Geospatial Technology Using Digital Image Processing for C-Factor

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Abstract

What is a C-Factor? C-Factor: the land-cover management factor that is a ratio comparing the soil loss from a specific type of vegetation cover (1). The Land Cover Management Factor is a variable used to explain the consequences of poor crop management from soil water erosion. Plants can reduce the runoff velocity and protect surface pores. The C-factor measures the combined effect of all interrelated cover and management variables, and it is the factor that is most readily changed by human activities (2). The easy way to obtain the C-Factor of an area would be to use NLCD (National Land Cover Dataset) data and then reclassify it to the appropriate classification. Due to the most recent release of NLCD data being from 2011, one may say that's too far of a stretch in comparison with today's land cover and land use terrain. With the knowledge of digital image processing and geographic information science the C-Factor can be produced.

Keywords: C-Factor, NDVI, NLCD

Literature Review

Numerous studies have been conducted on how to obtain the C-Factor with current Landsat8 aerial imagery. However, with the use of ArcMap 10.5.1 and digital image processing, the C-Factor can be produced from a Landsat8 image. The C-Factor is a variable that is used in the Revised Universal Soil Loss Equation (RUSLE). The RUSLE model is an empirical equation, which was developed in the 1960s, by Wischmeier and Smith (1965) to predict long-term inter-rill and rill erosion rates based on the analysis of data for a large number of experimental plots in the United States (3). As the climate continues to change throughout time, so does the monthly and yearly rainfall average. Inter-rill erosion is a process of soil detachment by the impact of raindrops, transport by shallow sheet flow, and delivery to rill channels (4). An example of how the RUSLE soil loss equation model could be used, would be to find out if the soil from a local coal mine is being distributed to a river near by which would make the stream health and water quality unhealthy.

Discussion.

The most common and simple method to produce the C-Factor is to first, download a 30-meter National Land Cover Dataset (NLCD) from the United States Department of Agricultures (USDA) website. The C-Factor essentially, is a reclassification of the NLCD land use and land cover features which assigns each reclassification to a value based off its vegetation cover erosion rate. The most recent NLCD dataset published for the USDA was in 2011. With no current NLCD data being published by the USDA, one may find it hard to conclude the C-Factor for the current year or past two years. The difficult part about the C-Factor is not assigning the vegetation cover type to its appropriate value but how to go about classifying specific characteristics to certain vegetation types from an Aerial image.

Area of Interest and Data Ob.

The study area is a South Eastern HUC8 (Hydrologic Unit Code) in Kentucky. The HUC8 boundary contains the counties of Lee, Wolfe, Breathitt, Perry, Knott, Letcher. The data acquired for this project is Landsat8 30-meter aerial imagery from earthexplore.com. After downloading the aerial imagery, the rest is up to ArcMap 10.5.1 and its raster calculator. The only Landsat8 bands necessary for this project is band 4 (red) and band 5 (NIR). With the two Landsat bands, I must first construct a Normalized Difference Vegetation Index (NDVI). The NDVI is the equation (NIR – red)/ (NIR + RED). With this equation you are able to view and calculate the amount of green vegetation. Healthy vegetation (chlorophyll) reflects more near-infrared (NIR) and green light compared to other wavelengths, but it absorbs more red and blue light. This is why our eyes see vegetation as the color green. If you could see near-infrared, then it would be strong for vegetation too (6). The NDVI was made by using the raster calculator toolset in ArcMap 10.5.1. The output NDVI will be a 16-bit Landsat8 NDVI image. Since the 16-bit NDVI image has such high color and tone values, I will need to make it a 8-bit image for the C-Factor.

Landsat8 Bands and Conversions.

Landsat8 has improved signal to noise performance to enable better characterization of land cover state and condition. Products are delivered as 16-bit images (scaled to 55,000 grey levels). Landsat 8 file sizes are larger than previous Landsat data, due to additional bands and the improved 16-bit data product (5). The second step to achieving the C-Factor from the Landsat8 NDVI, is to convert the 16-bit Landsat8 NDVI image to an 8-bit image on order to have a smaller integer value size.

The C-Factor ranges between the variables of 0 to 1. The 16-bit NDVI has a very high value range, but to obtain the C-Factor, I must divide it by 256 to have lower values for the third step. In ArcMap 10.5.1, the divide tool is used to create the 8-bit NDVI. The reason why I have to divide the 16-bit image by 256 is because 2 to the 8^{th} power is 256, making it half of 16.

Conclusions and Future Study

Now having the NDVI as an 8bit image we can apply the C-Factor equation. The C-Factor equation is (1.02 – 1.21 * NDVI). In ArcMap 10.5.1, we apply the raster calculator again and insert the formula as printed. Since the 8bit NDVI now has a low integer value range, when applying it to the C-Factor equation we should get values between 0 and 1. The areas that have a high value close to 1 have a high land-cover man agent factor. These areas that indicate high in land-cover management are majority farm lands that have large cut grass pastures or fields. A future study I would like to do in my master's program at NCSU would be to write an article for the C-factor conclusion.

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Figures title:

Figure 1:

Normalized Difference Vegetation Index (NDVI)

Remote sensing techniques are employed for monitoring and mapping condition of ecosystems of any part of earth. Vegetation cover is the one of most important biophysical indicator to soil erosion. Vegetation cover can be estimated using vegetation indices derived from satellite images. Vegetation indices allow us to delineate the distribution of vegetation and soil based on the characteristic reflectance patterns of green vegetation. The Normalized Difference Vegetation Index (NDVI), one of the vegetation indices, measures the amount of green vegetation. The spectral reflectance difference between Near Infrared (NIR) and red is used to calculate NDVI. The formula can be expressed as (Jensen, 2000);

$$NDVI = (NIR - red) / (NIR + red)$$

Figure 1. Is the NDVI equation used to develop the vegetation in the areas using the red and NIR Landsat8 bands.

Figure 2:

$$C\ factor = 1.02 - 1.21 * NDVI$$

The final C factor map was generated using the regression equation in Spatial Analyst tool of ArcGIS 9.3 software. The graphs of regression analysis and C factor are given in Fig. 4 and Fig.5 respectively.

Figure 2. Is the C-Factor equation used to produce the land cover management factor.