Sampling Protocols:
Front Range Forest Reconstruction Network (FRFRNet)

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USDA Forest Service – Rocky Mountain Research Station, Rocky Mountain Tree Ring Research, and Colorado Forest Restoration Institute

Objective of Sampling
The sampling protocols outlined here are intended to inform ongoing and future ecological restoration efforts in Front Range montane forests, those dominated by or with a significant component of ponderosa pine. Our overall objective with this project is to provide quantitative metrics that describe historical forest stand conditions, age structures, and fire regimes across a range of environmental conditions where montane forests occur. *"Historical" is defined in this study as conditions ca. 1860 to 1880 depending on dates of fire exclusion or timber harvest across study landscapes.*

Our sampling protocols are intended to reconstruct three components of the historical forest, and to contrast these patterns with current forest conditions:

1) Spatiotemporal patterns of pre-fire-exclusion fire regimes for individual stands; including timing of fire events, fire frequency, fire severity, fire extent and spatial patterning, and season of fire occurrence. Fire regimes will be reconstructed using both fire-scarred trees (to reconstruct timing, seasonality, and surface fire behavior of past fires) and stand age structures (to reconstruct timing and spatial patterns of stand-opening fire events).

2) Spatial patterns in current forest demography; including dates of recruitment of living trees and death (or outside) dates of all extant remnant (dead) trees that are able to be sampled.

3) Spatial patterns in pre-fire-exclusion forest structure and openings *at spatial scales up to ½ ha*; including tree basal areas, stem densities, and spatial arrangement of trees and openings (including but not limited to: whether trees were regularly, randomly, or clumply distributed; number of trees in clumps; numbers of numbers not in clumps; numbers of clumps per unit area; the relative spatial extent of openings per unit area).

Methods
We will establish a network of 0.5 ha plots to reconstruct the above metrics. Plots will be grouped by landscape units clustered in or near areas scheduled for ongoing or future restoration treatments. Five to 10 plots will be randomly established in any one landscape unit.

Layout of 0.5 ha plots is shown in Figure 1. Plot center points will be determined as randomly generated GPS locations. Plot center points may be adjusted 50 m in cardinal directions once on the plot such that they are not crossing major changes in slope or aspect. Plot center points will be permanently marked, and northernmost trees in each quadrant (tree no. 1 in each) will be tagged to designate magnetic north at time of sampling. Data to be recorded for each plot will include: 1) date sampled and crew members; 2) plot center UTMs; 3) elevation at plot center (m); 4) slope (%); 5) aspect (degree); 6) slope position (valley bottom, bottom slope, middle slope, top slope, ridge top); 7) slope shape (concave, convex, straight); and 8) a general plot description. Four photos will be taken on cardinal directions from the plot center point.

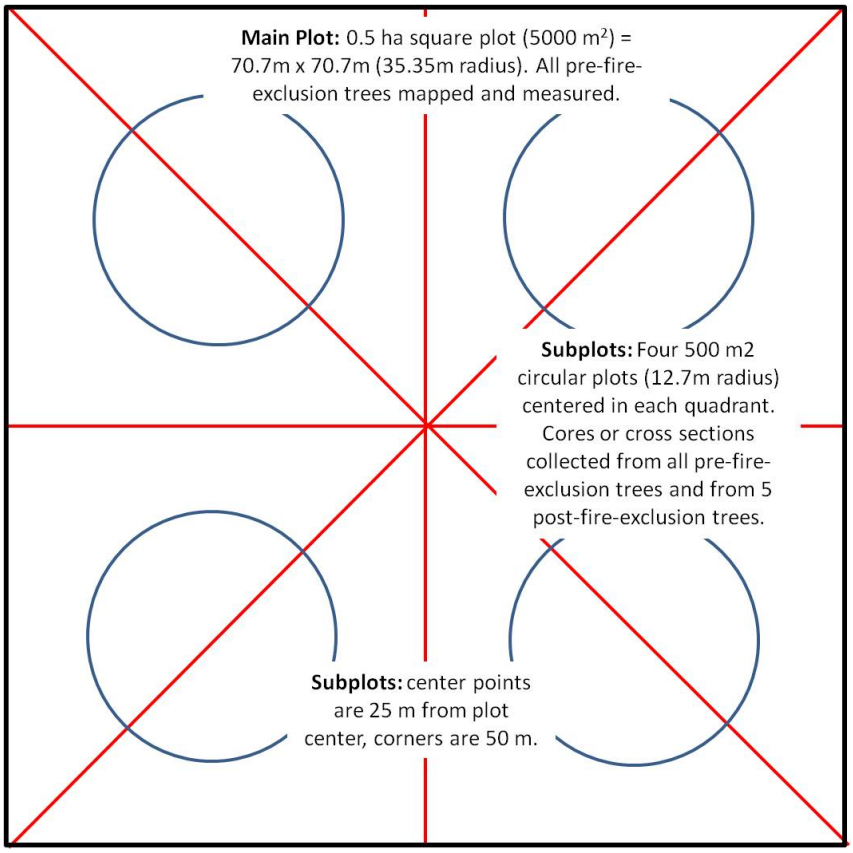
All pre-fire-exclusion trees will be mapped within each 0.5 ha plot. Pre-fire-exclusion trees are defined by one of three criteria: 1) living trees **≥ 25 cm** DBH; 2) additional living trees < 25 cm that exhibit old-age characteristics (as per Huckaby et al.); and 3) remnant trees (snags, logs, and stumps), excluding any recently dead trees < 25 cm DBH. Additional data to be collected for each pre-fire-exclusion tree include: 1) tree species; 2) status (Li = living, St = stump, Sn = snag, Lo = log); 3) DBH on living trees and DSH (diameter at sample height: 30 cm) on remnants;

and 4) any other notes about tree status (bark beetles, etc). DSH on remnants will be accompanied by condition class (remnant w/bark [Ba], remnant w/sapwood [Sa], remnant-eroded [Er]).

Stem mapping will be done by quadrant of the main plot. Quadrant centers will be determined as 25 m from plot center 45° from cardinal directions. In addition to quadrant centers, tapes will be extended to 50 m to the plot corner point that will be marked to assist in stem mapping. In each quadrant, trees will be mapped from the center of the quadrant starting with the northernmost tree and mapping clockwise with each tree numbered consecutively, accompanied by a quadrant letter designation. Quadrants are lettered clockwise from north: NE = A, SE = B, SW = C, NW = D. This will allow more than one quadrant to be mapped at the same time. Also mapped at the same time are the corners of the quadrant for later adjustment of the tree maps.

Four 500 m^2 circular subplots (12.7 m radius) will be established in the center of each quadrant (Figure 1) to collect additional data from all pre-fire-exclusion trees and from a subset of post-fire exclusion trees (i.e., <25 cm DBH). Within each subplot, all living pre-fire-exclusion trees will be cored at 30 cm stem height and cross sections will be cut from remnant trees that are able to be sampled (i.e., not too decayed) at 30 cm heights above estimated ground level. Final cores taken from each living tree should be no more than a field-estimated 10 rings from pith to minimize pith offset for assessing center dates (with maximum of four cores per any one tree; take the closest of the four as the sample for the tree). We will also collect cores from 5 of the nearest post-fire-exclusion (>4 cm and < 25 cm DBH) living trees to each subplot center point. Distance to the farthest of these trees from the subplot center point will be recorded for later conversion into stand structural estimates (tree densities and basal areas) for the post-settlement component. All living trees within the subplot will also be measured for DSH for later conversation of DSH to DBH on remnants trees. We will also measure tree height for at least one representative co-dominate tree in each subplot for site index estimate. A 5-cm soil core will also be collected from near each subplot center point and placed in a single labeled bag.

Cross sections also will be cut from any fire-scarred trees (living or dead) present in the 0.5 plot. We will also search around each plot center for additional fire-scarred trees. These will be sampled as encountered. In addition, fire-scarred trees will be opportunistically sampled as found while moving between plots. Sampled fire-scarred trees will be GPSed, and other data collected (species, DSH/DBH, height of sample cuts).



Equipment Needed:
GPS loaded with random plot points
Field data sheets (including some write-in-the-rain)(renew after each plot)
Tatum
PVC plot center stake (renew after each plot)
Hammer
Digital camera
5 50 m tapes
Compass
Chaining pins for subplot center points
12.7 m ropes for measuring subplot trees for coring/sections
Clinometer
Diameter calipers
Hypsometer
Increment borers (at least 3, more depending on crew)
Chainsaw and all safety gear (helmet, chaps, hearing protection)
WD-40 & steel wool (for cleaning borers)
Straws (renew as needed)
Straw tubes (2, empty straws and one for full cores)
Plastic wrap (for cross sections)(renew as needed)
Flagging (renew as needed)
Pin flags (renew as needed)
Aluminum tags and nails for northernmost trees (renew as needed)
Sharpies (renew as needed)
Pencils/pens (renew as needed)
Soil coring tool
Plastic bag for soil sample (renew as needed)

Specific methods:

1. Establish plot center. Plot can be moved 50 m on a cardinal direction from random coordinates to obtain uniform slope and aspect. Hammer in plot center stake. Record on plot data sheet: Plot number (four letter code: two-letter landscape unit code plus 2-number plot number); center point UTMs; date; crew members; start time (also record end time when done); center point elevation (if known; can be determined later from map); slope (percent); aspect (w/declination); slope position (valley bottom, bottom slope, middle slope, top slope, ridge top); slope shape (concave, convex, straight); general plot description. Take 4 photos on cardinal directions from plot center.
2. Layout four tapes 90° from each other on cardinal directions from plot center to 35.35m. Put in pin flag at tape end and flag nearest tree (for visibility while mapping). Layout fifth tape at 45° angle out to 25.0 m for each quadrant center point. Continue out to 50 for plot corner point; place pin flag and flag nearby tree (for visibility while mapping). Record GPS coordinates for each quadrant center point.
3. From each quadrant center point, record distance and azimuth using hypsometer for all pre-fire-exclusion trees (defined above) within quadrant, starting with northernmost tree 1 and moving clockwise. Also record for each tree: species; status; DBH (living trees) or DSH (remnants); and any other notes about tree condition. Place permanent tag on northernmost tree no. 1. Also map distance and azimuth to each corner of the quadrant.

4. For all trees within 12.7 m of the subplot center point, also collect either an increment core or cross section sample at 30 cm ht, and for living trees also record DSH. 12.7 m ropes can be used to determine which are subplot trees before mapping has occurred in the quadrant (cores can be placed in straws next to the subplot trees before numbering and collected after the quadrant has been mapped). Cores and sections are numbered by plot (two-letter landscape unit code plus two-number plot code), quadrant (NE = A, SE = B, SW = C, NW = D), and tree number. Also collect increment cores for the closest 5 living trees >4 cm to <25 cm DBH to plot center. Record dbh/dsh of all these 5 small trees and distance to farthest of the trees. Repeat for all quadrants.
5. Collect a cross section sample from any fire-scarred trees within the 0.5 ha plot. Sample will be mapped and numbered as part of the mapping effort. In addition, search surrounding area (out to ~100 m from plot center) for any other fire-scarred trees and cut cross sections from them. Record GPS coordinates, species, tree status, and cut height for any fire-scarred trees collected outside the plot; these are recorded as "F" trees on sample data sheets.
6. Collect top 5 cm of soil sample from each quadrant center point.