cubic feet. Ownership groups include Forest Service, Other Federal (BLM, DOD and DOE), State and local government and Private and Native American lands. Error bars represent 95% confidence intervals.

Across these counties, the majority of *Sawtimber* volume can be found on *Forest Service* land, ranging from 72% in Archuleta County to 83% in Gunnison County. In Archuleta and La Plata counties, 28% and 16% of *Sawtimber* volume can be found on *Private and Native American* lands, compared to 9% in Gunnison County (Table S5).

In Gunnison County, *Engelmann and other spruces* make up approximately 48% of the *Sawtimber* volume, followed by *Lodgepole pine* (18%), *True fir* (11%), *Cottonwood and aspen* (11%) and *Douglas-fir* (10%), with all remaining species groups accounting for 2% or less. In Archuleta County, *Ponderosa pine* accounts for 35% of the *Sawtimber* volume, followed by *True fir* (27%), *Douglas-fir* (20%), *Cottonwood and aspen* (10%), *Engelmann and other spruces* (6%), with all other species groups accounting for 1% or less (Table S6).

3.4.3 Other log volume

3.4.3.1 Statewide
The estimated volume of *Other log* in Colorado's non-reserved forests is 6,649 ± 162 MMCF (66,485,589 ± 1,618,986 CCF; Figure 1, Table S1). Much of this material is located on *Forest Service* lands (75%), 17% on *Private and Native American* lands, 5% on *Other Federal* lands and 3% on *State and local government* lands (Figure 2, Table S2). *Cottonwood and aspen* comprise 38% of the *Other log*, followed by *Engelmann and other spruces* (18%), *Lodgepole pine* (16%), *True fir* (13%), *Douglas-fir* (7%), *Ponderosa pine* (5%), and *Other western softwoods* and *Other western hardwoods* each less than 3% (Figure 3, Table S3).

3.4.3.2 County
Gunnison, Routt and Saguache counties have the highest volume of *Other log* in the state with 694 ± 59
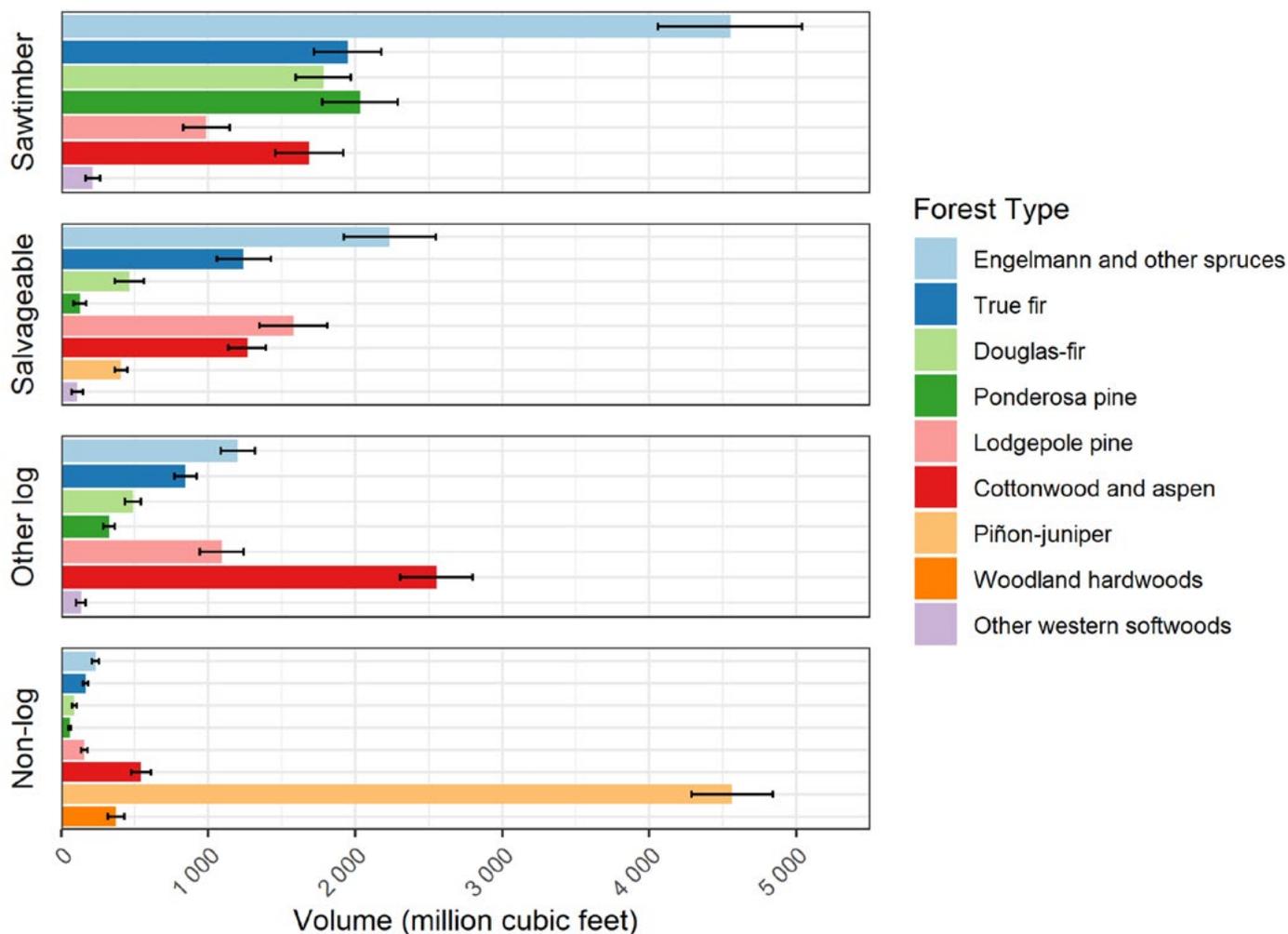
Figure 3. *Statewide estimates of standing wood volume in Colorado's non-reserved forests by volume category and forest type for 2012-2021. Categories reflect portions of either live trees (Sawtimber, Other log, Non-log) or salvageable standing dead trees (Salvageable). Volumes are reported in million cubic feet. Error bars represent 95% confidence intervals. For visual clarity, forest type values less than 500,000 CCF are not shown; this includes the Other western hardwoods group. Please refer to the supplemental Excel workbook for complete statewide volume estimates and confidence intervals.*

MMCF, 473 ± 39 MMCF and 464 ± 44 MMCF respectively. Grand and Eagle counties, each in the Northwest Area, also contain significant amounts of *Other log*, with 316 ± 28 MMCF and 305 ± 41 MMCF, respectively (Table S4).

Across all counties, the majority of *Other log* volume can be found within *Forest Service*, ranging from 54% in Routt County to 92% in Saguache County (Table S7). Routt County has the largest amount of *Other log* volume present on *Private and Native American* lands with 38%, while Saguache County has the least at 1% (Table S7). Please note, the way the ownership groups are grouped and defined may be misleading, with the above statement as a prime example. There is no tribal land in Routt County, meaning 38% of *Other log* volume is present on private land, so local context must be integrated into how these numbers are considered and digested.

Across the above counties, *Other log* volume varies widely by species group. Within these counties, the dominant forest type contributing to these volumes is *Cottonwood and aspen*, ranging from 33% of *Other log* volume in Grand County to 61% in Routt County (Table S8). Other species groups like *Lodgepole pine*, *Engelmann and other spruces* and *True fir* make up a significant portion of the *Other log* volume across these counties, varying from a low of 8% *Lodgepole pine* in Routt County to a high of 26% *True fir* in Grand County (Table S8).

3.4.4 Non-log volume

3.4.4.1 Statewide
The estimated volume of *Non-log* material in Colorado's non-reserved forests is 6,211 ± 142 MMCF (62,112,375 ± 1,415,218 CCF; Figure 1, Table S1). This material is distributed across various ownerships, with 44% on *Other*

Federal lands, 31% on *Private and Native American* lands, 22% on *Forest Service* lands, and 3% on *State and local government* lands (Figure 2, Table S2). Most *Non-log* volume is *Piñon-juniper* (73%), followed by *Cottonwood and aspen* (9%), *Woodland hardwoods* (6%), *Engelmann and other spruces* (4%) and *Douglas-fir, Ponderosa pine, True fir, Lodgepole pine, Other western softwoods* and *Other western hardwoods* each less than 3% (Figure 3, Table S3).

3.4.4.2 County
Rio Blanco, Mesa, Montrose, Las Animas and Moffat counties contain the highest volume of *Non-log* across the state with 796 ± 60 MMCF, 526 ± 41 MMCF, 514 ± 36 MMCF, 454 ±38 MMCF, and 404 ± 42 MMCF respectively (Table S4).

Across the ownerships of these counties, *Non-log* volumes are highest on *Other Federal* lands, except in Las Animas County, where *Private and Native American* lands account for 86% of *Non-log* volume (Table S9). Across the four counties (excluding Las Animas), the proportion of *Non-log* volume on *Other Federal* lands ranges from 58% in Mesa County to 88% in Moffat County.

Across these counties, and indeed the entire state, *Piñon-juniper* makes up the majority of *Non-log* volume (Table S10). However, *Piñon-juniper* does not make up a majority of *Non-log* volume in Clear Creek, Douglas, Gilpin, Grand, Routt, Teller and Gunnison counties. In these counties, species groups with the most *Non-log* volume include *Cottonwood and aspen* (41% and 39% of *Non-log* volume in Routt and Gunnison counties, respectively), *Engelmann and other spruces* (36% and 24% in Clear Creek and Teller counties, respectively), *Lodgepole pine* (59% and 21% in Gilpin and Grand counties, respectively) and *True fir* (28% in Grand County), among other species groups (Table S10).

3.4.5 Salvageable volume

3.4.5.1 Statewide
The estimated volume of *Salvageable* in Colorado's non-reserved forests is 7,458 ± 250 MMCF (74,579,792 ± 2,403,580 CCF; Figure 1, Table S1). Much of this material is located on *Forest Service* lands (77%), 11% on *Private and Native American*, 9% on *Other Federal*, and the remaining 2% on *State and local government* lands (Figure 2, Table S2). The distribution of forest types is as follows: *Engelmann and other spruces* constitute 30%, *Lodgepole pine* 21%, *True fir* 17%, *Cottonwood and aspen* 17%, *Douglas-fir* 6%, *Piñon-juniper* 5%, and *Ponderosa pine, Other western softwoods, Woodland hardwoods* and *Other western hardwoods* each less than 2% (Table S3).

3.4.5.2 County
Grand, Routt, Saguache, Jackson and Gunnison counties have the largest amount of *Salvageable* volume in the state, with 670 ± 63 MMCF, 569 ± 58 MMCF, 502 ± 60 MMCF, 478 ± 67 MMCF and 405 ±55 MMCF respectively. Lake and Douglas counties have the lowest volume at 10 ± 5 MMCF and 13 ± 4 MMCF respectively (Table S4).

The vast majority (65+%) of *Salvageable* volume can be found on *Forest Service* lands across these counties, while the county with the lowest *Salvageable* volume on *Forest Service* is Costilla County with no *Salvageable* volume currently estimated on *Forest Service* lands (Table S11). Of the five counties with the greatest total *Salvageable* volumes, 25% of *Salvageable* occurs on *Private and Native American* lands in Routt County, while 17% of *Salvageable* volume can be found on *State and local government* lands in Jackson County. In the Northwest Area counties (Jackson, Routt, Grand), the most *Salvageable* volume is found in *Lodgepole pine*, ranging from 39% in Routt County to 67% in Grand County. In the Southwest Area counties (Gunnison and Saguache) *Engelmann and other spruces* account for 35% of the *Salvageable* volume in Gunnison County and 65% in Saguache County (Table S12). Other counties have higher *Salvageable* volume in other species groups. For example, Boulder County has 26% of the *Salvageable* volume found in both *Douglas-fir* and *Other western softwoods*, while counties like Mesa and Moffat have nearly 40% of their *Salvageable* volume in *Cottonwood and aspen* (Table S12).

3.4.6 Gross live volume

3.4.6.1 Statewide
The estimated *Gross live* volume in Colorado's non-reserved forests is 26,064 ± 455 MMCF (260,644,744 ± 4,554,935 CCF). Much of this material is located on *Forest Service* lands (62%), 21% on *Private and Native American* lands, 14% on *Other Federal* lands, and 3% on *State and local government* lands (Table S2). *Engelmann and other spruces* comprise 23% of the *Gross live* volume, followed by *Cottonwood and aspen* (18%), *Piñon-juniper* (18%), *True fir* (11%), *Ponderosa pine* (9%), *Douglas-fir* (9%), *Lodgepole pine* (9%), *Woodland hardwoods* (1%), *Other western softwoods* (1%), and *Other western hardwoods* (<1%) (Table S3).

3.4.6.2 County
Gunnison County in the Southwest Area contains the highest *Gross live* volume with 2,182 ± 171 MMCF. Mesa, Rio Blanco and Routt counties in the Northwest Area also contain significant amounts of *Gross live* volume, with 1357 ± 115 MMCF, 1,350 ± 87 MMCF, and 1210 ± 101 MMCF, respectively (Table S4). Across these four counties

much of this volume falls on *Forest Service* land, ranging from 39% in Rio Blanco County to 85% in Gunnison County. Rio Blanco County is the only county of these four where most of the *Gross live* volume is not on *Forest Service* land, as 53% of the *Gross live* volume occurs on *Other Federal.* Pueblo and Gilpin counties contain the least amount of *Gross live* volume with 137 ± 34 MMCF and 160 ± 26 MMCF, respectively (Table S4).

Within Gunnison County, 38% of the *Gross live* volume is represented by *Engelmann and other spruces,* followed by *Cottonwood and aspen* (21%), *Lodgepole pine* (21%), *True fir* (11%) and *Douglas-fir* (7%), with all other species groups making up 1% or less (Table S12). Contrasted with Mesa County, 31% of the *Gross live* volume is *Cottonwood and aspen,* followed by *Piñon-juniper* (30%), *Engelmann and other spruces* (17%), *True fir* (12%), *Ponderosa pine* (4%), *Woodland hardwoods* (3%), *Douglas-fir* (2%), with all remaining species groups accounting for no *Gross live* volumes (Table S12).

An aspen stand in the Bear Creek Preserve at Telluride. **Credit: CSFS**

3.5 Discussion

This study characterizes, describes and quantifies standing volume across Colorado's non-reserved forests. Estimates were produced using a recent 10-year period of FIA field data and are intended to provide a consistent, standardized assessment of standing material at the county and regional scale. While appropriate for statewide and regional summaries, the estimates are not intended to represent current conditions at the project scale or in specific forest stands. All volume estimates should be interpreted as potential availability of biomass, not as definitive counts of accessible or merchantable material, since accessibility, ecological conditions and ownership constraints vary widely.

Standing woody volume is not evenly distributed across Colorado's forests. Higher volumes are concentrated in areas dominated by mid-to high-elevation forest types, particularly in parts of the southwest, northwest and central mountains. These forests typically contain larger, denser trees, contributing to *Sawtimber* and *Other log* volume categories. In contrast, forests characterized by woodland species are more common in the western and southern parts of the state and contribute a larger share of *Non-log* volume. Volume distribution by ownership generally reflects the ecological and geographic characteristics of the forest types within each ownership class, with federal lands *(Forest Service* and *Other Federal)* accounting for the largest share of statewide volume due to their extensive area. The relative acreage of different species groups also plays a role in the volume distribution, as, for example, *Engelmann and other spruces* is the second largest forest type by acreage in the state. Given the predominant make up of these forests, it is not surprising that the *Sawtimber* category is dominated by this species group (Figure 3). These interpretations, however, are regionally specific, so local knowledge and local expertise can help contextualize current forest conditions to add increased detail to our general findings.

Across non-reserved forestlands, *Gross live* volume is predominantly composed of *Sawtimber*, defined as wood that meets regional FIA specifications for size and defect. *Sawtimber* accounts for approximately half of all *Gross live* volume, reflecting relatively mature forest conditions in many areas. *Other log* and *Non-log* make up the remaining volume in roughly equal proportions. *Other log* volume generally mirrors the spatial patterns of *Sawtimber*, with concentrations in mid- to high-elevation conifer forests, while *Non-log* volume, primarily associated with woodland species, is most prominent in the western and southern counties. Notably, standing dead trees classified as *Salvageable* exceed the estimated volume in either the *Other log* or *Non-log* categories, highlighting the widespread tree mortality across the state. *Salvageable* is particularly abundant in *Engelmann* and other *spruces* and *Lodgepole pine* forest types, which have experienced extensive mortality from bark beetle outbreaks, though *True fir* and *Cottonwood and aspen* forests have also shown elevated levels of recent disturbance (CSFS, 2000-2024).

Previous efforts to estimate Colorado's forest volume provide a useful historical context for this assessment. The 1987 Benson and Green report estimated approximately 17 billion cubic feet (BCF) of growing-stock volume on timberland based on 1983 data. More recently, Thompson et al. (2017) estimated 35 BCF in net live volume across all forestlands using FIA data from 2004–2013. Within that total, they reported 23 BCF of growing-stock volume on non-reserved lands, of which 67% was classified as sawtimber material. Differences in scope, forest type inclusion and volume definitions limit direct comparison to current results, but collectively, these efforts reflect an evolving understanding of Colorado's forest resources. This analysis builds on that foundation by applying a consistent framework to estimate standing volume by ownership, forest type and material category using the most recent decade of FIA data available.

Although this report does not assess operational feasibility or market dynamics, an understanding of the current industry context helps underscore the value of accurate, standardized inventory data. Colorado continues to face challenges that limit the economic viability of forest management, including high treatment costs, a limited number of processing facilities, high transportation and other operational costs, and unreliable markets for certain wood products. At the same time, these facilities are underutilized, operating at less than half (44%) of their annual production capacity (Irey et al., 2025), indicating that multiple factors influence how available infrastructure is used. While approximately 90% of wood products used in the state are imported (Lynch & Mackes, 2001; Baral et al., 2025), 90% of the woody material harvested in Colorado is processed in-state (Irey et al., 2025), suggesting that existing mills play a key role in maintaining state capacity. Interest in emerging wood-based products, such as mass timber, biochar and other alternatives further highlights the need for reliable estimates of available volume to inform future analyses.

The State Forest, managed by the Colorado State Forest Service, is a 71,000-acre state trust property in north-central Colorado that stretches approximately 28 miles north and south along the Medicine Bow Mountains. **Credit: Field Peterson, CSFS**

3.5.1 Limitations and areas for future improvement

This assessment provides a snapshot in time based on FIA field measurements collected from 2012 to 2021. Because plots are measured on a 10-year cycle, recent disturbances such as the 2020 wildfires or ongoing insect and disease outbreaks may not be reflected in the data. Each plot represents a single point in time within a continually changing forest, and periodic reanalysis is needed as updated data become available.

Estimates do not account for factors that influence operational feasibility, such as slope, road access, cost-per-acre or nearby infrastructure. Even in areas that are physically accessible, not all stands will necessarily be treated, and not all volume procured. This analysis is not intended for project-level planning, but rather to offer a broad, standardized estimate of standing woody material across Colorado.

Future improvements include increasing spatial resolution, watershed analyses, inclusion of urban forests, updating estimates as new FIA data become available and refining methods as needed.

3.6 Conclusions ··

This analysis provides a standardized inventory of standing woody material across Colorado's non-reserved forestlands, based on the most recent and available 10 years of FIA data. Volume estimates are categorized by ownership, forest type and county to describe and quantify forest resources at broad spatial scales. The results highlight substantial standing volume across the state, including both live and salvageable

material, with distribution patterns varying by region and forest type. While this report does not evaluate feasibility, infrastructure or management opportunities, it provides a statewide snapshot of the material present to support informed decision-making by forest managers, policymakers and industry stakeholders who share a collective responsibility as stewards of Colorado's forests.

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3.8 Appendix A: Species Groupings and Volume Descriptions

Table A.1 Species groups, individual species and timber or woodland classification used in this analysis. Species and groups are based on Forest Inventory and Analysis (FIA) codes (SPGRPCD and SPCD) and reflect only those present in Colorado FIA plot data from 2012-2021. The timber or woodland classification (T/W) follows FIA designations.

Species Group (SPGRPCD)	Species (SPCD)	Timber (T) or Woodland (W)
Douglas-fir (10)	Douglas-fir, *Pseudotsuga menziesii* (202)	T
Ponderosa and Jeffrey pines (11)	ponderosa pine, *Pinus ponderosa* (122)	T
True fir (12)	white fir, *Abies concolor* (15) corkbark fir, *Abies lasiocarpa var. arizonica* (18) subalpine fir, *Abies lasiocarpa* (19)	T T T
Engelmann and other spruces (18)	Engelmann spruce, *Picea engelmannii* (93) blue spruce, *Picea pungens* (96)	T T
Lodgepole pine (21)	lodgepole pine, *Pinus contorta* (108)	T
Woodland softwoods (23)	Utah juniper, *Juniperus osteosperma* (65) Rocky Mountain juniper, *Juniperus scopulorum* (66) oneseed juniper, *Juniperus monosperma* (69) common or two-needle pinyon, *Pinus edulis* (106)	W W W W
Other western softwoods (24)	Rocky Mountain bristlecone pine, *Pinus aristata* (102) limber pine, *Pinus flexilis* (113) southwestern white pine, *Pinus strobiformis* (114)	T T T
Cottonwood and aspen (44)	eastern cottonwood, *Populus deltoides* (742) plains cottonwood, *Populus deltoides ssp. monilifera* (745) quaking aspen, *Populus tremuloides* (746) Fremont cottonwood, *Populus fremontii* (748) narrowleaf cottonwood, *Populus angustifolia* (749)	T T T T T
Other western hardwoods (47)	boxelder, *Acer negundo* (313) water birch, *Betula occidentalis* (374) green ash, *Fraxinus pennsylvanica* (544) chokecherry, *Prunus virginiana* (763) Siberian elm, *Ulmus pumila* (974) Russian-olive, *Elaeagnus angustifolia* (997) fleshy hawthorn, *Crataegus succulenta* (5092)	T T T T T T T
Woodland hardwoods (48)	curlleaf mountain-mahogany, *Cercocarpus ledifolius* (475) Gambel oak, *Quercus gambelii* (814)	W W

Table A.2 Volume descriptions and species groupings for woody material categories in this assessment. The descriptions differ for timber species (softwoods and hardwoods), measured at diameter at breast height (DBH), and woodland species, measured at diameter root collar (DRC).

Variable	Timber Species, *Softwoods*: Douglas fir, ponderosa pine, true fir, Engelmann and other spruces, lodgepole pine, other western softwoods	Timber Species, *Hardwoods*: Cottonwood and aspen, and other western hardwoods	Woodland Species, *All*: Piñon-juniper and woodland hardwoods
Gross live	The total volume of wood in the central stem of trees ≥5.0" DBH, from a 1-foot stump to the top (includes the non-merchantable top) including cull.	The total volume of wood in the central stem of trees ≥5.0" DBH, from a 1-foot stump to the top (includes the non-merchantable top) including cull.	The total volume of wood and bark in trees ≥ 1.5" DRC, from the DRC measurement point(s) to a 1.5" top diameter, including branches at least 1.5" in diameter along the length of the branch. Includes cull.
Sawtimber	The total volume of wood in the central stem of trees ≥9.0" DBH, from a 1-foot stump to a minimum 7.0" top diameter, or to where the central stem breaks into limbs, all of which are less than the minimum top diameter. Cull has been deducted and meets minimum merchantability standards.	The total volume of wood in the central stem of trees ≥11.0" DBH, from a 1-foot stump to a minimum 9.0" top diameter, or to where the central stem breaks into limbs, all of which are less than the minimum top diameter. Cull has been deducted and meets minimum merchantability standards.	N/A
Other log	The total volume of wood in the central stem of trees between 5-9" DBH from a 1-foot stump up to 4-7" top diameter. Cull has been deducted.	The total volume of wood in the central stem of trees between 5-11" DBH from a 1-foot stump up to 4-9" top diameter. Cull has been deducted.	N/A
Non-log	Any remaining material of wood in the central stem of trees ≥5.0" DBH, from a 1-foot stump to the top. Includes cull.	Any remaining material of wood in the central stem of trees ≥5.0" DBH, from a 1-foot stump to the top. Includes cull.	The total volume of wood and bark in trees ≥ 1.5" DRC, from the DRC measurement point(s) to a 1.5" top diameter, including branches at least 1.5" in diameter along the length of the branch. Includes cull.
Salvageable	The total volume of wood in the central stem of trees ≥1.0" DBH, from ground line to the tree tip.	The total volume of wood in the central stem of trees ≥1.0" DBH, from ground line to the tree tip.	The total volume of wood and bark in trees ≥ 1.5" DRC, from the DRC measurement point(s) to a 1.5" top diameter, including branches that are at least 1.5" in diameter along the length of the branch.

3.9 Appendix B: FIA Volume Variable Definitions

This appendix provides detailed definitions for FIA variables used in calculating wood volume estimates. Appendix K of the FIA Database User Guide contains detailed information on volume estimation (Burrill et al., 2024).

VOLCFGRS measures the gross volume in the central stem of timber species ≥ 5.0 inches DBH from a 1-foot stump to a minimum 4-inch top diameter outside bark, or to where the central stem breaks into limbs all of which are <4.0 inches in diameter. **VOLCFGRS_TOP** is the total volume of wood above the 4-inch top diameter of timber species. To estimate the live gross material of timber species, we filtered data for live, non-woodland species using these two variables. For woodland species, **VOLTSGRS** calculates the total volume of wood and bark ≥ 1.5 inches DRC, from the DRC measurement point(s) to a 1.5-inch top diameter, including branches that are at least 1.5 inches in diameter along the length of the branch. Only live woodland species data were used to estimate the live gross material using **VOLTSGRS**. Each of these variables includes 'cull', referring to portions of the tree that are generally unusable for industrial wood products due to defects such as rot or poor form (USDA Forest Service 2022).

For timber species, **VOLTSGRS** is also used to measure the total volume of wood in the central stem from ground level to the tree tip for trees with a diameter ≥1.0- inch. To identify salvageable material, we applied filters to **VOLTSGRS** to select for hard (salvageable) dead trees under the tree class code TREECLCD_RMRS. These are defined as dead trees that have less than 67% of the volume cull due to rotten or missing cubic-foot volume, making them potentially usable for industrial wood products.

VOLCFNET represents the net volume of wood in the central stem of timber species ≥ 5.0 inches DBH from a 1-foot stump to a minimum 4-inch top diameter, or to where the central stem breaks into limbs all of which are <4.0 inches in diameter. Volume losses due to defects such as rot, missing sections and form cull have been deducted from this estimate.

VOLCSNET measures the volume of wood in the sawlog portion of timber species ≥ 9.0 inches DBH minimum for softwoods, 11.0 inches DBH minimum for hardwoods, or to where the central stem breaks into limbs, all of which are less than the minimum top diameter. For a tree to be included in this measurement, it must meet certain merchantability standards: It should have at least one solid 8-foot log section, be reasonably free of form defect along the merchantable bole, and at least 34% of its volume must be merchantable (Burrill et al., 2024). Estimates exclude form cull and rotten/missing cull, and only live trees are considered.

3.10 Appendix C: Glossary ·······················

Note: All definitions in this glossary are derived from the USDA Forest Service Forest Inventory and Analysis (FIA) program, including terminology and definitions from Burrill et al. (2024) and the FIA online glossary (USDA Forest Service, 2023).

Cull: Cull refers to the portion of a tree that is considered unsuitable for industrial wood products due to defects such as disease, insect damage, deformities or other abnormalities. While excluded in calculating merchantable wood volume, cull is included in total wood volume assessments to reflect the comprehensive resource availability in a forest (Burrill et al., 2024).

Gross live material: For timber species, the gross volume is defined as the total volume of wood in the central stem of trees with a diameter at breast height (DBH) of at least 5.0 inches, extending from a one-foot stump to the top, including the non-merchantable top and cull. For woodland species, it encompasses the total volume of wood and bark in trees with a diameter at root collar (DRC) of 1.5 inches or more, from the DRC measurement point to a 1.5-inch top diameter, including branches at least 1.5 inches in diameter along the length of the branch and including cull.

Non-log: For timber species, non-log material consists of any remaining wood in the central stem of trees with a DBH of 5.0 inches or more, from a one-foot stump to the top, including cull. In woodland species, it includes all wood and bark in trees with a DRC of 1.5 inches or more, from the DRC measurement point to a 1.5-inch top diameter, including branches at least 1.5 inches in diameter along the length of the branch and including cull.

Non-reserved land: Non-reserved land refers to areas not specifically withdrawn from management for the production of wood products through statutory or administrative designation. Unlike reserved lands such as federal wilderness areas and national parks, non-reserved land is available for multiple uses including timber production, recreation and other forms of resource management. While the FIA program designates state-owned lands including state parks as reserved lands, this assessment designates state lands as non-reserved land. There are several multi-use land management frameworks in Colorado that include management for production of wood products.

Other log: Other log for timber species represent the volume of wood in the central stem of trees with a DBH between 5 and 9 inches for softwoods and between 5 and 11 inches for hardwoods, extending from a one-foot stump up to a top diameter of 4-7 inches for softwoods and 4-9 inches for hardwoods, with cull deducted. This category is not applicable to woodland species.

Salvageable: Salvageable wood for timber species refers to the total volume of wood in the central stem of trees with a DBH of 1.0 inch or more, from the ground line to the tree tip. For woodland species, it includes all wood and bark in trees with a DRC of 1.5 inches or more, from the DRC measurement point to a 1.5-inch top diameter, including branches that are at least 1.5 inches in diameter along the length of the branch.

Sawtimber: The sawtimber volume for timber species includes wood in the central stem of trees with a DBH of 9.0 inches or more for softwoods and 11.0 inches or more for hardwoods, measured from a one-foot stump to a minimum top diameter (7.0 inches for softwoods, 9.0 inches for hardwoods) or to where the central stem breaks into smaller limbs, excluding cull and meeting merchantability standards. This category is not applicable to woodland species.