Study area characteristics for: Limited conifer regeneration, but widespread regeneration of aspen seedlings following the Cameron Peak Fire, northwestern Colorado

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# Characterize study area

To characterize the Cameron Peak Fire study area and understand how well our study sites represent the broader landscape, we sampled 10,000 random points across the area burned by the Cameron Peak Fire. We then extracted the climate, topographic, vegetation disturbance attributes at each sample point and our study sites.

# Read in elevation data  
dem <- rast(here("Data", "Spatial", "DEM", "DEM30.tif"))  
  
# Read in climate data  
prism\_set\_dl\_dir(here("Data", "Spatial", "PRISM"))  
  
#normals  
ppt.normal <- prism\_archive\_subset("ppt", "annual normals", resolution="800m") %>% pd\_to\_file() %>% rast()  
ppt.normal.678910 <- prism\_archive\_subset("ppt", "monthly normals", resolution="4km", mon=6:10) %>% pd\_to\_file() %>% rast() %>% sum()  
ppt.normal.111212345 <- prism\_archive\_subset("ppt", "monthly normals", resolution="4km", mon=c(1,2,3,4,5,11,12)) %>% pd\_to\_file() %>% rast() %>% sum()  
tmean.normal <- prism\_archive\_subset("tmean", "annual normals", resolution="800m") %>% pd\_to\_file() %>% rast()  
tmin.normal.1 <- prism\_archive\_subset("tmax", "monthly normals", resolution="4km", mon=1) %>% pd\_to\_file() %>% rast()  
tmax.normal.7 <- prism\_archive\_subset("tmax", "monthly normals", resolution="4km", mon=7) %>% pd\_to\_file() %>% rast()  
tmax.normal.678910 <- prism\_archive\_subset("tmax", "monthly normals", resolution="4km", mon=6:10) %>% pd\_to\_file() %>% rast() %>% mean()  
  
# weather 2021  
ppt.2021 <- prism\_archive\_subset("ppt", "annual", year=2021) %>% pd\_to\_file() %>% rast()  
ppt.2021.678910 <- prism\_archive\_subset("ppt", "monthly", year=2021, mon=6:10) %>% pd\_to\_file() %>% rast() %>% sum()  
ppt.2021.1112 <- prism\_archive\_subset("ppt", "monthly", year=2020, mon=11:12) %>% pd\_to\_file() %>% rast() %>% sum()  
ppt.2021.12345 <- prism\_archive\_subset("ppt", "monthly", year=2021, mon=1:5) %>% pd\_to\_file() %>% rast() %>% sum()  
ppt.2021.111212345 <- ppt.2021.1112 + ppt.2021.12345  
tmax.2021.678910 <- prism\_archive\_subset("tmax", "monthly", year=2021, mon=6:10) %>% pd\_to\_file() %>% rast() %>% mean()  
  
# weather 2022  
ppt.2022 <- prism\_archive\_subset("ppt", "annual",year=2022) %>% pd\_to\_file() %>% rast()  
ppt.2022.678910 <- prism\_archive\_subset("ppt", "monthly", year=2022, mon=6:10) %>% pd\_to\_file() %>% rast() %>% sum()  
ppt.2022.1112 <- prism\_archive\_subset("ppt", "monthly", year=2021, mon=11:12) %>% pd\_to\_file() %>% rast() %>% sum()  
ppt.2022.12345 <- prism\_archive\_subset("ppt", "monthly", year=2022, mon=1:5) %>% pd\_to\_file() %>% rast() %>% sum()  
ppt.2022.111212345 <- ppt.2022.1112 + ppt.2022.12345  
tmax.2022.678910 <- prism\_archive\_subset("tmax", "monthly", year=2022, mon=6:10) %>% pd\_to\_file() %>% rast() %>% mean()  
  
# Read in aspen data  
aspen <- rast(here("Data", "Spatial", "Aspen", "srme\_skcv\_distribution\_binopt.tif"))  
aspen.live <- rast(here("Data", "Spatial", "Aspen", "Aspen-live-highmod.tif"))  
aspen.live.distance <- rast(here("Data", "Spatial","Processed", "aspen-live-highmod-dist.tif"))  
aspen.prefire.distance <- rast(here("Data", "Spatial", "Processed", "aspen-dist.tif"))  
  
# Read in fire severity data  
severity <- rast(here('Data', 'Spatial', 'MTBS', 'mtbs\_CO\_2020.tif'))   
CameronPeak <- st\_read(here("Data", "Spatial", "MTBS", "mtbs\_perims\_DD.shp")) %>%   
 filter(Incid\_Name == "CAMERON PEAK") %>% # pull out just Cameron Peak  
 st\_transform(st\_crs(severity)) # transform

## Reading layer `mtbs\_perims\_DD' from data source   
## `/Users/sarahhart/Library/CloudStorage/GoogleDrive-sarahjanehart13@gmail.com/My Drive/JOB/RESEARCH/Analyses/PostfireAspen/Data/Spatial/MTBS/mtbs\_perims\_DD.shp'   
## using driver `ESRI Shapefile'  
## Simple feature collection with 30730 features and 22 fields  
## Geometry type: MULTIPOLYGON  
## Dimension: XY  
## Bounding box: xmin: -166.1885 ymin: 17.94736 xmax: -65.33821 ymax: 70.15893  
## Geodetic CRS: NAD83

CameronPeak.severity <- crop(severity, st\_bbox(CameronPeak ))  
CameronPeak.severity[CameronPeak.severity >=5] <-NA  
   
# Read in distance to low severity fire  
CameronPeak.severitylow.distance <- rast(here("Data", "Spatial", "Processed", "CameronPeak.severitylow-dist.tif"))  
  
# Read in bark beetle data  
bb.presence <- rast(here("Data", "Spatial", "Dryad", "Rodman", "Rodman et al. RS\_DataArchive", "Data", "SpatialData", "BBPresence\_finalMasked.tif"))  
bb.severity <- rast(here("Data", "Spatial", "Dryad", "Rodman", "Rodman et al. RS\_DataArchive", "Data", "SpatialData", "BBSeverity\_finalMasked.tif"))  
  
# Sample and characterize patterns  
## Cameron Peak   
CameronPeak.sample.pts <- spatSample(CameronPeak.severity, 10000, method="random", replace=FALSE, na.rm=T, as.points=TRUE, values=TRUE, cells=FALSE)   
CameronPeak.sample.pts <- extract(aspen, CameronPeak.sample.pts, bind=T)  
CameronPeak.sample.pts <- extract(CameronPeak.severitylow.distance, CameronPeak.sample.pts, bind=T)  
CameronPeak.sample.pts <- extract(aspen.prefire.distance, CameronPeak.sample.pts, bind=T)  
CameronPeak.sample.pts <- extract(aspen.live.distance, CameronPeak.sample.pts, bind=T)  
CameronPeak.sample.pts <- extract(CameronPeak.severitylow.distance, CameronPeak.sample.pts, bind=T)  
CameronPeak.sample.pts <- extract(dem, CameronPeak.sample.pts, bind=T)  
CameronPeak.sample.pts <- extract(ppt.normal, CameronPeak.sample.pts, bind=T)  
CameronPeak.sample.pts <- extract(ppt.normal.111212345, CameronPeak.sample.pts, bind=T)  
CameronPeak.sample.pts <- extract(ppt.normal.678910, CameronPeak.sample.pts, bind=T)  
CameronPeak.sample.pts <- extract(tmean.normal, CameronPeak.sample.pts, bind=T)  
CameronPeak.sample.pts <- extract(tmin.normal.1, CameronPeak.sample.pts, bind=T)  
CameronPeak.sample.pts <- extract(tmax.normal.7, CameronPeak.sample.pts, bind=T)  
CameronPeak.sample.pts <- extract(tmax.normal.678910, CameronPeak.sample.pts, bind=T)  
  
CameronPeak.sample.pts <- extract(ppt.2021, CameronPeak.sample.pts, bind=T)  
CameronPeak.sample.pts <- extract(ppt.2021.111212345, CameronPeak.sample.pts, bind=T)  
CameronPeak.sample.pts <- extract(ppt.2021.678910, CameronPeak.sample.pts, bind=T)  
CameronPeak.sample.pts <- extract(tmax.2021.678910, CameronPeak.sample.pts, bind=T)  
  
CameronPeak.sample.pts <- extract(ppt.2022, CameronPeak.sample.pts, bind=T)  
CameronPeak.sample.pts <- extract(ppt.2022.111212345, CameronPeak.sample.pts, bind=T)  
CameronPeak.sample.pts <- extract(ppt.2022.678910, CameronPeak.sample.pts, bind=T)  
CameronPeak.sample.pts <- extract(tmax.2022.678910, CameronPeak.sample.pts, bind=T)  
  
CameronPeak.sample.pts <- extract(bb.presence, CameronPeak.sample.pts, bind=T)  
CameronPeak.sample.pts <- extract(bb.severity, CameronPeak.sample.pts, bind=T)  
   
CameronPeak.sample.df <- CameronPeak.sample.pts %>% as.data.frame()  
colnames(CameronPeak.sample.df) <- c("severity","seedsource.dist", "aspen", "distance.pre", "distance.post", "distance.high", "elevation", "ppt", "ppt.111212345", "ppt.678910", "tmean", "tmin1", "tmax7", "tmax.678910", "ppt.2021", "ppt.111212345.2021", "ppt.678910.2021", "tmax.678910.2021", "ppt.2022", "ppt.111212345.2022", "ppt.678910.2022", "tmax.678910.2022", "bb.presence", "bb.severity")  
write.csv(CameronPeak.sample.df, here("Results", "CameronPeak-attributes.csv"))  
  
## Study sites  
sites <- read.csv(here("Data", "Dryad", "Site.csv")) %>%   
 dplyr::select("Site", "Easting", "Northing", "Aspect", "Slope")   
sites.sf <- sites %>% st\_as\_sf(coords = c("Easting", "Northing"), crs = "EPSG:32613")   
sites.sf <- extract(CameronPeak.severity, sites.sf, bind=T)  
sites.sf <- extract(CameronPeak.severitylow.distance, sites.sf, bind=T)  
sites.sf <- extract(aspen, sites.sf, bind=T)  
sites.sf <- extract(aspen.prefire.distance, sites.sf, bind=T)  
sites.sf <- extract(aspen.live.distance, sites.sf, bind=T)  
sites.sf <- extract(CameronPeak.severitylow.distance, sites.sf, bind=T)  
sites.sf <- extract(dem, sites.sf, bind=T)  
sites.sf <- extract(ppt.normal, sites.sf, bind=T)  
sites.sf <- extract(ppt.normal.111212345, sites.sf, bind=T)  
sites.sf <- extract(ppt.normal.678910, sites.sf, bind=T)  
sites.sf <- extract(tmean.normal, sites.sf, bind=T)  
sites.sf <- extract(tmin.normal.1, sites.sf, bind=T)  
sites.sf <- extract(tmax.normal.7, sites.sf, bind=T)  
sites.sf <- extract(tmax.normal.678910, sites.sf, bind=T)  
  
sites.sf <- extract(ppt.2021, sites.sf, bind=T)  
sites.sf <- extract(ppt.2021.111212345, sites.sf, bind=T)  
sites.sf <- extract(ppt.2021.678910, sites.sf, bind=T)  
sites.sf <- extract(tmax.2021.678910, sites.sf, bind=T)  
  
sites.sf <- extract(ppt.2022, sites.sf, bind=T)  
sites.sf <- extract(ppt.2022.111212345, sites.sf, bind=T)  
sites.sf <- extract(ppt.2022.678910, sites.sf, bind=T)  
sites.sf <- extract(tmax.2022.678910, sites.sf, bind=T)  
  
sites.sf <- extract(bb.presence, sites.sf, bind=T)  
sites.sf <- extract(bb.severity, sites.sf, bind=T)  
   
sites.df <- sites.sf %>% as.data.frame()  
colnames(sites.df) <- c("Site", "Aspect", "Slope","severity", "seedsource.dist", "aspen", "distance.pre", "distance.post", "distance.high", "elevation", "ppt", "ppt.111212345", "ppt.678910", "tmean", "tmin1", "tmax7", "tmax.678910", "ppt.2021", "ppt.111212345.2021", "ppt.678910.2021", "tmax.678910.2021", "ppt.2022", "ppt.111212345.2022", "ppt.678910.2022", "tmax.678910.2022", "bb.presence", "bb.severity")  
  
# Calc folded aspect  
sites.df$Longitude <- sites %>% st\_as\_sf(coords = c("Easting", "Northing"), crs = "EPSG:32613") %>% st\_transform(crs="epsg:4326") %>% st\_coordinates() %>% as.data.frame() %>% st\_drop\_geometry() %>% pull(X)  
sites.df$Latitude <- sites %>% st\_as\_sf(coords = c("Easting", "Northing"), crs = "EPSG:32613") %>% st\_transform(crs="epsg:4326") %>% st\_coordinates() %>% as.data.frame() %>% st\_drop\_geometry() %>% pull(Y)  
sites.df$FoldedAspect <- abs( 180 - abs(sites.df$Aspect-225))  
sites.df$PotentialDirRad <- -1.467+1.582\*cos(DegToRad(sites.df$Latitude))\*cos(DegToRad(sites.df$Slope))-1.5\*cos(sites.df$FoldedAspect)\* sin(DegToRad(sites.df$Slope))\*sin(DegToRad(sites.df$Latitude))-0.262\*sin(DegToRad(sites.df$Latitude))\*sin(DegToRad(sites.df$Slope))+0.607\* sin(sites.df$FoldedAspect)\*sin(DegToRad(sites.df$Slope))  
sites.df$HeatLoad <- exp(sites.df$PotentialDirRad )  
  
write.csv(sites.df, here("Results", "sites-attributes.csv"), row.names=F)

# References