Lab 5 Oregon Fires

Ali Carmichael

Conservation/ecology Topics

- Explore how Oregon fires are changing due to fire suppression and climate change.
- Describe fundamental concepts in fire ecology, including fire severity.

Statistical Topics

- Describe the fundamental attributes of a raster dataset.

Computational Topics

- Explore raster attributes and metadata using R.
- Import rasters into R using the `terra` package.
- Plot raster files in R using the `ggplot2` package.
- Reproject raster and vector data
- Layer raster and vector data together

Lab part 1: reading in fire raster data and plotting

We will be working with the soil burn severity data from the 2020 Holiday Farm Fire (up the McKenzie E of Eugene), the 2020 Beachie Fire (near Portland) and the 2018 Terwilliger fire (up the McKenzie E of Eugene, near Cougar hotsprings).

We will use data downloaded from the USGS: https://burnseverity.cr.usgs.gov/products/baer

Specifically, BARC Fire Severity layers are created by first calculating spectral indices from pre- and post-fire satellite imagery that are sensitive to changes caused by fire. The two images are then subtracted showing the difference between them which is then binned into 4 burn severity classes (high, moderate, low, very low/unburned). Field crews ground-truth the severity classes.

The metadata files provide additional details on how the continuous data was binned into discrete catagories.

a. Read in each fire severity rasters, name them [fire name]_rast. The .tif files are the rasters.

HINT: The files are nested within folders so be aware of your file paths.

```r
terwilliger_rast <- rast("soil-burn-severity/2018_terwilliger_sbs/SoilSeverity.tif")
beachie_rast <- rast("soil-burn-severity/2020_beachiecreek_sbs/BeachieCreek_SBS_final.tif")
holiday_rast <- rast("soil-burn-severity/2020_holidayfarm_sbs/HolidayFarm_SBS_final.tif")
```

```r
#terwilliger_rast
#beachiecreek_rast
#holidayfarm_rast
```

b. Summarize the values of the rasters. Take note of the labels associated with the data values because you will need it for plotting.

```r
summary(values(terwilliger_rast))
```

```
##    SoilBurnSe
##  Min.   :1.00
##  1st Qu.:2.00
##  Median :2.00
##  Mean   :1.92
##  3rd Qu.:2.00
##  Max.   :4.00
##  NA's   :80287
```

```r
summary(values(beachie_rast))
```

```
##     Layer_1
##  Min.   :  1.00
##  1st Qu.:  3.00
##  Median :127.00
##  Mean   : 71.77
##  3rd Qu.:127.00
##  Max.   :127.00
```

```r
summary(values(holiday_rast))
```

```
##     Layer_1
##  Min.   :  1.00
##  1st Qu.:  3.00
##  Median :  4.00
##  Mean   : 60.83
##  3rd Qu.:127.00
##  Max.   :127.00
```

c. Plot each raster.. Set the scale to be `scale_fill_brewer(palette = "Spectral", direction=-1)`

HINT: Remember we have to turn them into "data.frames" for ggplot to recognize them as plot-able.

HINT HINT: Remember to check the labels of the data values to be able to set the fill.

```r
terwilliger_df <- as.data.frame(terwilliger_rast, xy = TRUE)

str(terwilliger_df)
```

```
## 'data.frame':    51544 obs. of  3 variables:
##  $ x         : num  419860 419890 419920 419950 420340 ...
##  $ y         : num  1119923 1119923 1119923 1119923 1119923 ...
##  $ SoilBurnSe: Factor w/ 4 levels "Unburned","Low",..: 1 2 1 2 2 2 1 2 1 1 ...
```

```r
ggplot() +
 geom_raster(data = terwilliger_df, aes(x = x, y = y,
                                        fill = SoilBurnSe)) +
    scale_fill_brewer(palette = "Spectral", direction=-1) +
    theme_minimal() +
  labs(
    title = "Terwilliger Fire",
  )
```

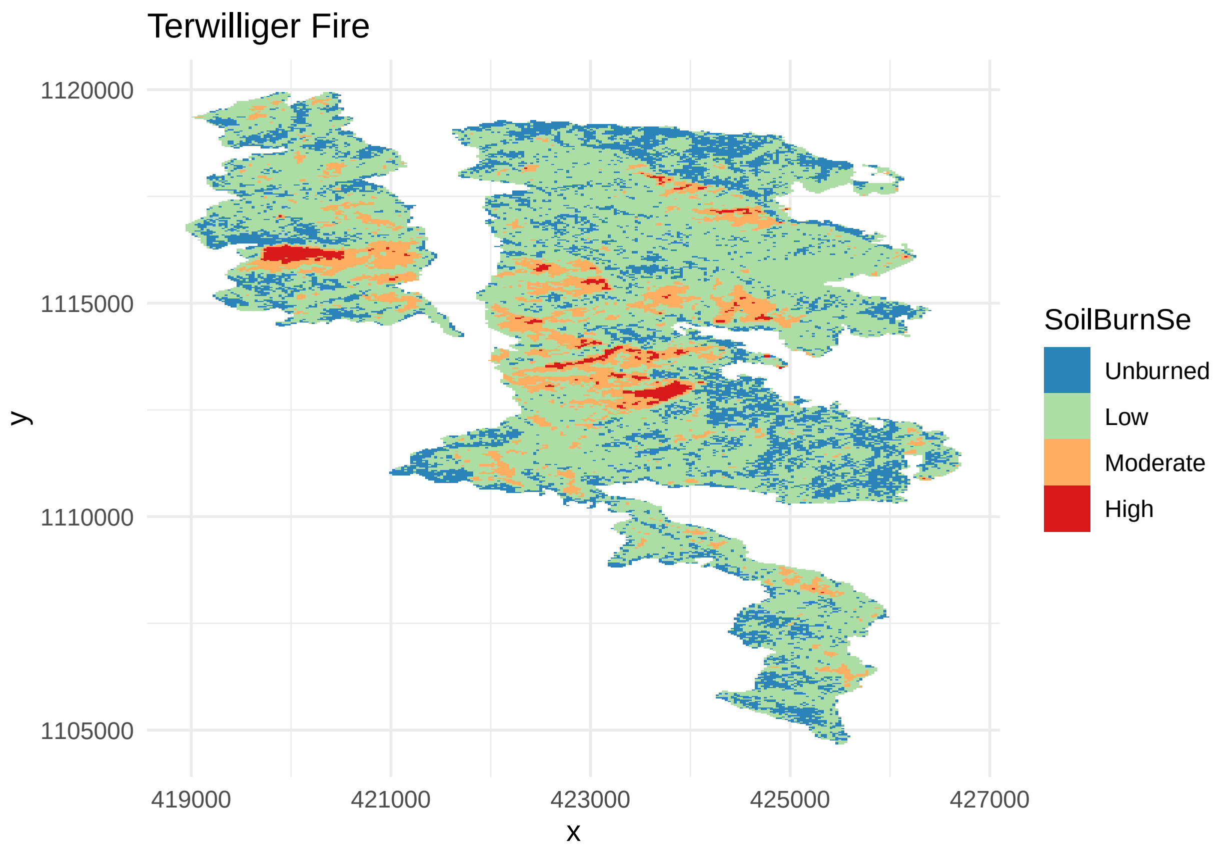


Figure 1: Terwilliger plot with ggplot2 using the Spectral color scale

```r
beachie_df <- as.data.frame(beachie_rast, xy = TRUE)

str(beachie_df)
```

```
## 'data.frame':    1948877 obs. of  3 variables:
##  $ x      : num  395819 395839 395859 395879 395899 ...
##  $ y      : num  1221232 1221232 1221232 1221232 1221232 ...
##  $ Layer_1: Factor w/ 127 levels "0","1","2","3",..: 3 3 3 3 3 3 3 3 3 3 ...
```

```r
ggplot() +
 geom_raster(data = beachie_df, aes(x = x, y = y,
                                    fill = Layer_1)) +
```

```
    scale_fill_brewer(palette = "Spectral", direction=-1) +
    theme_minimal() +
  labs(
    title = "Beachie Creek Fire",
  )
```

```
## Warning: Raster pixels are placed at uneven horizontal intervals and will be shifted
## i Consider using 'geom_tile()' instead.
```

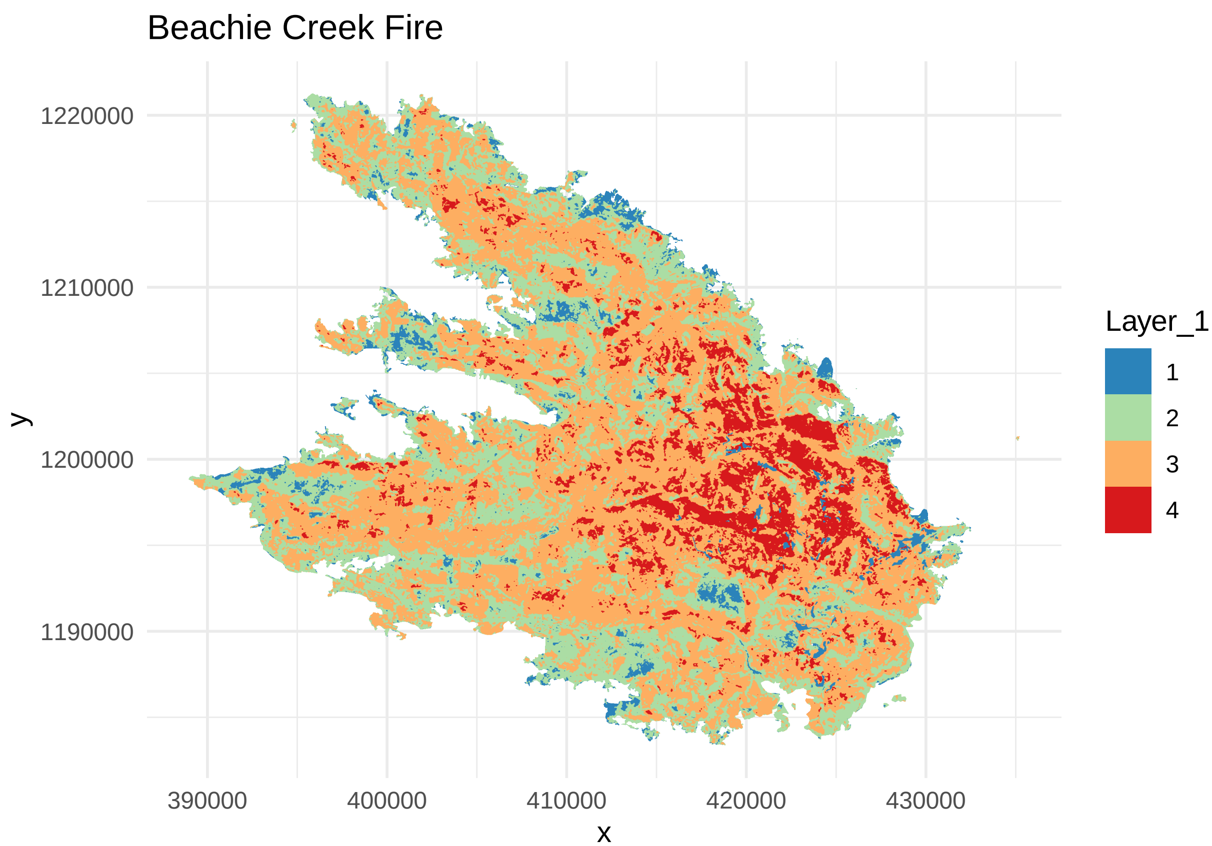


Figure 2: Beachie plot with ggplot2 using the Spectral color scale

```
holiday_df <- as.data.frame(holiday_rast, xy = TRUE)

str(holiday_df)
```

```
## 'data.frame':    1750770 obs. of  3 variables:
##  $ x      : num  541078 541098 541118 541138 541158 ...
##  $ y      : num  4903324 4903324 4903324 4903324 4903324 ...
##  $ Layer_1: Factor w/ 127 levels "0","1","2","3",..: 2 2 2 2 2 2 2 2 2 2 ...
```

```
ggplot() +
 geom_raster(data = holiday_df, aes(x = x, y = y,
                                    fill = Layer_1)) +
```

```r
    scale_fill_brewer(palette = "Spectral", direction=-1) +
  theme_minimal() +
  labs(
    title = "Holiday Farm Fire",
  )
```

```
## Warning: Raster pixels are placed at uneven horizontal intervals and will be shifted
## i Consider using 'geom_tile()' instead.
```

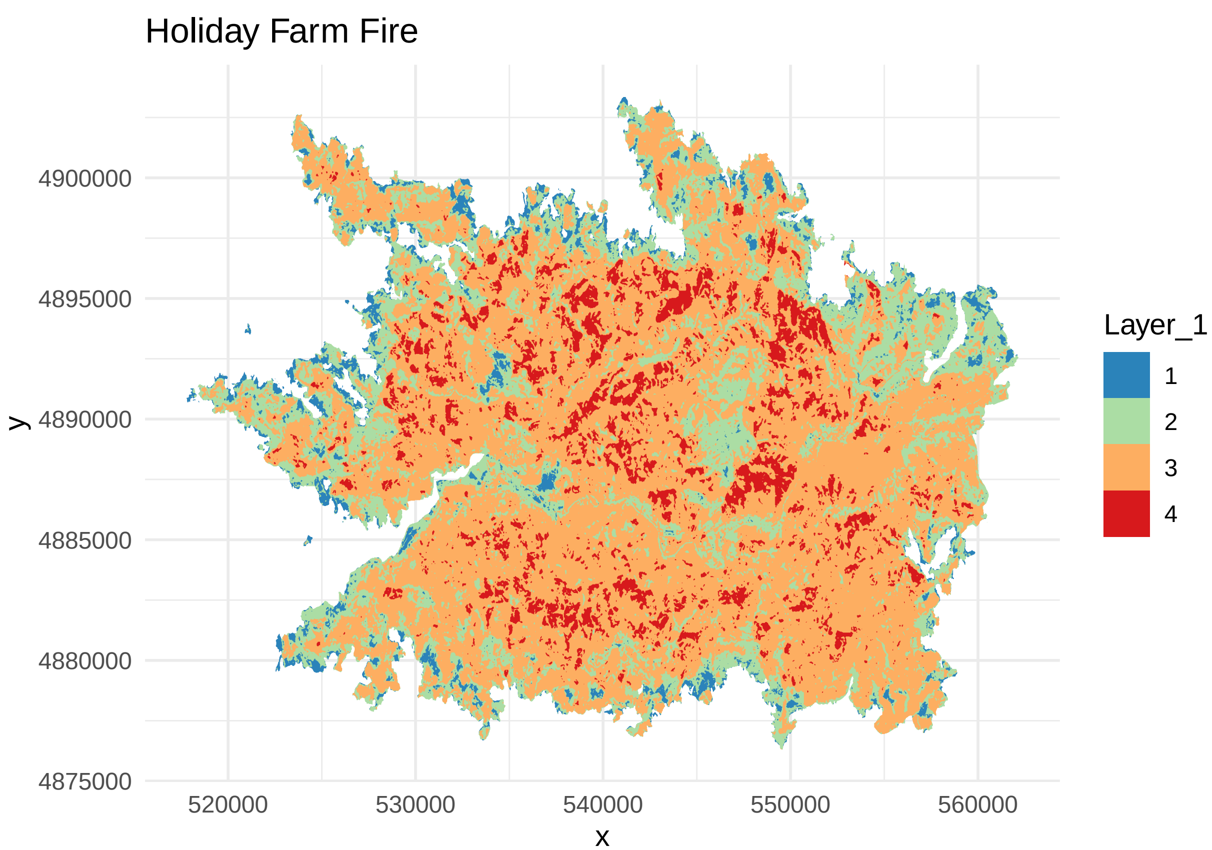


Figure 3: Holiday plot with ggplot2 using the Spectral color scale

d. Compare these visualizations what is something you notice? -ANSWER:

Lab part 2: Exploring the attributes of our spatial data.

a. What are the crs of the rasters? What are the units? Are they all the same?

```r
crs(terwilliger_rast, proj = TRUE)
```

```
## [1] "+proj=aea +lat_0=34 +lon_0=-120 +lat_1=43 +lat_2=48 +x_0=600000 +y_0=0 +datum=NAD83 +units=m +no
```

```r
crs(beachie_rast, proj = TRUE)
```

```
## [1] "+proj=aea +lat_0=34 +lon_0=-120 +lat_1=43 +lat_2=48 +x_0=600000 +y_0=0 +datum=NAD83 +units=m +no
```

```r
crs(holiday_rast, proj = TRUE)
```

```
## [1] "+proj=utm +zone=10 +datum=NAD83 +units=m +no_defs"
```

- ANSWER crs: Holiday: utm, zone Beachie: aea, latitude and longitude Terwilliger: aea, latitude and longitude
- ANSWER units: Holiday: meters Beachie: meters Terwilliger: meters
- ANSWER the same? : The Beachie Creek and Terwilliger have the same crs but the Holiday Farm fire has a different projection.

b. What about the resolution of each raster?

```r
res(terwilliger_rast)
```

```
## [1] 30 30
```

```r
res(beachie_rast)
```

```
## [1] 20 20
```

```r
res(holiday_rast)
```

```
## [1] 20 20
```

- ANSWER resolution: Holiday: 20x20 Beachie: 20x20 Terwilliger: 30x30
- ANSWER the same? : The Holiday and Beachie fire are the same resolution but the Terwilliger is not.

c. Calculate the min and max values of each raster. Are they all the same?

```r
# Terwilliger fire

minmax(terwilliger_rast)
```

```
##     SoilBurnSe
## min          1
## max          4
```

```r
# Beachie Creek fire

minmax(beachie_rast)
```

```
##     Layer_1
## min       1
## max     127
```

```r
# Holiday Fire

minmax(holiday_rast)
```

```
##     Layer_1
## min       1
## max     127
```

- ANSWER minmax: Holiday: min = 1 & max = 127 Beachie: min = 1 & max = 127 Terwilliger: min = 1 & max = 4
- ANSWER the same? : The Holiday Farm fire and the Beachie Creek fire have the same minimum and maximum but the Terwilliger has a different minimum and maximum.

Given we expect there to be 4 values for each bin of severity (high, moderate, low, very low/unburned), let's try to work out why there are values other than 1-4. After checking the metadata .txt and inspecting the metadata in the raster itself, I could not find an explicit mention of the meaning on the non 1-4 data (maybe you can?). Not great practices USGS! But it is likely missing data. Let's convert the Holiday data greater than 4 to NA, just like we would a regular matrix of data.

```r
holiday_rast[holiday_rast > 4] <- NA
summary(values(holiday_rast))
```

```
##     Layer_1
##  Min.   :1.0
##  1st Qu.:2.0
##  Median :3.0
##  Mean   :2.8
##  3rd Qu.:3.0
##  Max.   :4.0
##  NA's   :1536190
```

That's better :)

d. Do the same conversion for Beachie.

```r
beachie_rast[beachie_rast > 4] <- NA
summary(values(beachie_rast))
```

```
##     Layer_1
##  Min.   :1.0
##  1st Qu.:2.0
##  Median :3.0
##  Mean   :2.7
##  3rd Qu.:3.0
##  Max.   :4.0
##  NA's   :2437627
```

Lab part 3: Reprojection

From our exploration above, the rasters are not in the same projection, so we will need to re-project them if we are going to be able to plot them together.

We can use the `project()` function to reproject a raster into a new CRS. The syntax is `project(RasterObject, crs)`

a. First we will reproject our `beachie_rast` raster data to match the `holidat_rast` CRS. If the resolution is different, change it to match Holiday's resolution.

Don't change the name from beachie_rast.

```
beachie_rast <- project(beachie_rast,
                                 crs(holiday_rast))

# This should return TRUE
crs(beachie_rast, proj = TRUE) == crs(holiday_rast, proj = TRUE)
```

```
## [1] TRUE
```

b. Now convert the Terwilliger crs to the holiday crs. If the resolution is different, change it to match Holiday's resolution.

```
terwilliger_rast <- project(terwilliger_rast,
                                 crs(holiday_rast),
                            res = res(holiday_rast))

# This should return TRUE TRUE
crs(terwilliger_rast, proj = TRUE) == crs(holiday_rast, proj = TRUE)
```

```
## [1] TRUE
```

```
res(terwilliger_rast)[2] == res(holiday_rast)[2]
```

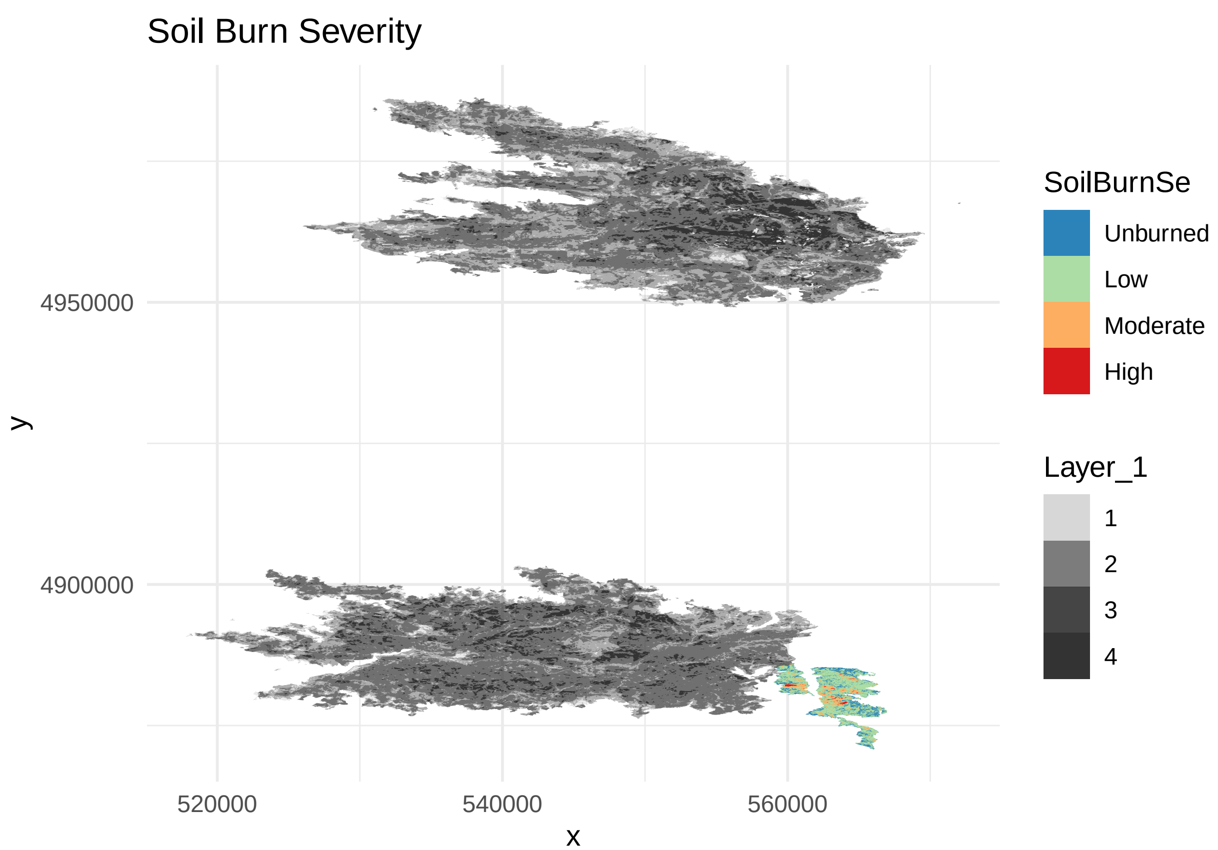
```
## [1] TRUE
```

c. Now you can plot all of the fires on the same map! HINT: Remember to re-make the dataframes.

```
terwilliger_new_df <- as.data.frame(terwilliger_rast, xy = TRUE)

beachie_new_df <- as.data.frame(beachie_rast, xy = TRUE)

holiday_new_df <- as.data.frame(holiday_rast, xy = TRUE)

ggplot() +
     geom_raster(data = terwilliger_new_df ,
                 aes(x = x, y = y,
                  fill = SoilBurnSe)) +
     geom_raster(data = beachie_new_df,
```

```r
                 aes(x = x, y = y,
                   alpha = Layer_1)) +
      geom_raster(data = holiday_new_df,
                 aes(x = x, y = y,
                   alpha = Layer_1)) +
    scale_fill_brewer(palette = "Spectral", direction=-1) +
  theme_minimal() +
  labs(
    title = "Soil Burn Severity"
  )
```

```
## Warning: Using alpha for a discrete variable is not advised.

## Warning: Raster pixels are placed at uneven horizontal intervals and will be shifted
## i Consider using `geom_tile()` instead.
## Raster pixels are placed at uneven horizontal intervals and will be shifted
## i Consider using `geom_tile()` instead.
```



Well that's annoying. It appears as though in 2018 the makers of these data decided to give 1,2,3,4 categorical names which are being interpreted as two different scales. If we look at the terwilliger_rast values we can see that in min max.

```r
terwilliger_rast$SoilBurnSe
```

```
## class       : SpatRaster
```

```
## dimensions  : 776, 417, 1  (nrow, ncol, nlyr)
## resolution  : 20, 20  (x, y)
## extent      : 558901, 567241, 4870585, 4886105  (xmin, xmax, ymin, ymax)
## coord. ref. : NAD83 / UTM zone 10N (EPSG:26910)
## source(s)   : memory
## categories  : SoilBurnSe, BAER_Acres
## name        : SoilBurnSe
## min value   :   Unburned
## max value   :       High
```

d. Let's deal with the the easy way and modify the dataframe. Convert High to 4, Moderate to 3, Low to 2, and Unburned to 1 using your data subsetting skills.

Somethings you will need to be careful of: - If you check the class of terwilliger__rast_df$SoilBurnSe it is a factor, which is a special class of data that are ordered categories with specific levels. R will not let you convert add a level. So first, convert the data to characters (using as.character()). - Now the data are characters, so you will not be able to add in numerics. So code the 1,2,3 as characters i.e., "1", "2"... - We will eventually want the data to be factors again so it will match up with the other rasters. So lastly, convert the data to a factor (using as.factor()).

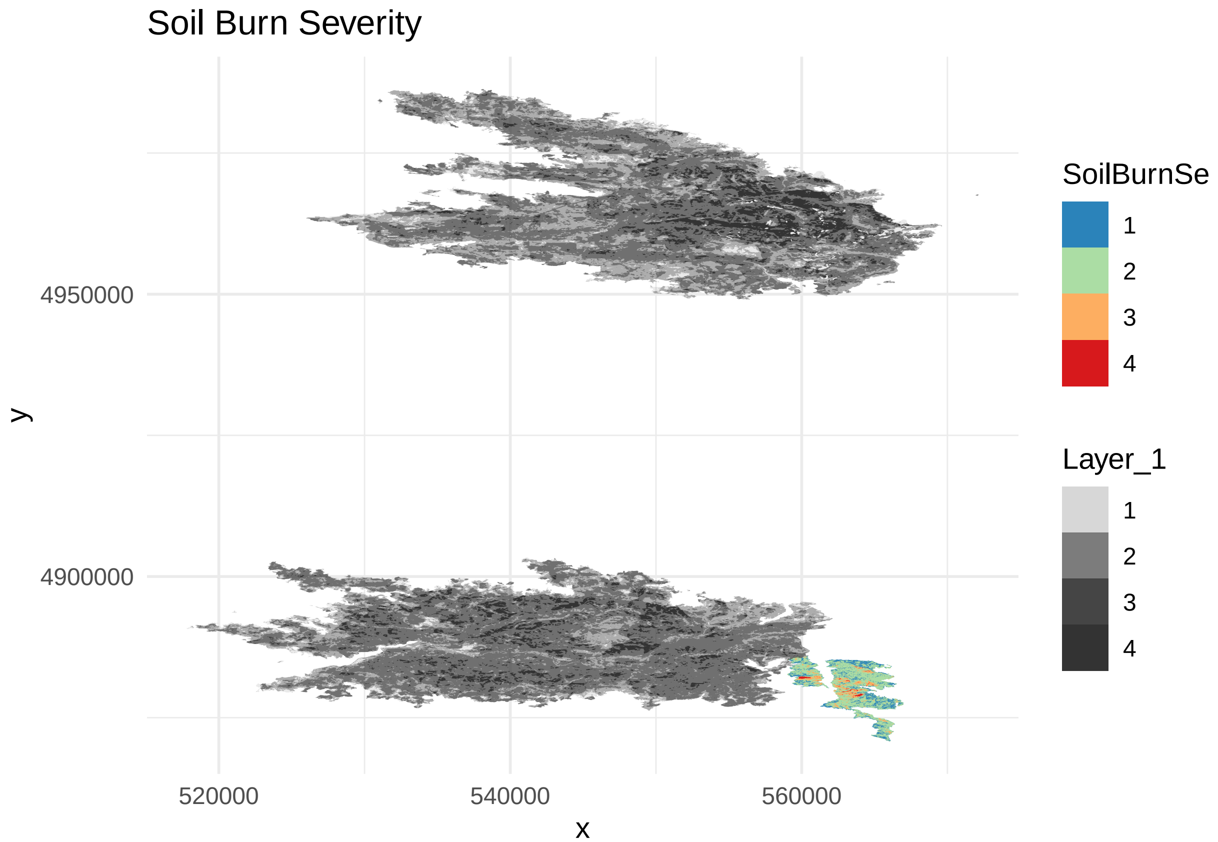
```
terwilliger_new_df$SoilBurnSe <- as.character(terwilliger_new_df$SoilBurnSe)

subset_df <- terwilliger_new_df[terwilliger_new_df$SoilBurnSe
                                %in% c("Unburned", "Low", "Moderate", "High"), ]

terwilliger_new_df$SoilBurnSe[terwilliger_new_df$SoilBurnSe == "Unburned"] <- "1"
terwilliger_new_df$SoilBurnSe[terwilliger_new_df$SoilBurnSe == "Low"] <- "2"
terwilliger_new_df$SoilBurnSe[terwilliger_new_df$SoilBurnSe == "Moderate"] <- "3"
terwilliger_new_df$SoilBurnSe[terwilliger_new_df$SoilBurnSe == "High"] <- "4"

terwilliger_new_df$SoilBurnSe <- as.factor(terwilliger_new_df$SoilBurnSe)
```

e. Try plotting again.

```
ggplot() +
     geom_raster(data = terwilliger_new_df ,
                 aes(x = x, y = y,
                  fill = SoilBurnSe)) +
     geom_raster(data = beachie_new_df,
                 aes(x = x, y = y,
                   alpha = Layer_1)) +
      geom_raster(data = holiday_new_df,
                 aes(x = x, y = y,
                   alpha = Layer_1)) +
    scale_fill_brewer(palette = "Spectral", direction=-1) +
  theme_minimal() +
  labs(
    title = "Soil Burn Severity"
  )
```

```
## Warning: Using alpha for a discrete variable is not advised.
```

```
## Warning: Raster pixels are placed at uneven horizontal intervals and will be shifted
## i Consider using `geom_tile()` instead.
## Raster pixels are placed at uneven horizontal intervals and will be shifted
## i Consider using `geom_tile()` instead.
```



The scale bar make sense! It would be nice to have a baselayer map to see where is Oregon these fires are.

Lab part 4: Adding in vector data

I found a nice ecoregion map on the OR spatial data website. https://spatialdata.oregonexplorer.info/geoportal/details;id=3c7862c4ae664993ad1531907b1e413e

a. Load the data into R, it is in the OR-ecoregions folder.

```
ecoregion_data <- st_read("OR-ecoregions/Ecoregions_OregonConservationStrategy.shp")
```

```
## Reading layer `Ecoregions_OregonConservationStrategy' from data source
##   `/Users/alicarmichael/Documents/ACarmichaelDSCI/BIO410/ds-environ-AC/5-OR-fires/OR-ecoregions/Ecor
##   using driver `ESRI Shapefile'
## Simple feature collection with 9 features and 6 fields
## Geometry type: POLYGON
## Dimension:     XY
## Bounding box:  xmin: 183871.7 ymin: 88600.88 xmax: 2345213 ymax: 1675043
## Projected CRS: NAD83 / Oregon GIC Lambert (ft)
```

b. Check the projection and re-project if needed. We did not cover this in the lecture demo, but for vector data, use st_transform()

```
#st_crs(ecoregion_shapefile, proj = TRUE)
rast <- crs(holiday_rast, proj = TRUE)

ecoregion_data <- st_transform(ecoregion_data, crs = rast)

#crs(ecoregion_data, proj = TRUE) == crs(holiday_rast, proj = TRUE)
#crs(ecoregion_data, proj = TRUE) == crs(terwilliger_rast, proj = TRUE)
#crs(ecoregion_data, proj = TRUE) == crs(beachie_rast, proj = TRUE)

#colnames(ecoregion_data)
```

c. Plot all of the data together (the rasters and vector data). You can layer on geom_sf into ggplot with the other rasters just like you would add another raster.

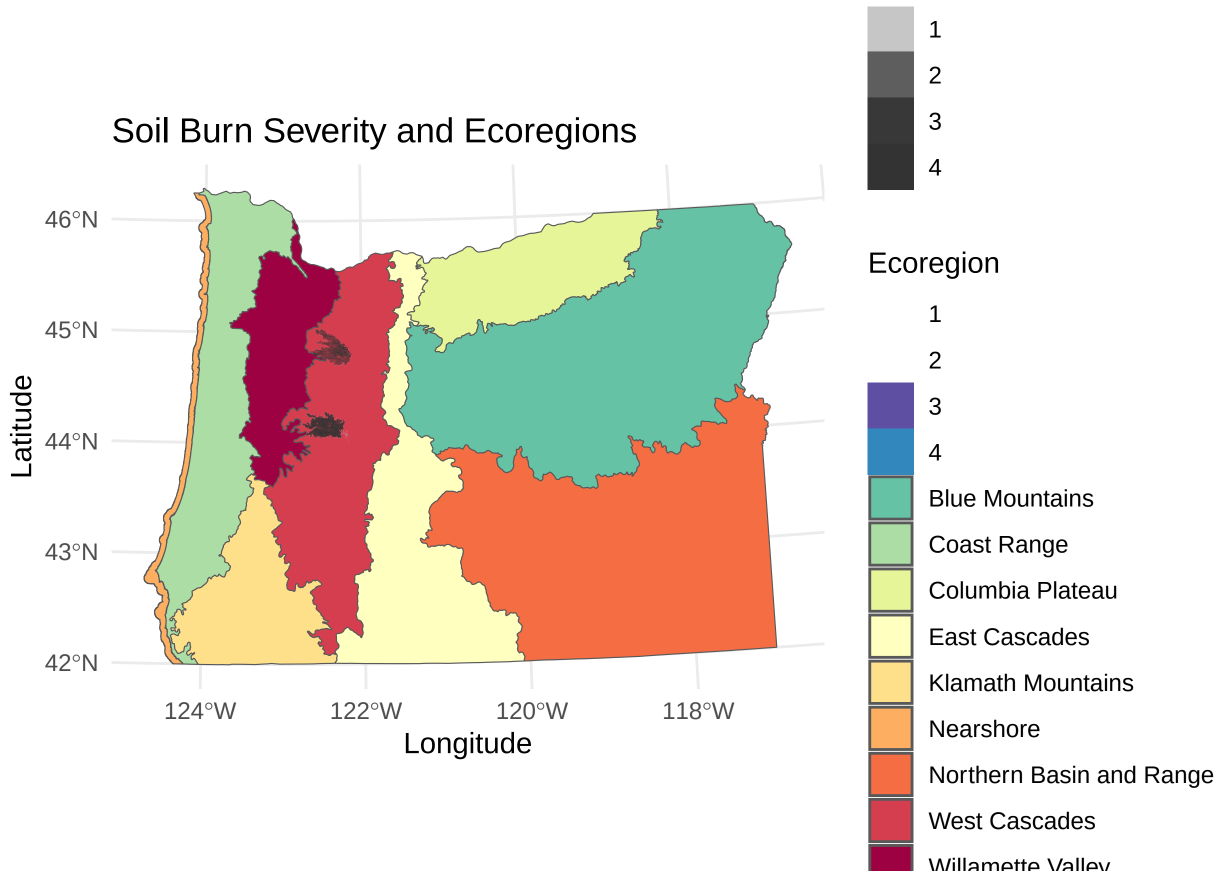
```
ggplot() +
      geom_sf(data = ecoregion_data,
                 aes(fill = Ecoregion)) +
     geom_raster(data = terwilliger_new_df ,
                 aes(x = x, y = y,
                  fill = SoilBurnSe)) +
     geom_raster(data = beachie_new_df,
                 aes(x = x, y = y,
                   alpha = Layer_1)) +
      geom_raster(data = holiday_new_df,
                 aes(x = x, y = y,
                   alpha = Layer_1)) +
      geom_raster(data = holiday_new_df,
                 aes(x = x, y = y,
                   alpha = Layer_1)) +
    scale_fill_brewer(palette = "Spectral", direction=-1) +
  theme_minimal() +
  labs(
    title = "Soil Burn Severity and Ecoregions",
    x = "Longitude",
    y = "Latitude",
  )
```

```
## Warning: Using alpha for a discrete variable is not advised.
```

```
## Warning: Raster pixels are placed at uneven horizontal intervals and will be shifted
## i Consider using `geom_tile()` instead.
## Raster pixels are placed at uneven horizontal intervals and will be shifted
## i Consider using `geom_tile()` instead.
## Raster pixels are placed at uneven horizontal intervals and will be shifted
## i Consider using `geom_tile()` instead.
```

```
## Warning in RColorBrewer::brewer.pal(n, pal): n too large, allowed maximum for palette Spectral is 11
## Returning the palette you asked for with that many colors
```

```
## Warning: Removed 101330 rows containing missing values or values outside the scale range
## (`geom_raster()`).
```



We could get fancy and zoom into the correct region using extent, which we will cover next week. For now, this looks pretty good.

Lab part 5: Exploring patterns of fire severity

a. Create a barplot with the count of each fire severity category.

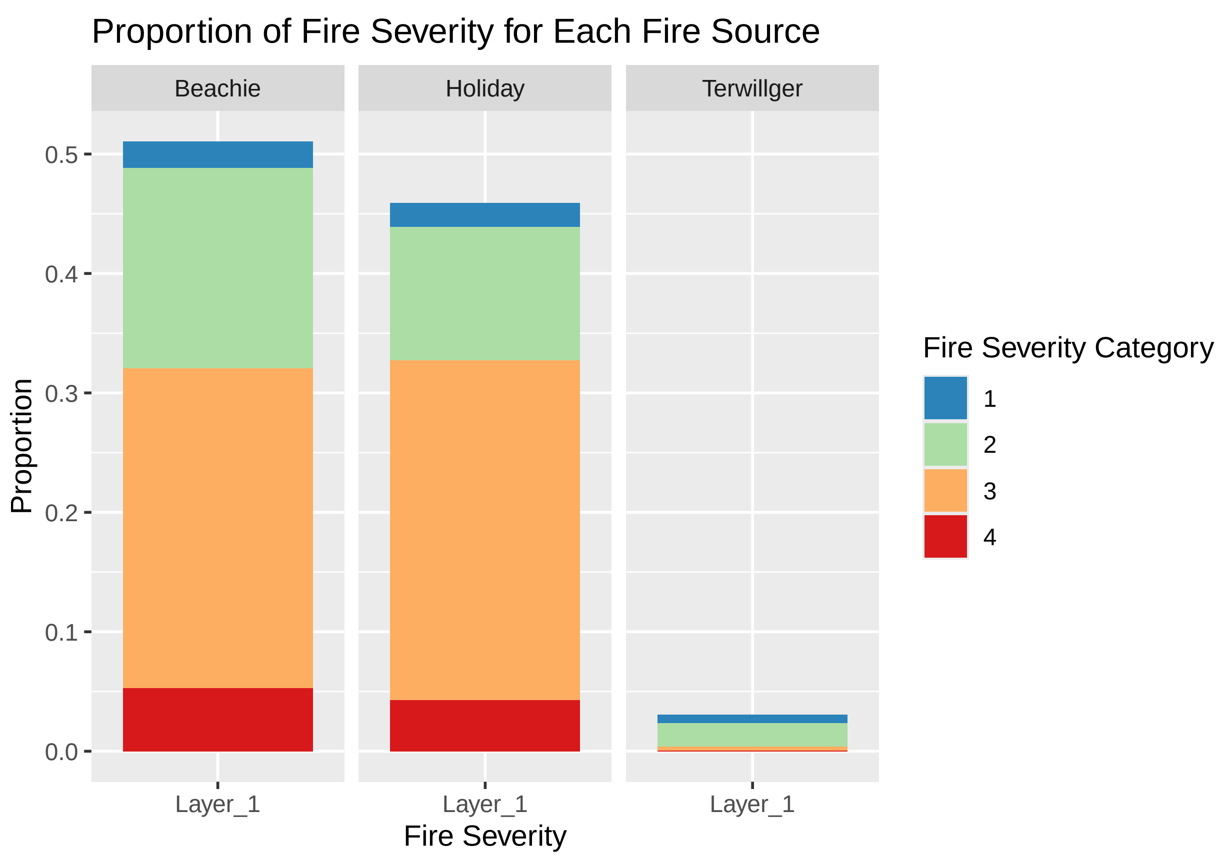
- Use scale_fill_brewer(palette = "Spectral", direction=-1) to get the bars to match the maps.
- Plot the proportion on the y. To do this, in geom_bar, include y = (..count..)/sum(..count..). EX: aes(x= Layer_1, y = (..count..)/sum(..count..)

HINT: Rather annoyingly, you will need to convert the layer values to factors again to get fill to recognize them. EX: fill=as.factor(Layer_1)

```
terwilliger_new_df$SoilBurnSe <- as.factor(terwilliger_new_df$SoilBurnSe)
holiday_new_df$Layer_1 <- as.factor(holiday_new_df$Layer_1)
beachie_new_df$Layer_1 <- as.factor(beachie_new_df$Layer_1)

terwilliger_new_df$Fire <- "Terwilliger"
holiday_new_df$Fire <- "Holiday"
beachie_new_df$Fire <- "Beachie"
```

```r
fire_df <- rbind(
  data.frame(Fire = "Terwillger", Layer_1 = terwilliger_new_df$SoilBurnSe),
  data.frame(Fire = "Holiday", Layer_1 = holiday_new_df$Layer_1),
  data.frame(Fire = "Beachie", Layer_1 = beachie_new_df$Layer_1)
  )

ggplot(data = fire_df, aes(x = "Layer_1", y = (..count..)/sum(..count..),
                           fill = as.factor(Layer_1))) +
  geom_bar() +
    scale_fill_brewer(palette = "Spectral", direction=-1) +
  labs(
    x = "Fire Severity",
    y = "Proportion",
    title = "Proportion of Fire Severity for Each Fire Source",
    fill = "Fire Severity Category"
  ) +
  facet_wrap(~Fire)
```

```
## Warning: The dot-dot notation (`..count..`) was deprecated in ggplot2 3.4.0.
## i Please use `after_stat(count)` instead.
## This warning is displayed once every 8 hours.
## Call `lifecycle::last_lifecycle_warnings()` to see where this warning was
## generated.
```



b. What do you notice about the frequency of different severity classes when you compare these barplots.

How does this relate to the Haldofsky reading? ANSWER: The Beachie Creek and Holiday Farm fires had a larger proportion of fire severity 2 and 3 than the Terwilliger fire. The largest cateogry of all three of the fires is the category 3. These fires all occured in very dry hot areas of Oregon which we know from the Haldofsky reading are extremely prone to wildfire. We also know that densely forested areas like where these fires occured are prone to higher fire severity.

Also, if the legend label bothers you (as it does for me) Check out this tutorial: https://www.datanovia.com/en/blog/ggplot-legend-title-position-and-labels/