Working with the difference Normalized Burn Index - Using spectral remote sensing to understand fire

Learning Objectives

After completing this tutorial, you will be able to:

- Calculate dNBR in R
- Be able to describe how the dNBR index is used to quantify fire severity.

What you need

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

[Download Week 6 Data (~500 MB)](

Calculate Normalized Burn Ratio (NBR)

The Normalized burn ratio (NBR) allows us to identify burned areas. The formula is similar to a normalized difference vegetation index (NDVI), except that it uses near-infrared (NIR) and shortwave-infrared (SWIR) wavelengths (Lopez, 1991; Key and Benson, 1995).

NBR index

NBR = ((NIR - SWIR)/ (NIR + SWIR))

The NIR and SWIR parts of the electromagnetic spectrum are a powerful combination of bands to use for this index given vegetation reflects strongly in the NIR region of the electromagnetic spectrum and weekly in the SWIR. Alternatively, it has been shown that a fire scar which contains scarred woody vegetation and earth will reflect more strongly in the SWIR part of the electromagnetic spectrum and beyond (see figure below).

NBR. Source: US Forest Service

NBR Bands

The NBR was originally developed for use with Landsat TM and ETM+ bands 4 and 7, but it will work with any multispectral sensor with a NIR band between 760 - 900 nm and a SWIR band between 2080 - 2350 nm. Thus this index can be used with both Landsat 8, MODIS and other multi (and hyper) spectral sensors.

difference NBR

The real power in using NBR for science associated with understanding the extent of a fire on the landscape is using the difference between the landscape. This difference is best measured immediate before the fire and then immediately after. NBR is less effective if time has passed and vegetation regrowth / regeneration has begun.

To calculate the difference, you subtract the post-fire NBR raster from the pre-fire NBR raster as follows:

d NBR equation. Source: http://gsp.humboldt.edu/olm_2015/Courses/GSP_216_Online/lesson5-1/NBR.html

The classification table below can be used to classify the raster according to the severity of the burn.

SEVERITY LEVEL
Enhanced Regrowth
Unburned
Low Severity
Moderate Severity
High Severity

How severe is severe?

Text about how this is a relative index and it needs to be taken into consideration that severity is a relatively qualtative term…

NBR & Landsat 8

Looking at the table below which shows the band distribution of Landsay 8, what bands should we use for Landsat 8?

Landsat 8 Bands

Band	Wavelength range (nanometers)	Spatial Resolution (m)	Spectral Width (nm)
Band 1 - Coastal aerosol	430 - 450	30	2.0
Band 2 - Blue	450 - 510	30	6.0
Band 3 - Green	530 - 590	30	6.0
Band 4 - Red	640 - 670	30	0.03
Band 5 - Near Infrared (NIR)	850 - 880	30	3.0
Band 6 - SWIR 1	1570 - 1650	30	8.0
Band 7 - SWIR 2	2110 - 2290	30	18
Band 8 - Panchromatic	500 - 680	15	18
Band 9 - Cirrus	1360 - 1380	30	2.0

NBR & MODIS

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

```r
# load spatial packages
library(raster)
library(rgdal)
library(rgeos)
library(RColorBrewer)
```

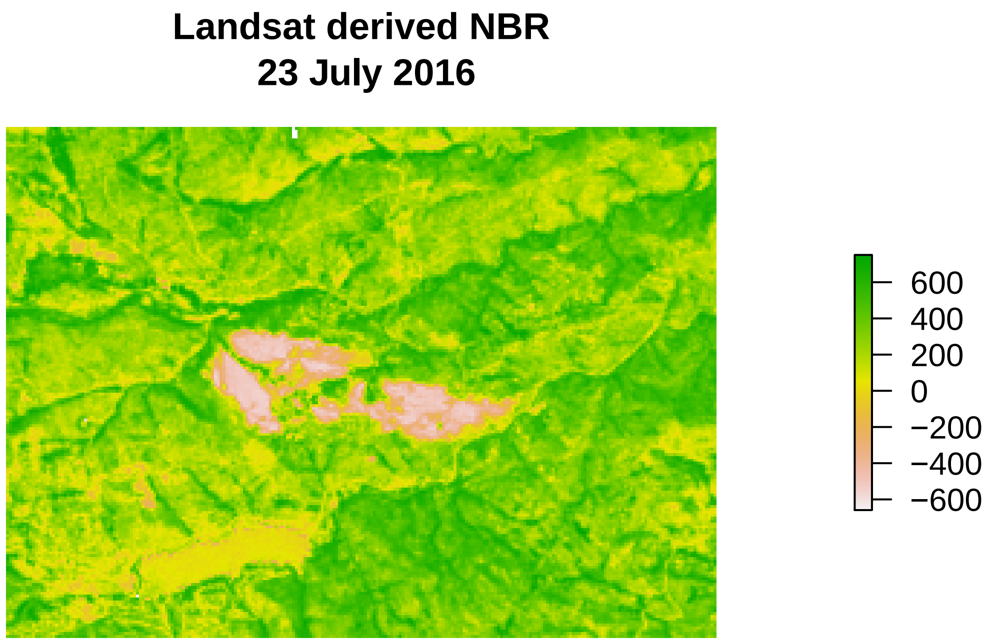

Figure 1: landsat derived NDVI plot

```
# turn off factors
options(stringsAsFactors = F)
```

```
all_landsat_bands <- list.files("data/week6/Landsat/LC80340322016205-SC20170127160728/crop",
           pattern=glob2rx("*band*.tif$"),
           full.names = T) # use the dollar sign at the end to get all files that END WITH
all_landsat_bands
## [1] "data/week6/Landsat/LC80340322016205-SC20170127160728/crop/LC80340322016205LGN00_sr_band1_crop.t
## [2] "data/week6/Landsat/LC80340322016205-SC20170127160728/crop/LC80340322016205LGN00_sr_band2_crop.t
## [3] "data/week6/Landsat/LC80340322016205-SC20170127160728/crop/LC80340322016205LGN00_sr_band3_crop.t
## [4] "data/week6/Landsat/LC80340322016205-SC20170127160728/crop/LC80340322016205LGN00_sr_band4_crop.t
## [5] "data/week6/Landsat/LC80340322016205-SC20170127160728/crop/LC80340322016205LGN00_sr_band5_crop.t
## [6] "data/week6/Landsat/LC80340322016205-SC20170127160728/crop/LC80340322016205LGN00_sr_band6_crop.t
## [7] "data/week6/Landsat/LC80340322016205-SC20170127160728/crop/LC80340322016205LGN00_sr_band7_crop.t

# stack the data
landsat_stack_csf <- stack(all_landsat_bands)
```

When you have calculated NBR - classify the output raster using the `classify()` function and the classes below.

SEVERITY LEVEL
Enhanced Regrowth
Unburned
Low Severity
Moderate Severity
High Severity

NOTE: your min an max values for NBR may be slightly different from the table shown above! If you have a smaller min value (< -700) then adjust your first class to that smallest number. If you have a largest max value (>1300) then adjust your last class to that largest value in your data.

Alternatively, you can set those values to NA if you think they are outside of the valid range of NBR (in this case they are not).

You can export the rasters if you want.

```
writeRaster(x = nbr_classified,
```

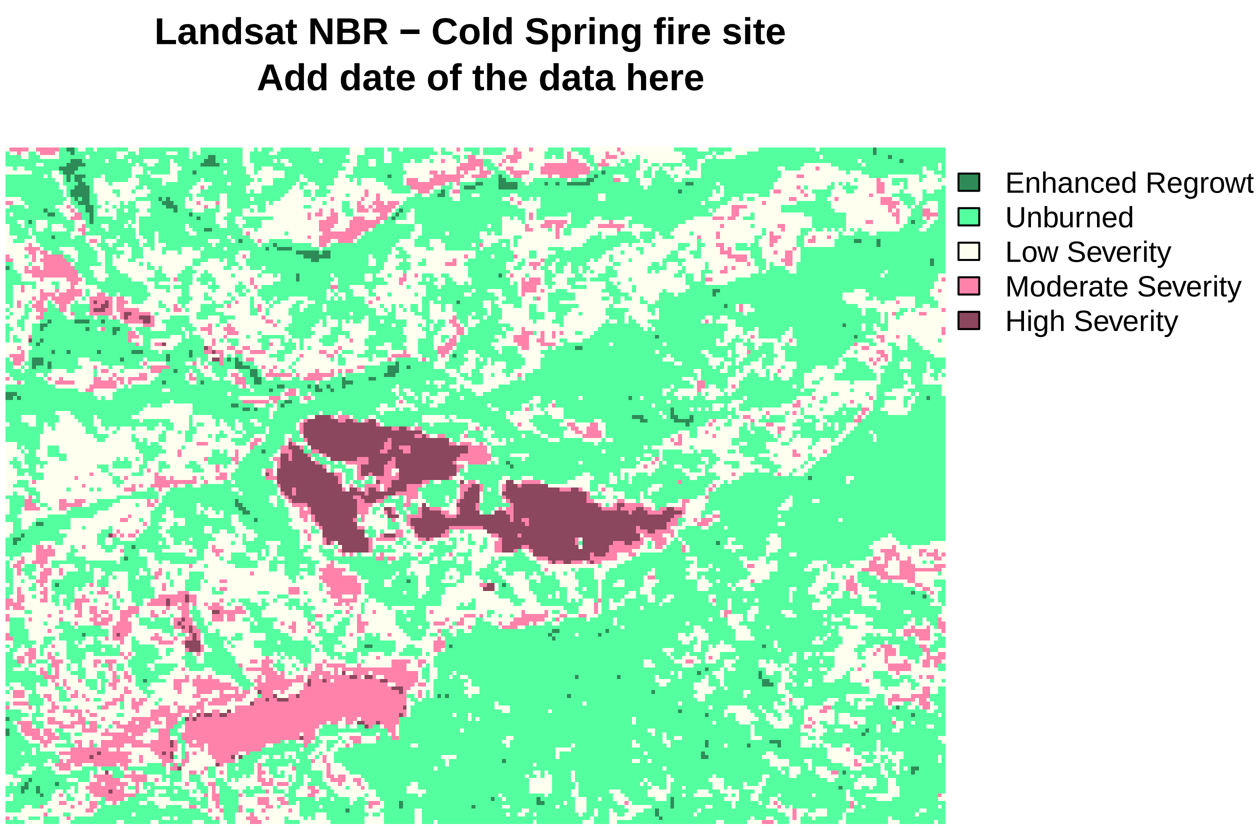

Figure 2: classified NBR output

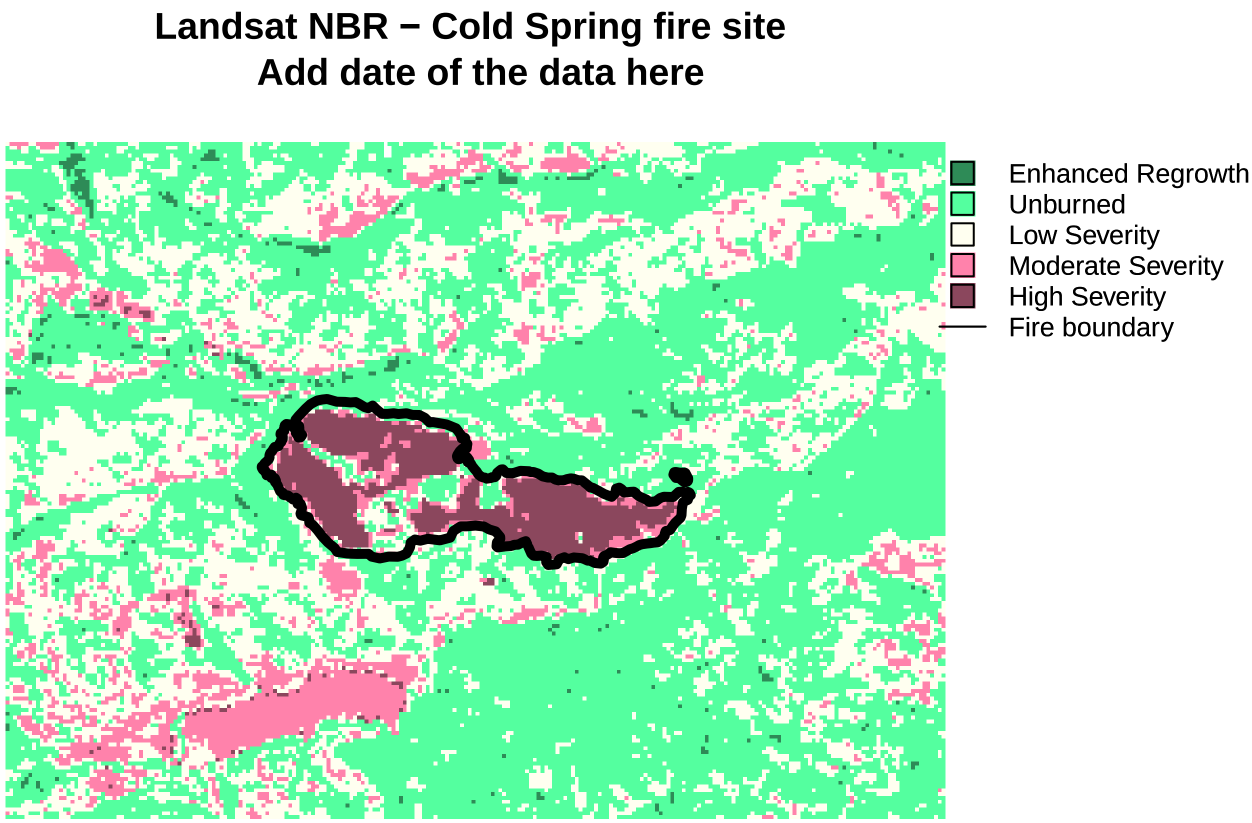

Figure 3: classified NBR output

Compare to fire boundary

As an example to see how our fire boundary relates to the boundary that we've identified using MODIS data, we can create a map with both layers. I'm using the shapefile in the folder:

`data/week6/vector_layers/fire-boundary-geomac/co_cold_springs_20160711_2200_dd83.shp`

Add fire boundary to map.

Make it look a bit nicer using a colobrewer palette. I used the `RdYlGn` palette:

`brewer.pal(5, 'RdYlGn')`

I also did a bit of legend trickery to get a box with a fill. There's probably a better way to do this!

```
legend(nbr_classified@extent@xmax-100, nbr_classified@extent@ymax,
       c("Enhanced Regrowth", "Unburned", "Low Severity", "Moderate Severity", "High Severity", "Fire bo
       col=c(rev(the_colors), "black"),
       pch=c(15,15, 15, 15, 15,NA),
       lty = c(NA, NA, NA, NA, NA, 1),
       cex=.8,
       bty="n",
       pt.cex=c(1.75))
legend(nbr_classified@extent@xmax-100, nbr_classified@extent@ymax,
       c("Enhanced Regrowth", "Unburned", "Low Severity", "Moderate Severity", "High Severity", "Fire bo
       col=c("black"),
       pch=c(22, 22, 22, 22, 22, NA),
```

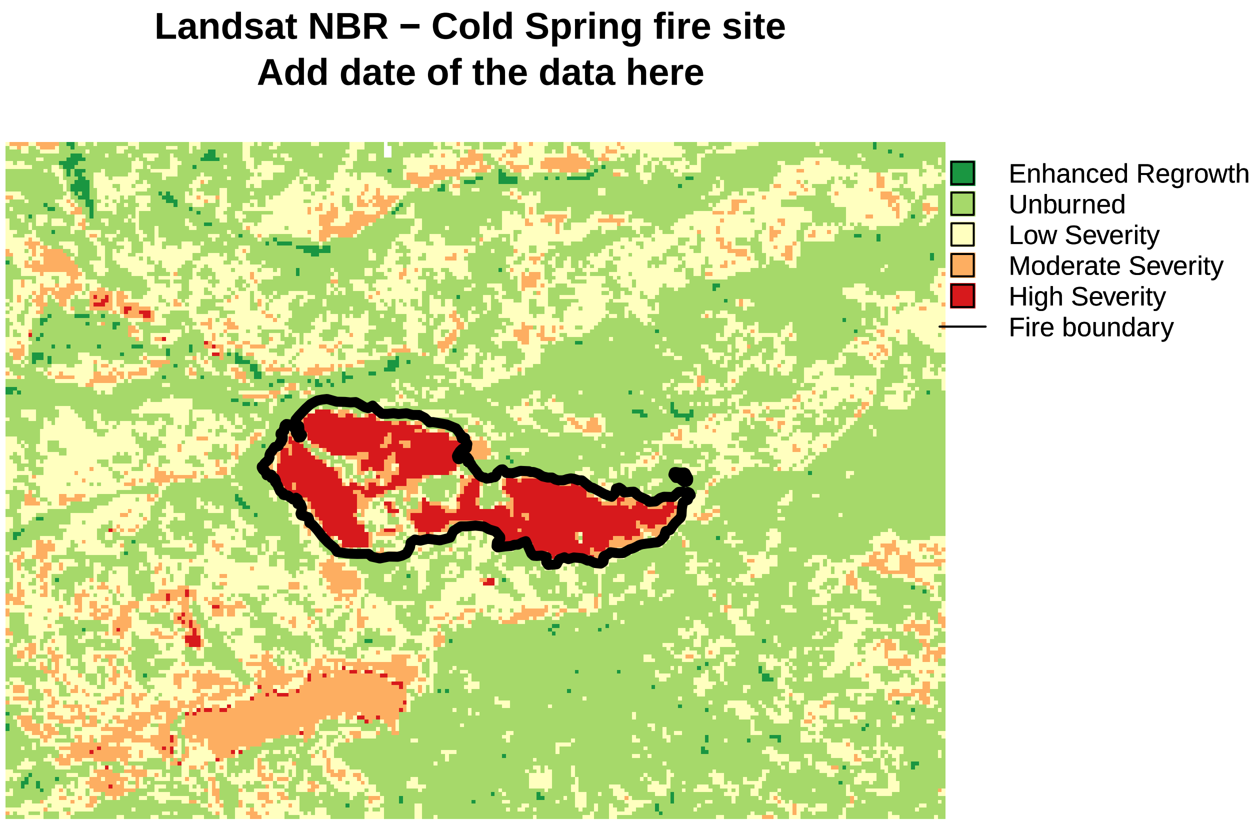

Figure 4: classified NBR output

```
        lty = c(NA, NA, NA, NA, NA, 1),
        cex=.8,
        bty="n",
        pt.cex=c(1.75))
```

Note that you will have to figure out what date these data are for! I purposefully didn't include it in the title of this map.

Additional Resources

- NBR stuff...

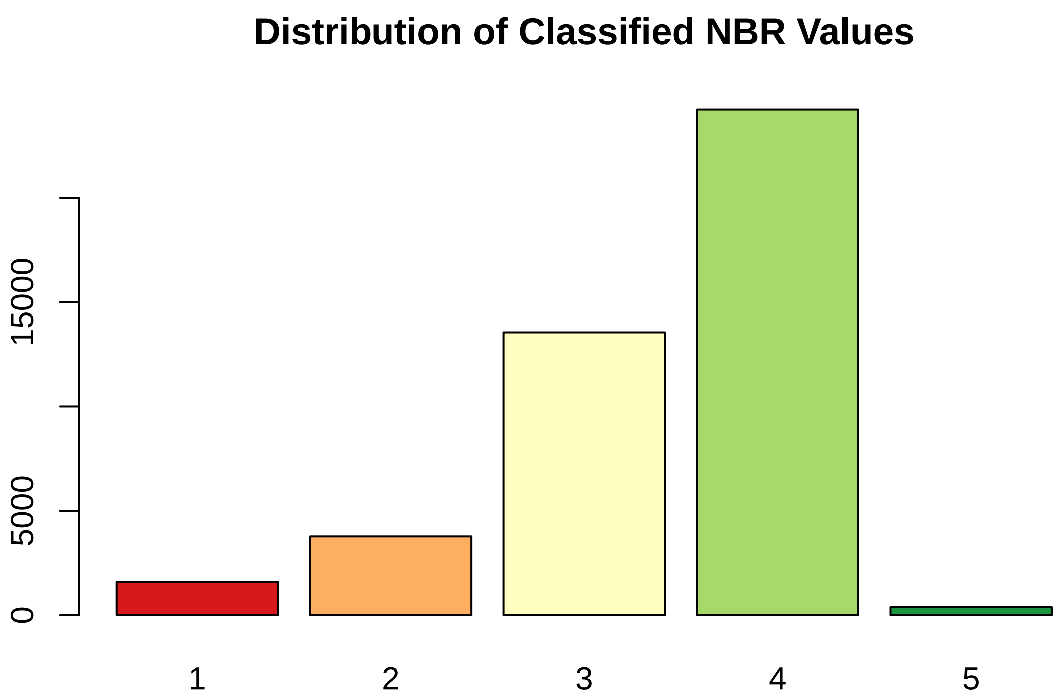

Figure 5: plot hist