#this code is part of the Short\_large\_fires project by Dr. R. Chelsea Nagy

# Here we import, project, intersect, organize data layers

# Key layers are the Short ignitions, level 3 ecoregions, mean monthly wind speed, mean monthly fuel moisture, biomass, and biophysical setting

# Libraries ---------------------------------------------------------------

library(tidyverse)

library(gridExtra)

library(raster)

library(rgdal)

library(sf)

library(lubridate)

library(ncdf4)

library(doParallel)

library(foreach)

# To be used in the parallelized sections of the code

UseCores <- detectCores() -1

# set projections

#EPSG:102003 USA\_Contiguous\_Albers\_Equal\_Area\_Conic

proj\_ea <- "+proj=aea +lat\_1=29.5 +lat\_2=45.5 +lat\_0=37.5 +lon\_0=-96 +x\_0=0 +y\_0=0 +datum=NAD83 +units=m +no\_defs"

#EPSG:102005 USA\_Contiguous\_Equidistant\_Conic

proj\_ed <- "+proj=eqdc +lat\_0=39 +lon\_0=-96 +lat\_1=33 +lat\_2=45 +x\_0=0 +y\_0=0 +datum=NAD83 +units=m +no\_defs"

#WGS 84 the gridmet projection

proj\_ll <- "+proj=longlat +datum=WGS84 +no\_defs +ellps=WGS84 +towgs84=0,0,0"

# import data layers -------------------------------------------------------

#Import the USA States layer

#usa\_shp <- st\_read(dsn = paste0("data/raw/conus"),

#layer = "cb\_2016\_us\_state\_20m", quiet= TRUE) %>%

#st\_transform(., proj\_ea) %>%

#subset(., NAME != "Alaska" &

#NAME != "Hawaii" &

#NAME != "Puerto Rico") %>%

#mutate(area\_m2 = as.numeric(st\_area(geometry)),

#StArea\_km2 = area\_m2/1000000,

#group = 1) %>%

#st\_simplify(., preserveTopology = TRUE)

#plot(usa\_shp[5])

# Dissolve to the USA Boundary

#conus <- usa\_shp %>%

#group\_by(group) %>%

#st\_union()

#plot(conus)

# Import the Level 3 Ecoregions

eco = paste0("data/raw/us\_eco\_l3")

ecoreg <- st\_read(dsn = eco, layer = "us\_eco\_l3", quiet= TRUE) %>%

st\_transform(., proj\_ea) %>%

st\_simplify(., preserveTopology = TRUE, dTolerance = 1000) %>%

mutate(area\_m2 = as.numeric(st\_area(geometry)),

EcoArea\_km2 = area\_m2/1000000)

plot(ecoreg[2])

# Intersects states with ecoregions

#state\_eco <- st\_intersection(usa\_shp, ecoreg) %>%

#dplyr::select(STUSPS, NAME, StArea\_km2, US\_L3CODE, US\_L3NAME, EcoArea\_km2, NA\_L2NAME, NA\_L1CODE, NA\_L1NAME, geometry)

#plot(state\_eco[2])

# Read the FPA (Short) database class

shrt\_fire <- st\_read(dsn = paste0("data/raw/fpa-fod/Data/FPA\_FOD\_20170508.gdb"),

layer = "Fires", quiet= TRUE) %>%

st\_transform(., proj\_ea) %>%

filter(STATE != "AK" & STATE != "PR" & STATE != "HI" & FIRE\_SIZE >= 0.01) %>%

dplyr::select(FPA\_ID, LATITUDE, LONGITUDE, ICS\_209\_INCIDENT\_NUMBER, ICS\_209\_NAME, MTBS\_ID, MTBS\_FIRE\_NAME,

FIRE\_YEAR, DISCOVERY\_DATE, DISCOVERY\_DOY, STAT\_CAUSE\_DESCR, FIRE\_SIZE, STATE) %>%

mutate(IGNITION = ifelse(STAT\_CAUSE\_DESCR == "Lightning", "Lightning", "Human"),

FIRE\_SIZE\_m2 = FIRE\_SIZE\*4046.86,

FIRE\_SIZE\_km2 = FIRE\_SIZE\_m2/1000000,

FIRE\_SIZE\_ha = FIRE\_SIZE\_m2\*10000,

DISCOVERY\_DAY = day(DISCOVERY\_DATE),

DISCOVERY\_MONTH = month(DISCOVERY\_DATE),

DISCOVERY\_YEAR = FIRE\_YEAR)

# add a column to indicate whether the fire id (FPA\_ID) is duplicated

shrt\_fire <- shrt\_fire %>%

mutate(is\_id\_duplicated = duplicated(FPA\_ID))

stopifnot(sum(shrt\_fire$is\_id\_duplicated) == 3)

# ensure that duplicated fire ids get modified to be unique

shrt\_fire <- shrt\_fire %>%

mutate(row\_id = 1:n(),

clean\_id = ifelse(is\_id\_duplicated,

paste(FPA\_ID, row\_id, sep = "\_"),

FPA\_ID)) %>%

dplyr::select(-row\_id)

# verify that clean\_id is a unique identifier (no repeats)

stopifnot(!any(duplicated(shrt\_fire$clean\_id)))

#Extract average monthly wind data to Short ------------------------------------------------

#Bring in average monthly wind data

wind\_dl <- list.files(paste0("data/climate/ws/ws/"), pattern = "tif", full.names = TRUE)

wind <- lapply(wind\_dl, raster)

shrt\_jan <- shrt\_fire %>%

subset(DISCOVERY\_MONTH == "1") %>%

st\_transform(., proj\_ll)

shrt\_jan <- as(shrt\_jan, "Spatial")

wind\_jan <- raster::extract(wind[[5]],

shrt\_jan, sp = TRUE)

wind\_jan <- st\_as\_sf(wind\_jan) %>%

mutate(Wind = vs\_Jan) %>%

dplyr::select(-starts\_with("vs\_"))

shrt\_feb <- shrt\_fire %>%

subset(DISCOVERY\_MONTH == "2") %>%

st\_transform(., proj\_ll)

shrt\_feb <- as(shrt\_feb, "Spatial")

wind\_feb <- raster::extract(wind[[4]],

shrt\_feb, sp = TRUE)

wind\_feb <- st\_as\_sf(wind\_feb) %>%

mutate(Wind = vs\_Feb) %>%

dplyr::select(-starts\_with("vs\_"))

shrt\_mar <- shrt\_fire %>%

subset(DISCOVERY\_MONTH == "3") %>%

st\_transform(., proj\_ll)

shrt\_mar <- as(shrt\_mar, "Spatial")

wind\_mar <- raster::extract(wind[[8]],

shrt\_mar, sp = TRUE)

wind\_mar <- st\_as\_sf(wind\_mar) %>%

mutate(Wind = vs\_Mar) %>%

dplyr::select(-starts\_with("vs\_"))

shrt\_apr <- shrt\_fire %>%

subset(DISCOVERY\_MONTH == "4") %>%

st\_transform(., proj\_ll)

shrt\_apr <- as(shrt\_apr, "Spatial")

wind\_apr <- raster::extract(wind[[1]],

shrt\_apr, sp = TRUE)

wind\_apr <- st\_as\_sf(wind\_apr) %>%

mutate(Wind = vs\_Apr) %>%

dplyr::select(-starts\_with("vs\_"))

shrt\_may <- shrt\_fire %>%

subset(DISCOVERY\_MONTH == "5") %>%

st\_transform(., proj\_ll)

shrt\_may <- as(shrt\_may, "Spatial")

wind\_may <- raster::extract(wind[[9]],

shrt\_may, sp = TRUE)

wind\_may <- st\_as\_sf(wind\_may) %>%

mutate(Wind = vs\_May) %>%

dplyr::select(-starts\_with("fm100\_"))

shrt\_jun <- shrt\_fire %>%

subset(DISCOVERY\_MONTH == "6") %>%

st\_transform(., proj\_ll)

shrt\_jun <- as(shrt\_jun, "Spatial")

wind\_jun <- raster::extract(wind[[7]],

shrt\_jun, sp = TRUE)

wind\_jun <- st\_as\_sf(wind\_jun) %>%

mutate(Wind = vs\_Jun) %>%

dplyr::select(-starts\_with("vs\_"))

shrt\_jul <- shrt\_fire %>%

subset(DISCOVERY\_MONTH == "7") %>%

st\_transform(., proj\_ll)

shrt\_jul <- as(shrt\_jul, "Spatial")

wind\_jul <- raster::extract(wind[[6]],

shrt\_jul, sp = TRUE)

wind\_jul <- st\_as\_sf(wind\_jul) %>%

mutate(Wind = vs\_Jul) %>%

dplyr::select(-starts\_with("vs\_"))

shrt\_aug <- shrt\_fire %>%

subset(DISCOVERY\_MONTH == "8") %>%

st\_transform(., proj\_ll)

shrt\_aug <- as(shrt\_aug, "Spatial")

wind\_aug <- raster::extract(wind[[2]],

shrt\_aug, sp = TRUE)

wind\_aug <- st\_as\_sf(wind\_aug) %>%

mutate(Wind = vs\_Aug) %>%

dplyr::select(-starts\_with("vs\_"))

shrt\_sep <- shrt\_fire %>%

subset(DISCOVERY\_MONTH == "9") %>%

st\_transform(., proj\_ll)

shrt\_sep <- as(shrt\_sep, "Spatial")

wind\_sep <- raster::extract(wind[[12]],

shrt\_sep, sp = TRUE)

wind\_sep <- st\_as\_sf(wind\_sep) %>%

mutate(Wind = vs\_Sep) %>%

dplyr::select(-starts\_with("vs\_"))

shrt\_oct <- shrt\_fire %>%

subset(DISCOVERY\_MONTH == "10") %>%

st\_transform(., proj\_ll)

shrt\_oct <- as(shrt\_oct, "Spatial")

wind\_oct <- raster::extract(wind[[11]],

shrt\_oct, sp = TRUE)

wind\_oct <- st\_as\_sf(wind\_oct) %>%

mutate(Wind = vs\_Oct) %>%

dplyr::select(-starts\_with("vs\_"))

shrt\_nov <- shrt\_fire %>%

subset(DISCOVERY\_MONTH == "11") %>%

st\_transform(., proj\_ll)

shrt\_nov <- as(shrt\_nov, "Spatial")

wind\_nov <- raster::extract(wind[[10]],

shrt\_nov, sp = TRUE)

wind\_nov <- st\_as\_sf(wind\_nov) %>%

mutate(Wind = vs\_Nov) %>%

dplyr::select(-starts\_with("vs\_"))

shrt\_dec <- shrt\_fire %>%

subset(DISCOVERY\_MONTH == "12") %>%

st\_transform(., proj\_ll)

shrt\_dec <- as(shrt\_dec, "Spatial")

wind\_dec <- raster::extract(wind[[3]],

shrt\_dec, sp = TRUE)

wind\_dec <- st\_as\_sf(wind\_dec) %>%

mutate(Wind = vs\_Dec) %>%

dplyr::select(-starts\_with("vs\_"))

shrt\_wind <- wind\_jan %>%

bind\_rows(., wind\_feb) %>%

bind\_rows(., wind\_mar) %>%

bind\_rows(., wind\_apr) %>%

bind\_rows(., wind\_may) %>%

bind\_rows(., wind\_jun) %>%

bind\_rows(., wind\_jul) %>%

bind\_rows(., wind\_aug) %>%

bind\_rows(., wind\_sep) %>%

bind\_rows(., wind\_oct) %>%

bind\_rows(., wind\_nov) %>%

bind\_rows(., wind\_dec)

str(shrt\_wind)

#make into a data frame

shrt\_wind\_df <- as.data.frame(shrt\_wind) %>%

dplyr::select("clean\_id", "Wind")

#Extract average monthly fuel moisture data to Short ------------------------------------------------

#Bring in average monthly fuel moisture data

fm\_dl <- list.files(paste0("data/climate/fm/fm100/"), pattern = "tif", full.names = TRUE)

fm <- lapply(fm\_dl, raster)

shrt\_jan <- shrt\_fire %>%

subset(DISCOVERY\_MONTH == "1") %>%

st\_transform(., proj\_ll)

shrt\_jan <- as(shrt\_jan, "Spatial")

fm\_jan <- raster::extract(fm[[5]],

shrt\_jan, sp = TRUE)

fm\_jan <- st\_as\_sf(fm\_jan) %>%

mutate(fm = fm100\_Jan) %>%

dplyr::select(-starts\_with("fm100"))

shrt\_feb <- shrt\_fire %>%

subset(DISCOVERY\_MONTH == "2") %>%

st\_transform(., proj\_ll)

shrt\_feb <- as(shrt\_feb, "Spatial")

fm\_feb <- raster::extract(fm[[4]],

shrt\_feb, sp = TRUE)

fm\_feb <- st\_as\_sf(fm\_feb) %>%

mutate(fm = fm100\_Feb) %>%

dplyr::select(-starts\_with("fm100"))

shrt\_mar <- shrt\_fire %>%

subset(DISCOVERY\_MONTH == "3") %>%

st\_transform(., proj\_ll)

shrt\_mar <- as(shrt\_mar, "Spatial")

fm\_mar <- raster::extract(fm[[8]],

shrt\_mar, sp = TRUE)

fm\_mar <- st\_as\_sf(fm\_mar) %>%

mutate(fm = fm100\_Mar) %>%

dplyr::select(-starts\_with("fm100"))

shrt\_apr <- shrt\_fire %>%

subset(DISCOVERY\_MONTH == "4") %>%

st\_transform(., proj\_ll)

shrt\_apr <- as(shrt\_apr, "Spatial")

fm\_apr <- raster::extract(fm[[1]],

shrt\_apr, sp = TRUE)

fm\_apr <- st\_as\_sf(fm\_apr) %>%

mutate(fm = fm100\_Apr) %>%

dplyr::select(-starts\_with("fm100\_"))

shrt\_may <- shrt\_fire %>%

subset(DISCOVERY\_MONTH == "5") %>%

st\_transform(., proj\_ll)

shrt\_may <- as(shrt\_may, "Spatial")

fm\_may <- raster::extract(fm[[9]],

shrt\_may, sp = TRUE)

fm\_may <- st\_as\_sf(fm\_may) %>%

mutate(fm = fm100\_May) %>%

dplyr::select(-starts\_with("fm100\_"))

shrt\_jun <- shrt\_fire %>%

subset(DISCOVERY\_MONTH == "6") %>%

st\_transform(., proj\_ll)

shrt\_jun <- as(shrt\_jun, "Spatial")

fm\_jun <- raster::extract(fm[[7]],

shrt\_jun, sp = TRUE)

fm\_jun <- st\_as\_sf(fm\_jun) %>%

mutate(fm = fm100\_Jun) %>%

dplyr::select(-starts\_with("fm100\_"))

shrt\_jul <- shrt\_fire %>%

subset(DISCOVERY\_MONTH == "7") %>%

st\_transform(., proj\_ll)

shrt\_jul <- as(shrt\_jul, "Spatial")

fm\_jul <- raster::extract(fm[[6]],

shrt\_jul, sp = TRUE)

fm\_jul <- st\_as\_sf(fm\_jul) %>%

mutate(fm = fm100\_Jul) %>%

dplyr::select(-starts\_with("fm100\_"))

shrt\_aug <- shrt\_fire %>%

subset(DISCOVERY\_MONTH == "8") %>%

st\_transform(., proj\_ll)

shrt\_aug <- as(shrt\_aug, "Spatial")

fm\_aug <- raster::extract(fm[[2]],

shrt\_aug, sp = TRUE)

fm\_aug <- st\_as\_sf(fm\_aug) %>%

mutate(fm = fm100\_Aug) %>%

dplyr::select(-starts\_with("fm100\_"))

shrt\_sep <- shrt\_fire %>%

subset(DISCOVERY\_MONTH == "9") %>%

st\_transform(., proj\_ll)

shrt\_sep <- as(shrt\_sep, "Spatial")

fm\_sep <- raster::extract(fm[[12]],

shrt\_sep, sp = TRUE)

fm\_sep <- st\_as\_sf(fm\_sep) %>%

mutate(fm = fm100\_Sep) %>%

dplyr::select(-starts\_with("fm100\_"))

shrt\_oct <- shrt\_fire %>%

subset(DISCOVERY\_MONTH == "10") %>%

st\_transform(., proj\_ll)

shrt\_oct <- as(shrt\_oct, "Spatial")

fm\_oct <- raster::extract(fm[[11]],

shrt\_oct, sp = TRUE)

fm\_oct <- st\_as\_sf(fm\_oct) %>%

mutate(fm = fm100\_Oct) %>%

dplyr::select(-starts\_with("fm100\_"))

shrt\_nov <- shrt\_fire %>%

subset(DISCOVERY\_MONTH == "11") %>%

st\_transform(., proj\_ll)

shrt\_nov <- as(shrt\_nov, "Spatial")

fm\_nov <- raster::extract(fm[[10]],

shrt\_nov, sp = TRUE)

fm\_nov <- st\_as\_sf(fm\_nov) %>%

mutate(fm = fm100\_Nov) %>%

dplyr::select(-starts\_with("fm100\_"))

shrt\_dec <- shrt\_fire %>%

subset(DISCOVERY\_MONTH == "12") %>%

st\_transform(., proj\_ll)

shrt\_dec <- as(shrt\_dec, "Spatial")

fm\_dec <- raster::extract(fm[[3]],

shrt\_dec, sp = TRUE)

fm\_dec <- st\_as\_sf(fm\_dec) %>%

mutate(fm = fm100\_Dec) %>%

dplyr::select(-starts\_with("fm100\_"))

shrt\_fm <- fm\_jan %>%

bind\_rows(., fm\_feb) %>%

bind\_rows(., fm\_mar) %>%

bind\_rows(., fm\_apr) %>%

bind\_rows(., fm\_may) %>%

bind\_rows(., fm\_jun) %>%

bind\_rows(., fm\_jul) %>%

bind\_rows(., fm\_aug) %>%

bind\_rows(., fm\_sep) %>%

bind\_rows(., fm\_oct) %>%

bind\_rows(., fm\_nov) %>%

bind\_rows(., fm\_dec)

#make into a dataframe

shrt\_fm\_df <- as.data.frame(shrt\_fm)

# %>% dplyr::select("FPA\_ID", "fm", "clean\_id", "NA\_L3NAME")

#merge wind, fm, Short

shrt\_wind\_fm <- left\_join(shrt\_wind\_df, shrt\_fm\_df, by = "clean\_id")

head(shrt\_wind\_fm)

##################################

# Import biomass data ----------------------------------------------------

bio <- raster(paste0("data/raw/NBCD\_countrywide\_biomass\_mosaic/NBCD\_countrywide\_biomass\_mosaic.tif"))

# extract biomass to short data

shrt\_bio <- raster::extract(bio, as(shrt\_fire, "Spatial"), sp = TRUE)

#convert to dataframe

shrt\_bio\_df <-as.data.frame(shrt\_bio) %>%

dplyr::select("clean\_id", "NBCD\_countrywide\_biomass\_mosaic")

#join with shrt\_wind\_fm

shrt\_clim\_bio <- left\_join(shrt\_wind\_fm, shrt\_bio\_df, by = "clean\_id")

###

#output in case bps crashes it

#this did not work

write.table(shrt\_clim\_bio, "data/merged/shrt\_clim\_bio.csv", sep=",", row.names=FALSE)

#this did not work

library(maptools)

writeSpatialShape(shrt\_clim\_bio, "data/merged/shrt\_clim\_bio.shp")

###

##################################

#Add ecoregion to Short data and join with other data

fire\_eco <- st\_intersection(shrt\_fire, ecoreg)

#this runs forever

fire\_eco\_df <-as.data.frame(fire\_eco) %>%

dplyr::select("clean\_id", "NA\_L3CODE","NA\_L3NAME","NA\_L1CODE","NA\_L1NAME","EcoArea\_km2")

#join with shrt\_clim\_bio

shrt\_clim\_bio\_eco <- left\_join(shrt\_clim\_bio, fire\_eco\_df, by = "clean\_id")

##################################

# Import biophysical setting ---------------------------------------------

bps.ref <- "+proj=aea +lat\_1=29.5 +lat\_2=45.5 +lat\_0=23 +lon\_0=-96 +x\_0=0 +y\_0=0 +ellps=GRS80 +towgs84=0,0,0,0,0,0,0 +units=m +no\_defs"

bps <- raster(paste0("data/raw/us\_130bps/grid/us\_130bps"))

#bps\_trans <- st\_transform(bps, proj\_ea)

#Nate's code to transform and extract

shrt\_bps <- shrt\_fire %>%

st\_transform(., bps.ref)

shrt\_bps <- raster::extract(bps, as(shrt\_fire, "Spatial"), sp = TRUE)

shrt\_bps <- st\_transform(shrt\_bps, proj\_ea)

#this runs forever

#convert to dataframe

#change variable name here to bps variable name (instead of biomass)

shrt\_bps\_df <-as.data.frame(shrt\_bps) %>%

dplyr::select("clean\_id", "NBCD\_countrywide\_biomass\_mosaic")

#join with shrt\_wind\_fm

shrt\_clim\_veg\_eco <- left\_join(shrt\_clim\_bio\_eco, shrt\_bps, by = "clean\_id")

######################

#do not need below????

#need to join shrt\_veg , shrt\_wind, shrt\_fm plus ecoreg to one master dataset with all extracted variables

#start with shrt\_wind and shrt\_fm

#try left\_join.sf

#this did not work

shrt\_wind\_fm <- left\_join.sf(shrt\_wind, shrt\_fm\_df, by = "FPA\_ID")

shrt\_wind\_fm <- left\_join.sf(shrt\_wind, shrt\_fm\_df, by = "FPA\_ID")

# check for NA values in the input data frames

mean(is.na(shrt\_wind\_df$Wind))

mean(is.na(shrt\_fm\_df$fm))

# convert the sf object to a data frame, then try to merge

merged <- shrt\_wind\_df %>%

left\_join(shrt\_fm\_df)

View(merged)

any(duplicated(merged$FPA\_ID))

any(duplicated(shrt\_wind\_df$FPA\_ID))

any(duplicated(shrt\_fm\_df$FPA\_ID))

shrt\_wind\_df[duplicated(shrt\_wind\_df$FPA\_ID), ]

shrt\_wind\_df %>%

filter(FPA\_ID == "ICS209\_2009\_KS-DDQ-128")

merged %>%

filter(FPA\_ID == "ICS209\_2009\_KS-DDQ-128")

all(unique(shrt\_wind\_df$FPA\_ID) == unique(shrt\_fm\_df$FPA\_ID))

all(levels(shrt\_wind$FPA\_ID) == levels(shrt\_fm\_df$FPA\_ID))

#try st\_join

#this did not work

shrt\_clm<-st\_join(shrt\_wind, shrt\_fm\_df, left = TRUE, by = "FPA\_ID")

shrt\_clm<-st\_join(shrt\_wind, shrt\_fm, left = TRUE)

shrt\_clm<-st\_join(shrt\_wind\_df, shrt\_fm\_df, left = TRUE, by = "FPA\_ID")

######################

# Subset the FPA data to large fires (90th%tile) ---------------------------------------

cl <- makeCluster(UseCores)

lrg\_shrt\_fire <- foreach(i = 1:NROW(shrt\_clim\_veg\_eco)) %dopar% {

st\_intersection(shrt\_clim\_veg\_eco[i], ecoreg)} das

stopCluster(cl)

tt3<-unique(lrg\_shrt\_fire$L3CODE)

output=NULL

for (i in tt3) {

subby<-shrt\_clim\_veg\_eco[shrt\_clim\_veg\_eco$L3CODE==i,]

ninety<-subset(subby, FIRE\_SIZE\_ha >= quantile(FIRE\_SIZE\_ha, 0.90))

outputy<-rbind(outputy,data.frame(ninety[,]))

}