MODIS data in in R.

Learning Objectives

After completing this tutorial, you will be able to:

- Open MODIS imagery in R
- Create NBR index using MODIS imagery in R
- Calculate total burned area in R.

What you need

You will need a computer with internet access to complete this lesson and the data for week 6 of the course.

{% include/data_subsets/course_earth_analytics/_data-week6-7.md %}

First, let's import MODIS data. Below notice that we have used a slightly different version of the `list.files()` `pattern=` argument.

We have used `glob2rx("*sur_refl*.tif$")` to select all layers that both

1. Contain the word `sur_refl` in them and
2. Contain the extension `.tif`

Let's import our MODIS image stack.

```
# open modis bands (layers with sur_refl in the name)
all_modis_bands_july7 <-list.files("data/week6/modis/reflectance/07_july_2016/crop",
           pattern=glob2rx("*sur_refl*.tif$"),
           full.names = T)
# create spatial raster stack
all_modis_bands_st_july7 <- stack(all_modis_bands_july7)

# view range of values in stack
all_modis_bands_st_july7[[2]]
## class       : RasterLayer
## dimensions  : 2400, 2400, 5760000  (nrow, ncol, ncell)
## resolution  : 463.3, 463.3  (x, y)
## extent      : -10007555, -8895604, 3335852, 4447802  (xmin, xmax, ymin, ymax)
## coord. ref. : +proj=sinu +lon_0=0 +x_0=0 +y_0=0 +a=6371007.181 +b=6371007.181 +units=m +no_defs
## data source : /Users/lewa8222/Documents/earth-analytics/data/week6/modis/reflectance/07_july_2016/cr
## names       : MOD09GA.A2016189.h09v05.006.2016191073856_sur_refl_b02_1
## values      : -32768, 32767  (min, max)
```

Reflectance values range 0-1

As we've discussed in class, the normal range of reflectance values is 0-1 where 1 is the BRIGHTEST values and 0 is the darkest value. Have a close look at the min and max values in the second raster layer of our stack, above. What do you notice?

The min and max values are widely outside of the expected range of 0-1 - min: -32768, max: 32767 What could be causing this? We need to better understand our data before we can work with it more. Have a look at the table in the MODIS users guide. The data that we are working with is the MOD09GA product. Look closely at the table on page 14 of the guide. Part of the table can be seen below.

Click here to check out the MODIS user guide - check out page 14 for the MOD09GA table.

The column headings for the table below:

Group

Notice the valid values for the MOD09GA reflectance product. The range is -100 to 16000.

Looking at the table, answer the following questions

1. What is valid range of values for our data?
2. What is the scale factor associated with our data?

Explore our data

Looking at histograms of our data, we can see that the range of values is not what we'd expect. We'd expect values between -100 to 10000 yet instead we have much larger numbers.

```
# turn off scientific notation
options("scipen"=100, "digits"=4)
hist(all_modis_bands_st_july7,
  col="springgreen")
```

Scale Factor

Looking at the metadata, we can see that our data have a scale factor. Let's deal with that before doing anything else. The scale factor is .0001. This means we should multiple each layer by that value to get the actual reflectance values of the data.

We can apply this math to all of the layers in our stack using a simple calculation shown below:

```
# deal with nodata value --  -28672
all_modis_bands_st_july7 <- all_modis_bands_st_july7 * .0001
# view histogram of each layer in our stack
hist(all_modis_bands_st_july7,
   xlab="Reflectance Value",
   col="springgreen")
```

Great - now the range of values in our data appear more reasonable. Next, let's get rid of data that are outside of the valid data range.

NoData Values

Next, let's deal with no data values. We can see that our data have a "fill" value of -28672 which we can presume to be missing data. But also we see that valid range values begin at -100. Let's set all values less than -100 to NA to remove the extreme negative values that may impact out analysis.

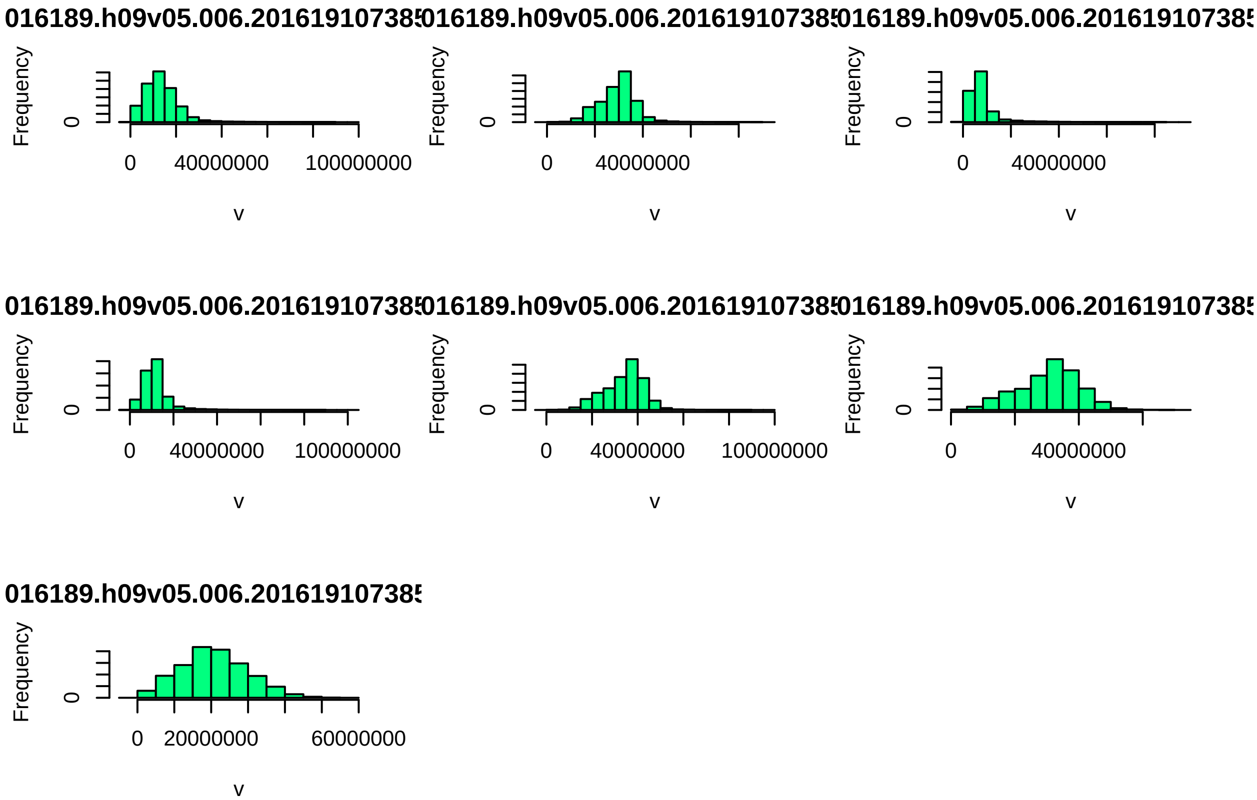

Figure 1: MODIS stack band 2 plot

```
# deal with nodata value --  -28672
all_modis_bands_st_july7[all_modis_bands_st_july7 < -100 ] <- NA
# plot histogram
hist(all_modis_bands_st_july7,
   xlab="Reflectance Value",
  col="springgreen")
title(main = "MY Title")
```

Next we plot MODIS layers. Use the MODIS band chart to figure out what bands you need to plot to create a RGB (true color) image.

Band	Wavelength range (nm)	Spatial Resolution (m)	Spectral Width (nm)
Band 1 - red	620 - 670	250	2.0
Band 2 - near infrared	841 - 876	250	6.0
Band 3 - blue/green	459 - 479	500	6.0
Band 4 - green	545 - 565	500	3.0
Band 5 - near infrared	1230 – 1250	500	8.0
Band 6 - mid-infrared	1628 – 1652	500	18
Band 7 - mid-infrared	2105 - 2155	500	18

In the plot below, i've called attention to the AOI boundary with a yellow color. Why is it so hard to figure out where the study area is in this MODIS image?

MODIS cloud mask

Next, we can deal with clouds in the same way that we dealt with them using Landsat data. However, our cloud mask in this case is slightly different with slightly different cloud cover values as follows:

State

SEVERITY LEVEL
Unburned
Low Severity
Moderate Severity
High Severity

After we've calculated NBR, we may want to calculate total burn AREA. We can do this using the `freq()` function in R. This function gives us the total number of pixels associated with each value in our classified raster.

1. **Calculate frequency ignoring NA values:** `freq(modis_nbr_cl, useNA='no')`
2. **Calculate frequency, ignore NA & only include values that equal 5:** `freq(modis_nbr_cl, useNA='no', value=5)`

Let's use the MODIS data from 7 July 2016 to calculate the total area of land classified as:

1. Burn: moderate severity
2. Burn: high severity

```
# get summary counts of each class in raster
freq(modis_nbr_cl, useNA='no')
##      value count
## [1,]     4    24

final_burn_area_high_sev <- freq(modis_nbr_cl, useNA='no', value=5)
final_burn_area_moderate_sev <- freq(modis_nbr_cl, useNA='no', value=4)
```

We can perform the steps that we performed above, on the MODIS post-fire data too. Below is a plot of the July 17 data.

```
par(col.axis="white", col.lab="white", tck=0)
# clouds removed
plotRGB(all_modis_bands_st_mask_july17,
        1,4,3,
        stretch="lin",
        main="Final data plotted with mask\n Post Fire - 17 July 2016",
        axes=T)
box(col="white")
```

Next we calculate NBR on our post fire data. Then we can crop and finally plot the final results!

Post fire NBR results

```
the_colors = c("palevioletred4","palevioletred1","ivory1")
barplot(modis_nbr_july17_cl,
        main="Distribution of burn values - Post Fire",
        col=rev(the_colors),
        names.arg=c("Low Severity","Moderate Severity","High Severity"))
```

Finally, plot the reclassified data. Note that we only have 3 classes: 2, 3 and 4.

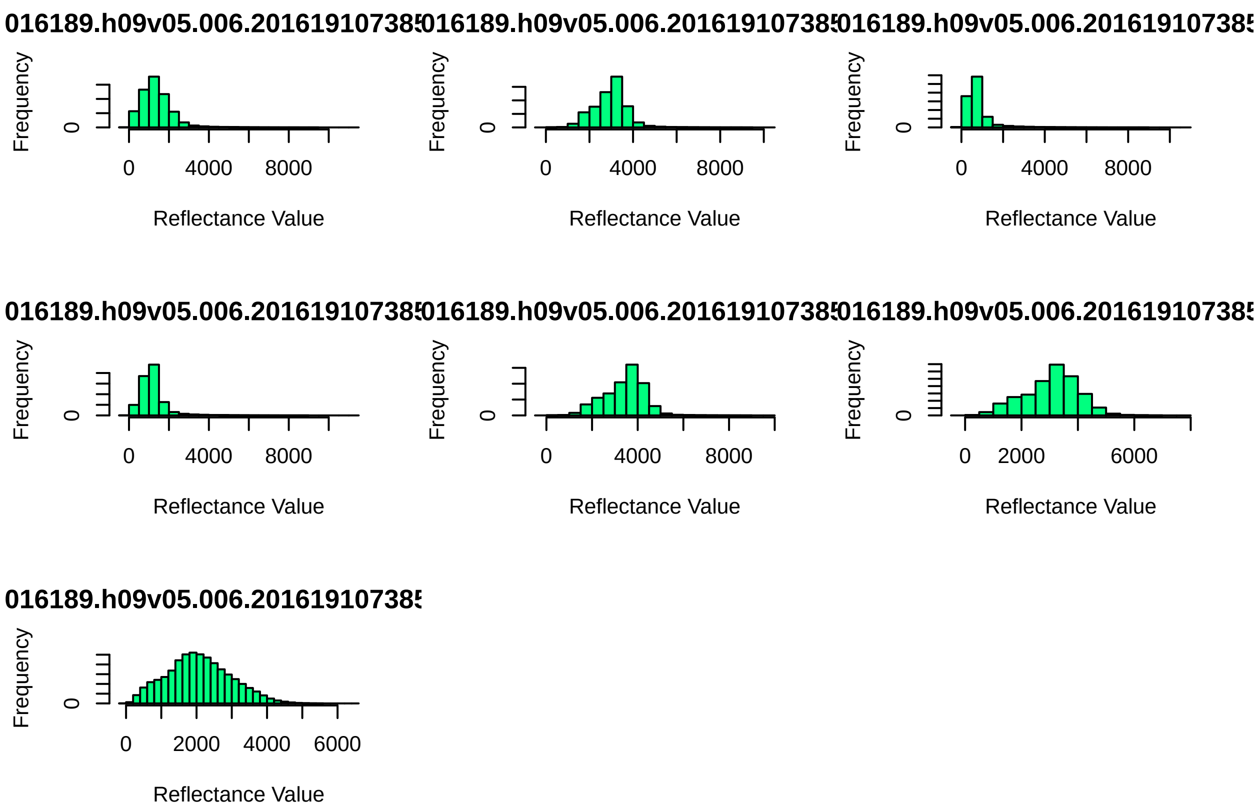

Figure 2: MODIS stack histogram plot

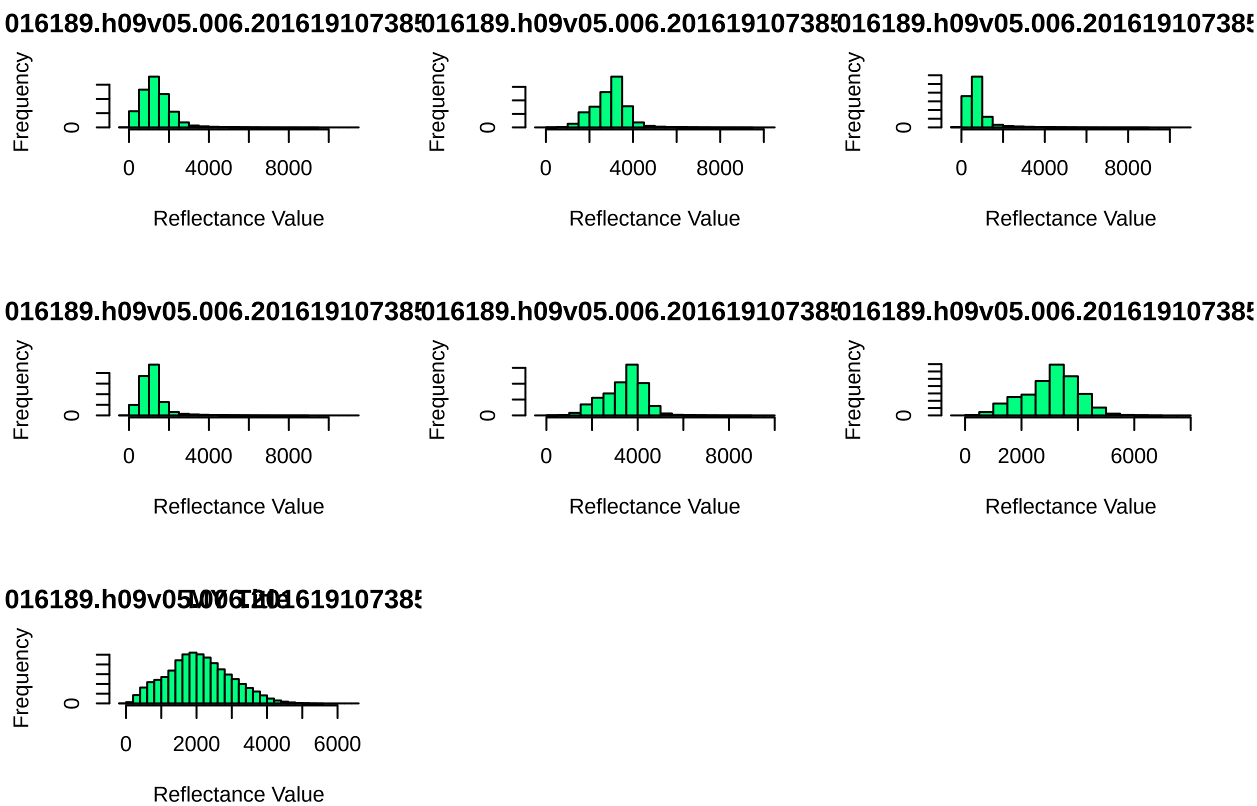

Figure 3: MODIS stack histogram plot with NA removed

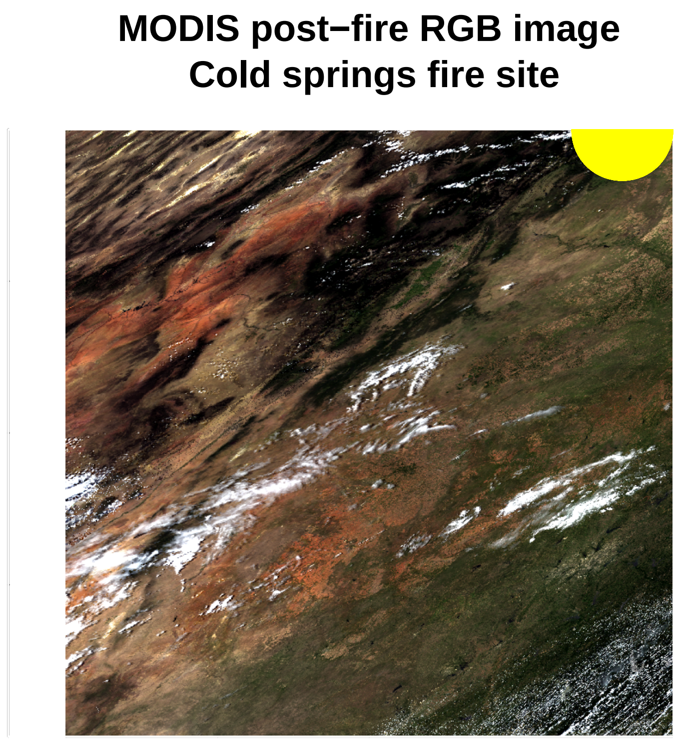

Figure 4: plot MODIS stack

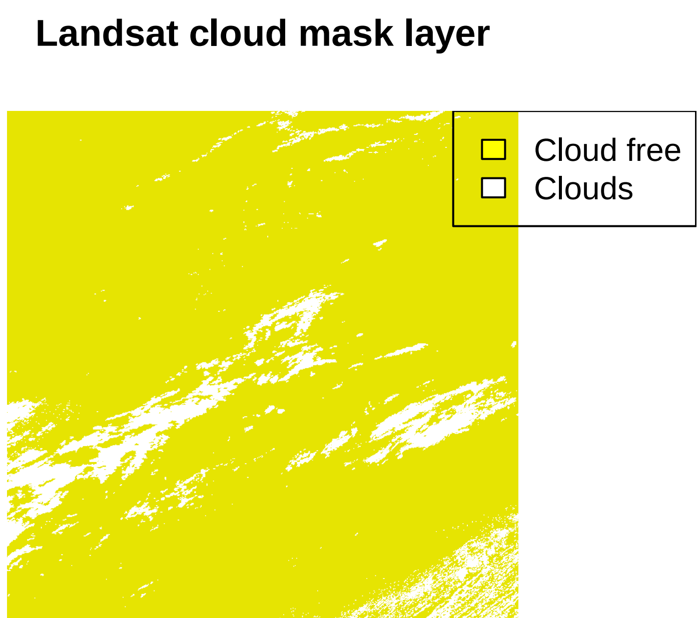

Figure 5: cloud mask plot

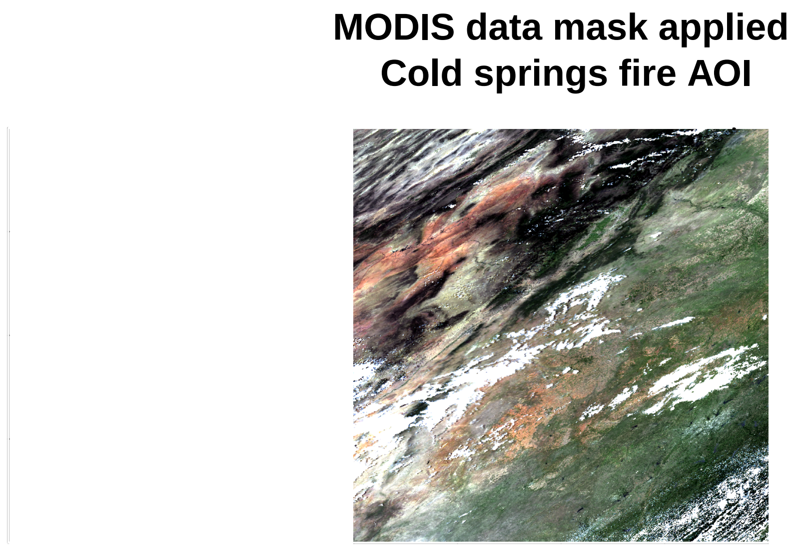

Figure 6: MODIS with cloud mask

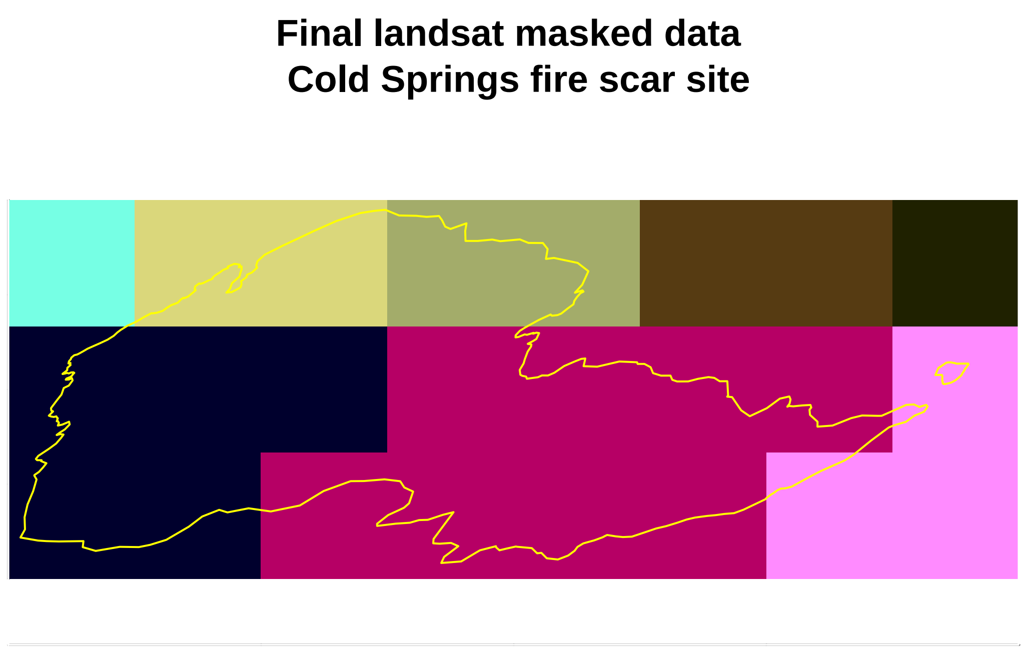

Figure 7: cropped data

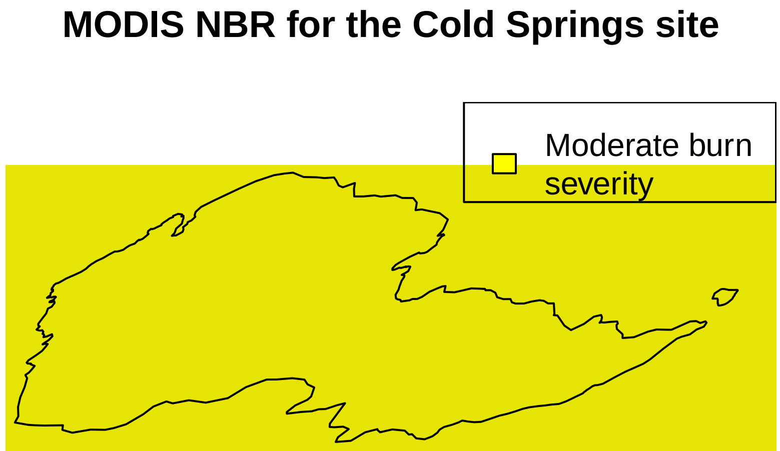

Figure 8: Classified pre fire NBR

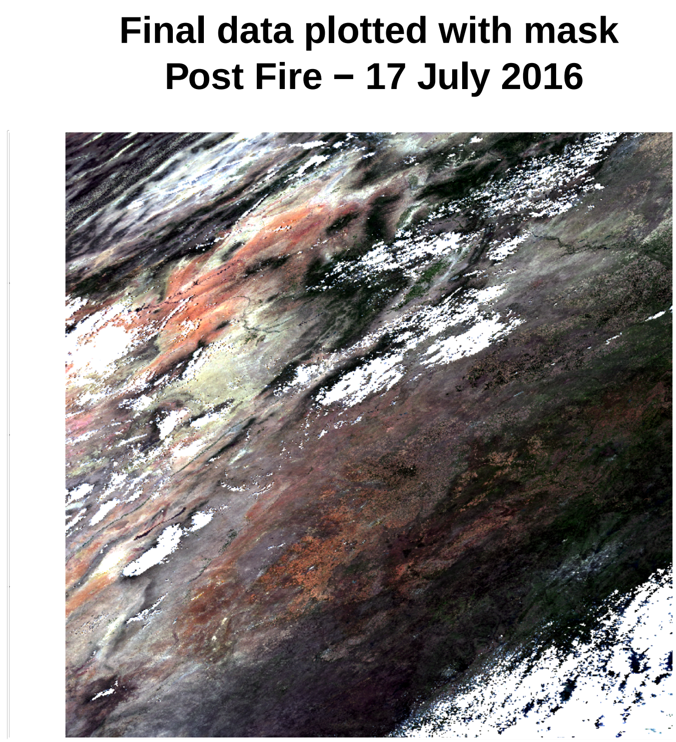

Figure 9: RGB post fire

Figure 10: barplot of final post fire classified data.

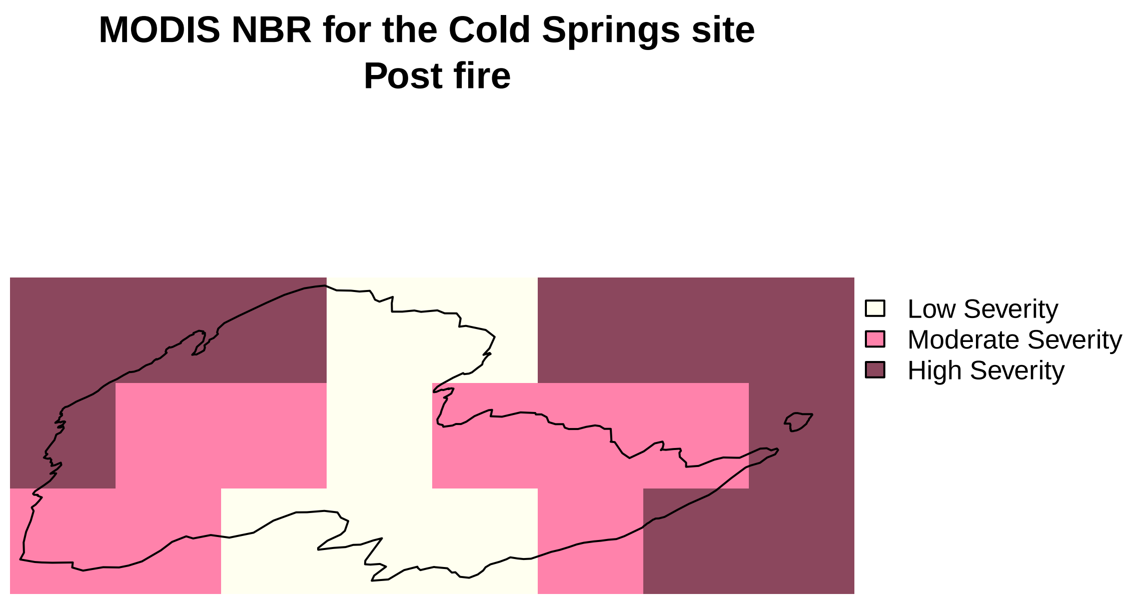

Figure 11: MODIS NBR plot w colors