

Using a 1 Year Post Fire Extended Assessment to Determine Appropriate NBR and Vegetation Indices, and Their Efficacy for Assessing Burn Severity in Rangeland Ecosystems

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Abstract

The Normalized Burn Ratio (NBR) is an index based on remote sensing data and is used to calculate the extent and severity of a fire. There are two strategies of NBR, initial assessment and extended assessment; the latter being more representative of burn severity. The NBR assessment type chosen depends on the timing of the imagery used to assess burn severity. The NBR has proven to respond consistently well in forested ecosystems due to high amounts of vegetation. However, it is not a good indicator of burn severity in rangeland ecosystems due to low vegetation and high bare ground reflectance in rangelands. Previous work at ISU's GIS Center has determined the potential of using a modified NBR to circumvent the negative effects that remote sensing imagery generates due to vegetation and bare ground characteristics. Higher spatial and spectral resolution data may more accurately correct for these negative effects. This study applies a one year post fire extended assessment NBR and two modified NBR algorithms to Landsat imagery. This study also demonstrates the use of vegetation indices applied on a higher spatial resolution Quickbird image for burn severity assessment.

Introduction

The objective of the NBR is to highlight areas that have been burned and differentiate the levels of burn severity that occurred within a fire. Utilizing Landsat TM/ETM+ imagery, the NBR was developed integrating the two bands which *respond most to fire*, Landsat bands 4 (Near Infrared (NIR) at 0.83 μm) and band 7 (Short Wave Infrared (SWIR) at 2.21 μm). The NBR developed using Landsat in forested ecosystems is as follows:

$$\frac{\text{NIR} - \text{SWIR}}{\text{NIR} + \text{SWIR}}$$

In this study we explore ways to modify this NBR equation to one that is more applicable to rangeland ecosystems. A study area, located in Southeast Idaho's Upper Snake River Plain, is used to demonstrate the modified NBRs. The study area is a sagebrush-steppe rangeland ecosystem, consisting primarily of native and non-native grasses, forbs, and many shrub sub-species of sage and rabbitbrush. The characteristics of low vegetation and especially high amounts of bare ground, such as is present in this study area, are difficult for satellite sensors to differentiate. This adversely affects the results of the NBR. Landsat imagery was used to show an NBR (using equation above) and a modified NBR for an August 2000 fire. Higher spatial resolution imagery (Quickbird) was also used to demonstrate burn severity. Because Quickbird does not have a mid-infrared band, it is not possible to perform an NBR. This study investigated the results of high resolution (2.5 mpp) Quickbird imagery vegetation indices with moderate resolution (28.5 mpp) Landsat imagery NBRs.

Materials/Methods

Pre and post-fire Landsat images of an August, 2000 fire were used to generate an NBR and two modified NBRs using ENVI software. The first modified NBR substitutes the SWIR band 5 at 1.65 μm for band 7:

$$\frac{\text{NIR} - \text{SWIR}}{\text{NIR} + \text{SWIR}}$$

The second modified NBR uses the Red band 3 at 0.66 μm , the NIR band 4 at 0.83 μm , and the SWIR band 5 at 1.65 μm :

$$\frac{2.5 + \text{NIR} - \text{Red} - (\text{SWIR} \times 2)}{\text{NIR} - \text{Red} - (\text{SWIR} \times 2)}$$

Band Math algorithm techniques were used in ENVI to produce the pre and post-fire NBRs. ArcMap was used to produce the differenced NBR. The Quickbird vegetation indices included a differenced 1) NDVI, 2) Reverse NDVI, and 3) SAVI. ENVI and ArcMap software were used to process these images. The algorithm for NDVI where Red = 0.66 μm and NIR = 0.83 μm :

$$\frac{\text{NIR} - \text{Red}}{\text{NIR} + \text{Red}}$$

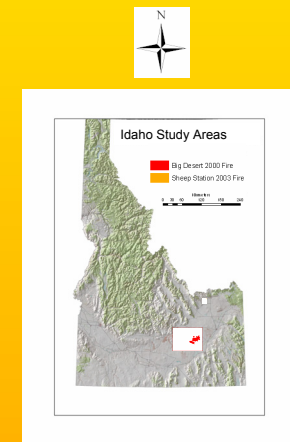
A reverse NDVI was done to show if the reverse intensity/color would be easier for visual qualitative interpretations:

$$\frac{\text{Red} - \text{NIR}}{\text{Red} + \text{NIR}}$$

To minimize soil brightness, an adjustment factor of 0.5 was used in the SAVI formula:

$$\frac{1.5 + (\text{NIR} - \text{Red})}{(\text{NIR} - \text{Red})}$$

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Landsat Normalized Burn Ratios From Big Desert

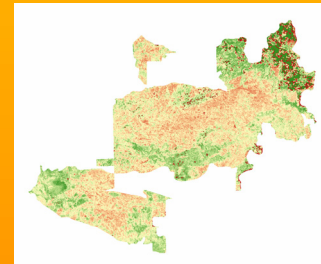


Figure 1a

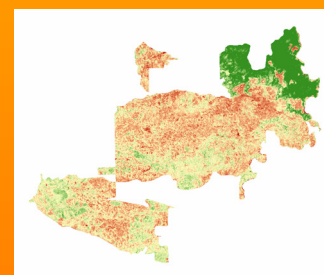


Figure 1b

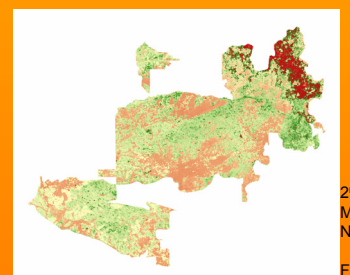


Figure 1c

Quickbird Vegetation Indices From Sheep Station

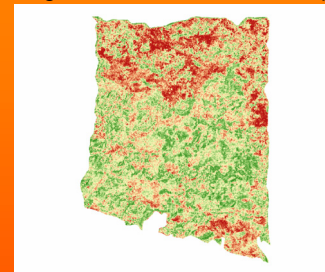
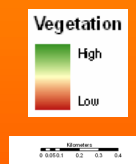


Figure 2a

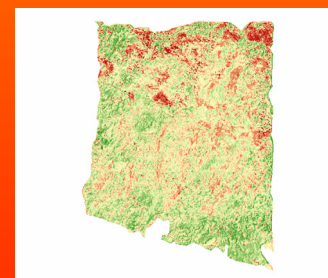


Figure 2b

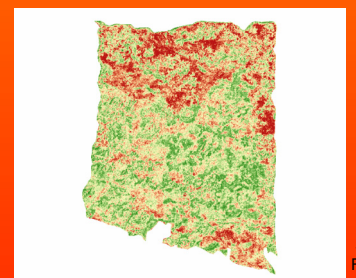


Figure 2c

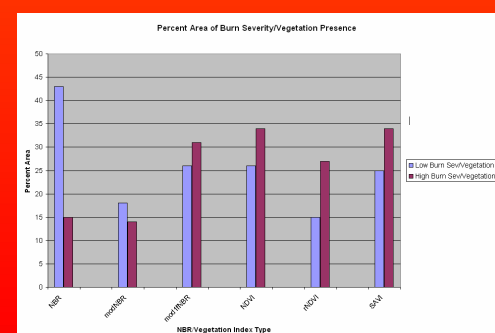


Figure 3

Results/Discussion

This study was performed to gain experience using different imagery types and their applicability for NBRs and vegetation indices. The results in figures 1 and 2 above show the visible differences between applied algorithms. The Quickbird results show that there is more vegetation in the Northern half of the spring image following the 2003 fire (figure 2). However, although Quickbird has much better spatial resolution, it is limited by the type of vegetation indices it can yield due to its spectral resolution. The Quickbird NDVI and SAVI yield very similar results (the latter using a 0.5 soil adjustment factor), indicating that the SAVI number doesn't account for the large soil reflectance very well (figures 2a & 2c). It is shown that to yield the best model, the timing of imagery is essential as well as similar plant phenological cycles. The Quickbird results would have been more useful for fire severity prediction if there was a pre-fire image at the same time as the post-fire image. There is more low severity burn area in the 2000 fire predicted with the NBR algorithms (figure 3). These Landsat NBR results are strong due to the timing of imagery around the fire dates. However, due to Landsat's 30 meter spatial resolution, the NBR results are constrained spatially.

