## Title of project or data set

The Dynamic Temperate and Boreal Fire and Forest-Ecosystem Simulator (DYNAFFOREST): Development and evaluation

## Abstract

Fire is a dominant disturbance in temperate and boreal biomes, and increasing burned area with climate change may fundamentally alter forests. Improved information about how fire-induced changes to forests may feedback to affect subsequent burning at regional scales could inform forest management and climate-mitigation strategies. However, fire is simplistically represented in Earth System Models, and regional statistical fire models often assume sufficient fuels, contributing to uncertainty in future projections. To address this challenge, we developed the Dynamic Temperate and Boreal Fire and Forest-Ecosystem Simulator (DYNAFFOREST). DYNAFFOREST represents the hierarchical structuring of forests, from individual cohorts to continental extents, making it possible to simulate feedbacks between fire and forests at broad scales over decades to centuries. We parameterized DYNAFFOREST for the western United States of America and benchmarked simulations with observations. DYNAFFOREST recreated patterns of forest cover, structure, and downed fuels, and was capable of capturing average 20th-century fire activity.

## Creators

|  |  |  |  |  |  |
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## Timeframe

* January 2018 to October 2021
* Data collection completed

## Geographic location

**Western United States**

## Methods

We developed a coupled fire and forest ecosystem model called the Dynamic Temperate and Boreal Fire and Forest ecosystem Simulator (DYNAFFOREST). DYNAFFOREST is broken into two modules: a forest-ecosystem module and a fire module. We constructed DYNAFFOREST with a hierarchical structure where the forest-ecosystem module operates at a 1-kmspatial resolution, and the fire module operates at a 12-kmresolution. The time step of both modules is annual. We then evaluated how DYNAFFOREST performs relative to a set of observed benchmarks.

We evaluated DYNAFFOREST by simulating forests and fires in the western US forced with mid-20th century climate. We chose the western US because forest fire has long been a prevalent disturbance, and climate change is causing fire activity to rapidly increase, threatening people and ecosystems. The western US is also data rich. For example, the USDA Forest Inventory and Analysis (FIA) network includes approximately 160,000 permanent plots across the United States designed to provide insights into forest condition. This allowed us to develop a robust parameterization for plant functional types (PFTs) in the western US. The wealth of data also ensured that we started simulations from relatively high-quality initial conditions, and that we could benchmark model runs against several independent datasets.

We selected five study regions that collectively include 56% of all forested area in the western US: the coastal and Inland Pacific Northwest of Oregon and Washington (~ 148,000 km2 of forest) (hereafter, PNW), northern Idaho (~ 97,000 km2 of forest) (Idaho), the Greater Yellowstone Ecosystem in southern Montana and northern Wyoming (~ 47,500 km2 of forest) (GYE), the southern Rockies, including parts of Utah, Colorado, New Mexico, and Arizona (~ 135,000 km2 of forest) (Southern Rockies), and the Sierra Nevada Mountains (~ 77,000 km2 of forest) (Sierras). Study regions were selected because they represent the range of forest types and fire regimes that characterize the western US, from dry pinyon- and ponderosa-pine woodlands, where frequent low-severity fires burned every 5-15 years prior to Euro-American settlement, to wet Douglas-fir forests of the Pacific Northwest, where fire return intervals could exceed 700 years, with infrequent yet extensive high severity, stand replacing fire events. We grouped tree species in the western US into 12 PFTs and also included a grassland PFT.

We initialized the model with the gridded PFT map, a stand-age map derived from remote sensing, historical fire records, and forest inventory plots, and information on fuel loads based on forest type. Initial cohort heights were derived from the stand-age map using internal model equations. Initial DBHs, live biomass, and stand densities were calculated from initial cohort heights.

The forest ecosystem module was forced with 1965-1994 daily temperature from the TopoWx dataset and average growing season volumetric soil moisture in the rooting zone (0- to 100-cm depth). Temperature data was used to calculate tree-seedling germination and establishment thresholds. Volumetric soil moisture was used in fire severity equations and was also converted to soil water potential based on % sand, silt, and clay from SoilGrids250m 2.0 for calculations of tree regeneration and cohort mortality. Inputs to the fire module included the 1984-2019 climatological mean annual aridity (the ratio of total annual precipitation to total annual potential evapotranspiration), topography (slope angle and topographic complexity), and factors that influence fire ignition density (the 1987-2019 mean lightning strike density and 1990 human population density).

Initial fuel loads were representative of the forest types found in our study regions but did not reflect spatial heterogeneity due to the past legacies of harvest, fire, or drought. Thus, we ran a 200-year spin up simulating the coupled response of vegetation to fire and climate in the five study regions to generate spatially heterogeneous fuels conditions consistent with internal model logic. After the spin up, we ran a 100-year experiment to benchmark model performance. Because several processes are probabilistic in the model, including fire, mortality and recruitment, we ran five replicates of each region to account for model-based variability. No forest harvest was simulated.

We benchmarked simulated forest characteristics from model year 300 and simulated fire activity from simulation years 201-300. Classical tests of statistical significance are problematic with simulated data because large sample sizes can artificially inflate significance. Thus, we used a pattern-oriented modeling approach. Patterns of several simulated variables at stand (1-km grid-cell) to western-US scales were compared to observed datasets to evaluate model skill. We compared modeled and observed distributions of tree sizes and cohort densities for each PFT and region, and biomass pools and fire-regime characteristics for each region and across the western US (pooling all five study regions). Data limitations constrained our ability to benchmark the model with completely independent observational datasets, but we prioritized independence whenever possible.

We represented model distributions of variables by calculating their median, inter-quartile range (IQR), skewness, and minimum and maximum for each PFT (when appropriate), study region, and pooling across all study regions for each of the five replicates. We then calculated the average median, IQR, skewness, and minimum, and maximum values across the replicates to compare with observed distributions. Observed distributions of tree sizes, stand densities, and biomass pools came from FIA plots that were classified as forested lands and sampled since 2000, when the USFS adopted a standard fixed-radius plot design. FIA plots were not filtered based on disturbance history. For tree sizes and stand densities, model evaluation was conducted with the one-third of FIA plots that were not used in model parameterization. We identified all FIA plots dominated by the PFTs represented in DYNAFFOREST and calculated the median tree height and DBH for each plot. We then compared simulated distributions of heights and DBHs with the FIA plots dominated by the same PFT. To ensure accurate comparison, we limited our analysis to simulated cohorts with a DBH >2.54 cm (the cutoff for tree measurement in FIA protocols).

Simulated annual median fire size, annual number of fires, fire perimeter shape complexity (perimeter length to patch area ratio), and annual total area burned were compared to observed fire records from the period 1985-1994 from the same database used in model parameterization. Fires came from the Western US MTBS-Interagency (WUMI) wildfire database, which includes large fires (>404 ha) from the US Forest Service’s Monitoring Trends in Burn Severity database as well as a quality-controlled list of mostly smaller fires >100 ha maintained by the National Wildfire Coordinating group. Because we wanted to test the fire module’s ability to generate fire characteristics consistent with the mid-20th century fire regime, we chose 1985-1994 to exclude more recent observations during years where climate change has profoundly altered fire activity in the western US. This temporal window is best suited for our current purposes because of 1) the broad spatial extent of our modeling that captures tremendous variability in fuels, aridity/climate, ignition patterns, and fire regime characteristics; and 2) because our goal in this paper was to develop a model that could generate fire consistent with mid-20th century fire seasons. Subsequent development of the fire module for forecasting interannual effects of climate on fire will require more advanced statistical models and benchmarking methods.

The simulated percent of area that burned at high severity each year was independently benchmarked against a remotely-sensed burn severity product. The database provides composite burn index (CBI) for all fires > 404 ha in the observational record at a 30-m spatial resolution. To ensure the remotely-sensed product was comparable to model outputs, we first included only portions of 1985-1994 fires that fell within our initial simulated forested areas. We then masked out portions of those fires where the prefire NDVI was below 0.35 to exclude non-forested vegetation potentially misclassified as forest. We aggregated the 30-m CBI estimates within each observed fire to a 1-km2 resolution. We used a CBI value of 2.25, equivalent to > 95% tree mortality, as the cutoff to define stand replacing fire in each grid cell. We then calculated the percent of annual burned area that was stand replacing for each region.

## Data Tables

**Table name(s):** fire.metrics\_cascades\_size-1\_num-1\_replicate-1, fire.metrics\_cascades\_size-1\_num-1\_replicate-2, fire.metrics\_cascades\_size-1\_num-1\_replicate-3, fire.metrics\_cascades\_size-1\_num-1\_replicate-4, fire.metrics\_cascades\_size-1\_num-1\_replicate-5, fire.metrics\_idaho\_size-1\_num-1\_replicate-1, fire.metrics\_idaho\_size-1\_num-1\_replicate-2, fire.metrics\_idaho\_size-1\_num-1\_replicate-3, fire.metrics\_idaho\_size-1\_num-1\_replicate-4, fire.metrics\_idaho\_size-1\_num-1\_replicate-5, fire.metrics\_sierra\_size-1\_num-1\_replicate-1, fire.metrics\_sierra\_size-1\_num-1\_replicate-2, fire.metrics\_sierra\_size-1\_num-1\_replicate-3, fire.metrics\_sierra\_size-1\_num-1\_replicate-4, fire.metrics\_sierra\_size-1\_num-1\_replicate-5, fire.metrics\_Southern\_Rockies\_size-1\_num-1\_replicate-1, fire.metrics\_Southern\_Rockies\_size-1\_num-1\_replicate-2, fire.metrics\_Southern\_Rockies\_size-1\_num-1\_replicate-3, fire.metrics\_Southern\_Rockies\_size-1\_num-1\_replicate-4, fire.metrics\_Southern\_Rockies\_size-1\_num-1\_replicate-5, fire.metrics\_yellowstone\_size-1\_num-1\_replicate-1, fire.metrics\_yellowstone\_size-1\_num-1\_replicate-2, fire.metrics\_yellowstone\_size-1\_num-1\_replicate-3, fire.metrics\_yellowstone\_size-1\_num-1\_replicate-4, fire.metrics\_yellowstone\_size-1\_num-1\_replicate-5

**Table description(s):** Fire metrics (e.g. area burned, perimeter size) from DYNAFFOREST runs. All tables have the same column format. Replicate tables (1-5) are produced from replicate runs of the same model (with stochastic elements). Region (Cascades, Idaho, Sierra, Southern Rockies, or Yellowstone) is specified within the table name. Each year/fire.id combination is a unique fire.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Column name | Description | Unit | Code explanation or date format | Empty value code |
| year | The year of the model in which the fire occurred | model-year | N/A | N/A |
| fire.id | A unique identifier for each fire that occurred in any given year. Identifier numbers begin at 1 and count up for each year.  | N/A | N/A | N/A |
| area.burned.ha | The total area burned, in hectares, for each fire.  | hectares | N/A | N/A |
| area.burned.sr.ha | Area burned as stand replacing, where ‘stand replacing’ is defined as a composite burn index of >2.5, or approximately >95% tree mortality. | hectares | N/A | N/A |
| percent.hs | Percent of the area burned that was stand replacing | percent | N/A | N/A |
| perim | Perimeter length of the fire | meters | N/A | N/A |
| area | Total area of the fire | hectares | N/A | N/A |

**Table name(s):** above\_ground\_biomass\_cascades\_yr.300.size-1.num-1.replicate-1, above\_ground\_biomass\_cascades\_yr.300.size-1.num-1.replicate-2, above\_ground\_biomass\_cascades\_yr.300.size-1.num-1.replicate-3, above\_ground\_biomass\_cascades\_yr.300.size-1.num-1.replicate-4, above\_ground\_biomass\_cascades\_yr.300.size-1.num-1.replicate-5, above\_ground\_biomass\_idaho\_yr.300.size-1.num-1.replicate-1, above\_ground\_biomass\_idaho\_yr.300.size-1.num-1.replicate-2, above\_ground\_biomass\_idaho\_yr.300.size-1.num-1.replicate-3, above\_ground\_biomass\_idaho\_yr.300.size-1.num-1.replicate-4, above\_ground\_biomass\_idaho\_yr.300.size-1.num-1.replicate-5, above\_ground\_biomass\_sierra\_yr.300.size-1.num-1.replicate-1, above\_ground\_biomass\_sierra\_yr.300.size-1.num-1.replicate-2, above\_ground\_biomass\_sierra\_yr.300.size-1.num-1.replicate-3, above\_ground\_biomass\_sierra\_yr.300.size-1.num-1.replicate-4, above\_ground\_biomass\_sierra\_yr.300.size-1.num-1.replicate-5, above\_ground\_biomass\_Southern\_Rockies\_yr.300.size-1.num-1.replicate-1, above\_ground\_biomass\_Southern\_Rockies\_yr.300.size-1.num-1.replicate-2, above\_ground\_biomass\_Southern\_Rockies\_yr.300.size-1.num-1.replicate-3, above\_ground\_biomass\_Southern\_Rockies\_yr.300.size-1.num-1.replicate-4, above\_ground\_biomass\_Southern\_Rockies\_yr.300.size-1.num-1.replicate-5, above\_ground\_biomass\_yellowstone\_yr.300.size-1.num-1.replicate-1, above\_ground\_biomass\_yellowstone\_yr.300.size-1.num-1.replicate-2, above\_ground\_biomass\_yellowstone\_yr.300.size-1.num-1.replicate-3, above\_ground\_biomass\_yellowstone\_yr.300.size-1.num-1.replicate-4, above\_ground\_biomass\_yellowstone\_yr.300.size-1.num-1.replicate-5

**Table description(s):** Above ground biomass metrics from DYNAFFOREST runs. All tables have the same column format. Replicate tables (1-5) are produced from replicate runs of the same model (with stochastic elements). Region (Cascades, Idaho, Sierra, Southern Rockies, or Yellowstone) is specified within the table name. Each row is a grid cell.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Column name | Description | Unit | Code explanation or date format | Empty value code |
| x | Geographic coordinate related to the underlying map grid cells; number specifying which grid cell on an east-west axis | N/A | N/A | N/A |
| y | Geographic coordinate related to the underlying map grid cells; number specifying which grid cell on a north-south axis | N/A | N/A | N/A |
| height.m | Tree height of the forest cohort | meters | N/A | 0 = no trees within the grid cell (pft also = 0; see pft below) |
| stand\_age | Stand age of the forest cohort.  | years | N/A | 0 = no trees within the grid cell (pft also = 0; see pft below) |
| DBH.cm | DBH of the forest cohort | centimeters | N/A | 0 = no trees within the grid cell (pft also = 0; see pft below) |
| stem.biomass.kg | Stem biomass of the forest cohort, calculated from an allometric equation. | kilograms | N/A | 0 = no trees within the grid cell (pft also = 0; see pft below) |
| leaf.biomass.kg | Leaf biomass of the forest cohort, calculated from an allometric equation. | kilograms | N/A | 0 = no trees within the grid cell (pft also = 0; see pft below) |
| branch.biomass.kg | Branch biomass of the forest cohort, calculated from an allometric equation. | kilograms | N/A | 0 = no trees within the grid cell (pft also = 0; see pft below) |
| stand.density.ha | Number of trees per hectare in the forest cohort | trees ha-1 | N/A | 0 = no trees within the grid cell (pft also = 0; see pft below) |
| soil.moisture | Average growing season volumetric soil moisture in the rooting zone (0-100 cm depth) | m3m-3 | N/A | N/A |
| psi | Soil water potential within the specified grid cell | MPa | N/A | N/A |
| stress | Probability of drought stress | Dim. | N/A | N/A |
| background.prob | Probability of trees within the forest cohort reaching the maximum age; feeds into the mortality equation | N/A | N/A | 0 = no trees within the grid cell (pft also = 0; see pft below) |
| death\_prob | Probability of cohort mortality from fire | N/A | N/A | 0 = no trees within the grid cell (pft also = 0; see pft below) |
| stressed | Outcome of stress probability equation | Dim. | 0/1 |  |
| dead | Outcome of death probability equation | Dim. | 0/1 | N/A |
| pft | Plant functional type – a coarse characterization of the vegetation type at any given site. PFTs are Aspen, Mixed Conifer, Coastal Douglas-fir, Interior Douglas-fir, Engelmann spruce/fir, Fire-needle pine, Hemlock/cedar, Lodgepole pine, Mixed fir, Pinyon pine, Northern Ponderosa pine, Southern Ponderosa pine (see Fig. 2 for the distribution of these PFTs across the study regions). | N/A | 1 – Aspen, 2 – Mixed Confier, 3 – Coasta Douglas-fir, 4 – Interior Douglas-fir, 5 – Engelmann spruce/fir, 6 – Five-needle pine, 7 – Hemlock/cedar, 8 – Lodgepole pine, 9 – Mixed fir, 10 – Pinyon pine, 11 – Northern Ponderosa pine, 12 – Southern Ponderosa pine | 0 – Grassland/shrubland/not forested land |
| year | The model-year for which all information is given. | model-years | N/A | N/A |

**Table name(s):** Fuels\_cascades\_yr.300.size-1.num-1.replicate-1, Fuels\_cascades\_yr.300.size-1.num-1.replicate-2, Fuels\_cascades\_yr.300.size-1.num-1.replicate-3, Fuels\_cascades\_yr.300.size-1.num-1.replicate-4, Fuels\_cascades\_yr.300.size-1.num-1.replicate-5, Fuels\_idaho\_yr.300.size-1.num-1.replicate-1, Fuels\_idaho\_yr.300.size-1.num-1.replicate-2, Fuels\_idaho\_yr.300.size-1.num-1.replicate-3, Fuels\_idaho\_yr.300.size-1.num-1.replicate-4, Fuels\_idaho\_yr.300.size-1.num-1.replicate-5, Fuels\_sierra\_yr.300.size-1.num-1.replicate-1, Fuels\_sierra\_yr.300.size-1.num-1.replicate-2, Fuels\_sierra\_yr.300.size-1.num-1.replicate-3, Fuels\_sierra\_yr.300.size-1.num-1.replicate-4, Fuels\_sierra\_yr.300.size-1.num-1.replicate-5, Fuels\_Southern\_Rockies\_yr.300.size-1.num-1.replicate-1, Fuels\_Southern\_Rockies\_yr.300.size-1.num-1.replicate-2, Fuels\_Southern\_Rockies\_yr.300.size-1.num-1.replicate-3, Fuels\_Southern\_Rockies\_yr.300.size-1.num-1.replicate-4, Fuels\_Southern\_Rockies\_yr.300.size-1.num-1.replicate-5, Fuels\_yellowstone\_yr.300.size-1.num-1.replicate-1, Fuels\_yellowstone\_yr.300.size-1.num-1.replicate-2, Fuels\_yellowstone\_yr.300.size-1.num-1.replicate-3, Fuels\_yellowstone\_yr.300.size-1.num-1.replicate-4, Fuels\_yellowstone\_yr.300.size-1.num-1.replicate-5

**Table description(s):** Above ground biomass metrics from DYNAFFOREST runs. All tables have the same column format. Replicate tables (1-5) are produced from replicate runs of the same model (with stochastic elements). Region (Cascades, Idaho, Sierra, Southern Rockies, or Yellowstone) is specified within the table name. Each row is a grid cell.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Column name | Description | Unit | Code explanation or date format | Empty value code |
| x | Geographic coordinate related to the underlying map grid cells; number specifying which grid cell on an east-west axis | N/A | N/A | N/A |
| y | Geographic coordinate related to the underlying map grid cells; number specifying which grid cell on a north-south axis | N/A | N/A | N/A |
| litter.kg | Biomass of forest floor litter within the grid cell | kilograms | N/A | N/A |
| cwd.kg | Biomass of coarse woody debris within the grid cell | kilograms | N/A | N/A |
| snag.kg | Biomass of standing snags within the grid cell | kilograms | N/A | N/A |
| pft | Plant functional type – a coarse characterization of the vegetation type at any given site. PFTs are Aspen, Mixed Conifer, Coastal Douglas-fir, Interior Douglas-fir, Engelmann spruce/fir, Fire-needle pine, Hemlock/cedar, Lodgepole pine, Mixed fir, Pinyon pine, Northern Ponderosa pine, Southern Ponderosa pine (see Fig. 2 for the distribution of these PFTs across the study regions). | N/A | 1 – Aspen, 2 – Mixed Confier, 3 – Coasta Douglas-fir, 4 – Interior Douglas-fir, 5 – Engelmann spruce/fir, 6 – Five-needle pine, 7 – Hemlock/cedar, 8 – Lodgepole pine, 9 – Mixed fir, 10 – Pinyon pine, 11 – Northern Ponderosa pine, 12 – Southern Ponderosa pine | 0 – Grassland/shrubland/not forested land |
| fire.id | A unique identifier for the fire that occurred in that grid cell in the given year. | N/A | N/A | 0 = no fire occurred |
| avail.litter.kg | Amount of forest floor litter available to burn within the grid cell in the given year. Determined as a function of fuel moisture. | kilograms | N/A | NA = no available litter |
| avail.cwd.kg | Amount of coarse woody debris available to burn within the grid cell in the given year. Determined as a function of fuel moisture. | kilograms | N/A | N/A = no available coarse woody debris |
| ck | Percent crown kill | % | N/A | N/A |
| fire.sev | Probability of cohort death | proportion | N/A | N/ |
| fire.death | Outcome of probabilistic estimate of cohort death | Dim. | 0/1 | N/A |
| death | Tree mortality in the given year within the forest cohort | Dim. | 0/1 | N/A |
| year | The model-year for which all information is given. | model-years | N/A | N/A |
| psi | Soil water potential within the specified grid cell | MPa | N/A | N/A |
| sm.annual | Mean growing season volumetric soil moisture | m3 m-3 | N/A | N/A |
| sm.max | Maximum growing season volumetric soil moisture | m3 m-3 | N/A | N/A |

**Table name(s):** FIA\_plots\_validation.txt, FIA\_plots\_evaluation.txt

**Table description(s):** FIA data, collected from 2000 to 2018. Explanations for column name descriptions, units, and codes can be found at https://www.fia.fs.fed.us/library/database-documentation/current/ver90/FIADB%20User%20Guide%20P2\_9-0-1\_final.pdf. FIA plots from each region were split into validation and evaluation datasets, with each table name reflecting whether data contained within were used for validation or evaluation.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Column name | Description | Unit | Code explanation or date format | Empty value code |
| PLOT\_CN |  |  |  |  |
| STATCD |  |  |  |  |
| COUNTYCD |  |  |  |  |
| PLOT |  |  |  |  |
| ELEV |  |  |  |  |
| DESIGNCD |  |  |  |  |
| MEASYEAR |  |  |  |  |
| MEASMON |  |  |  |  |
| MEASDAY |  |  |  |  |
| forest |  |  |  |  |
| region |  |  |  |  |
| COND\_STATUS\_CD |  |  |  |  |
| FORTYPCD |  |  |  |  |
| FLDTYPCD |  |  |  |  |
| STDAGE |  |  |  |  |
| BALIVE |  |  |  |  |
| CARBON\_DOWN\_DEAD |  |  |  |  |
| CARBON\_LITTER |  |  |  |  |
| CARBON\_SOIL\_ORG |  |  |  |  |
| CARBON\_STANDING\_DEAD |  |  |  |  |
| state |  |  |  |  |
| LAT |  |  |  |  |
| LON |  |  |  |  |

**Table name(s): tree.csv**

**Table description(s):** There is one “tree.csv” file for each of the following states: AZ, CA, CO, ID, MT, NM, NV, OR, UT, WA, WY. FIA Tree Table data. Column names and brief column descriptions are included. For full column descriptions, units, and explanations of codes see: https://www.fia.fs.fed.us/library/database-documentation/current/ver80/FIADB%20User%20Guide%20P2\_8-0.pdf

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Column name | Description | Unit | Code explanation or date format | Empty value code |
| PLOT\_CN | Plot sequence number |  |  |  |
| SUBP | Subplot number |  |  |  |
| TREE | Tree record number |  |  |  |
| STATUSCD | Status code |  |  |  |
| SPCD | Species code |  |  |  |
| DIA | Current diameter at breast height |  |  |  |
| HT | Total height |  |  |  |
| AGENTCD | Cause of death (agent) code |  |  |  |
| MORTYR | Mortality year – the estimated year in which a remeasured tree died or was cut. |  |  |  |
| TOTAGE | Total age – The age of a live tree  |  |  |  |
| MORTCD | Mortality code |  |  |  |
| STANDING\_DEAD\_CD | Standing dead code |  |  |  |
| PREV\_STATUS\_CD | Previous tree status code |  |  |  |

**Table name(s): cascades\_dwm.txt, idaho\_dwm.txt, sierra\_dwm.txt, Southern\_Rockies\_dwm.txt, Yellowstone\_dwm.txt**

**Table description(s):** FIA carbon Table data. Column names and brief column descriptions are included. For full column descriptions, units, and explanations of codes see:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Column name | Description | Unit | Code explanation or date format | Empty value code |
| YEAR |  |  |  |  |
| pltID |  |  |  |  |
| PLOT\_STATUS\_CD |  |  |  |  |
| PLOT\_STATUS |  |  |  |  |
| PLT\_CN |  |  |  |  |
| VOL\_1HR |  |  |  |  |
| VOL\_10HR |  |  |  |  |
| VOL\_100HR |  |  |  |  |
| VOL\_1000HR |  |  |  |  |
| VOL\_PILE |  |  |  |  |
| BIO\_DUFF |  |  |  |  |
| BIO\_LITTER |  |  |  |  |
| BIO\_1HR |  |  |  |  |
| BIO\_10HR |  |  |  |  |
| BIO\_100HR |  |  |  |  |
| BIO\_1000HR |  |  |  |  |
| BIO\_PILE |  |  |  |  |
| CARB\_DUFF |  |  |  |  |
| CARB\_LITTER |  |  |  |  |
| CARB\_1HR |  |  |  |  |
| CARB\_10HR |  |  |  |  |
| CARB\_100HR |  |  |  |  |
| CARB\_1000HR |  |  |  |  |
| CARB\_PILE |  |  |  |  |
| BIO |  |  |  |  |
| VOL |  |  |  |  |
| CARB |  |  |  |  |

**Table name(s): cascades\_biomass.txt, idaho\_biomass.txt, sierra\_biomass.txt, Southern\_Rockies\_biomass.txt, Yellowstone\_biomass.txt**

**Table description(s):** FIA data for each listed study region, collected from 2001- 2018. Explanations for column name descriptions, units, and codes can be found at https://www.fia.fs.fed.us/library/database-documentation/current/ver90/FIADB%20User%20Guide%20P2\_9-0-1\_final.pdf.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Column name | Description | Unit | Code explanation or date format | Empty value code |
| YEAR |  |  |  |  |
| pltID |  |  |  |  |
| COMPONENT |  |  |  |  |
| PLOT\_STATUS\_CD |  |  |  |  |
| PLOT\_STATUS |  |  |  |  |
| PLT\_CN |  |  |  |  |
| BIO\_ACRE |  |  |  |  |
| nStems |  |  |  |  |
| CARB\_ACRE |  |  |  |  |

## Spatial data objects

Cascades directory – Contained within are “cascades\_SR.nc]” [netcdf of stand replacing fires within the given region], “cascades\_total.nc” [netcdf of total probability of fires and total area of fires within the given region], “fires.MTBS.nc”, and “forest\_grid.tif”

Idaho directory – Contained within are “idaho\_SR.nc” [netcdf of stand replacing fires within the given region], “idaho\_total.nc” [netcdf of total probability of fires and total area of fires within the given region], “fires.MTBS.nc”, and “forest\_grid.tif”

Sierra directory – Contained within are “sierra\_SR.nc” [netcdf of stand replacing fires within the given region], “sierra\_total.nc” [netcdf of total probability of fires and total area of fires within the given region], “fires.MTBS.nc”, and “forest\_grid.tif”

southern\_rockies directory – Contained within are “Southern\_Rockies\_SR.nc” [netcdf of stand replacing fires within the given region], “Southern\_Rockies\_total.nc” [netcdf of total probability of fires and total area of fires within the given region], “fires.MTBS.nc”, and “forest\_grid.tif”

Yellowstone directory – Contained within are “yellowstone\_SR.nc” [netcdf of stand replacing fires within the given region], “yellowstone\_total.nc” [netcdf of total probability of fires and total area of fires within the given region], “fires.MTBS.nc”, and “forest\_grid.tif”

All “fires.MTBS.nc” files for each region are netcdf files of all historical fires from the Monitoring Trends in Burn Severity (MTBS) dataset, compiled from the Western US MTBS-Interagency [WUMI] wildfire database

All “forest\_grid.tif” files for each region are rasters of forested areas in the specified study region, used for clipping historical fire data and other model input data to just forested areas

## Articles

**Hansen, W.D.,** M.A. Krawchuk, A.T. Trugman, and A.P. Williams. In Press. The Dynamics Temperate and Boreal Fire and Forest-Ecosystem Simulator (DYNAFFOREST): Development and evaluation. Environmental Modelling and Software. DOI: <https://doi.org/10.1016/j.envsoft.2022.105473>

## Ancillary files: software, code, protocols included

**Model scripts:**

Model\_10-10-2021.R

model\_functions\_10-10-2021.R

fire\_model\_functions\_10-10-2021.R

**Main paper scripts:**

area\_burned\_shape\_param\_obs\_sim\_12\_2\_2020.Rmd

drivers\_aboveground biomass.Rmd

FIA\_DWN\_benchmarking.Rmd

generating rasters for maps.Rmd

**Appendices scripts:**

FIA\_height\_DBH\_fitting.Rmd

FIA\_stand density.Rmd