

Remote Sensing Imagery in Agriculture: Image Conversion to NDVI

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Farmers can monitor the condition and overall health of their crops using images acquired by remote sensing instruments operating at ground level or in the air from planes or space platforms. This publication outlines the steps necessary to convert a remotely sensed image's measurements of visible light (red) and near-infrared (NIR) to a standard vegetation index called the normalized difference vegetation index (NDVI) (these bands are usually found in color infrared (CIR) images). The NDVI was first presented in the late 1970s and continues to be the most popular remote sensing index. The NDVI is strongly influenced by green plant productivity and leaf chlorophyll concentrations, and has the ability to normalize the data (to a certain degree). Chlorophyll content and leaf orientation (such as seen with a wilted or diseased leaves) are influenced by a variety of factors including available chemical nutrients, water, or infestation by destructive insects or disease. For this reason, the NDVI for healthy plants differs from those stressed by such factors as those listed above.

The NDVI ratio is calculated by dividing the difference in the near-infrared (NIR) and red color bands by the sum of the NIR and red colors bands for each pixel in the image as follows:

$$\text{NDVI} = (\text{NIR} - \text{red}) / (\text{NIR} + \text{red})$$

To convert an image, this equation must be applied to each pixel in the image, or a subset of pixels. Although the process seems easy, it is actually quite difficult to find software that will do this calculation. Most regular photo software does not have the ability to perform the mathematical color band operations on each pixel, and even if it does, the software may not be able to properly save or convert an image for display on a computer screen. The most common software that does the pixel conversion are Arcview® (ESRI Inc.), Multispec® (free – Laboratory for Applications of Remote Sensing, Purdue University), PixelWrench (Tetracam, Inc.), or the advanced versions of Agleader SMS software. In each program some amount of training and time may be required to achieve the desired results. The conversion process can also be programmed into computer languages, such as VisualBasic.NET (Microsoft Corp.) or C++, but this procedure is usually time consuming and requires moderate to high level programming skills.

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Figure 1. April 13, 2000, image for fields in northwest Kansas*. This false color composite was created using spectral bands 4 (NIR), 3 (red), 2 (green) and assigned to the red, green and blue color areas of the computer monitor.



Figure 2. April 13, 2000, image with NDVI values shown. Yellow equals low biomass while green equals high biomass. Notice that the NDVI has also normalized spectral variation among spliced images so the "stitch lines" between images are eliminated.

* Source Program: Earth Science Enterprise Scientific Data Purchase, NASA, Stennis Space Center Data Provider: Positive Systems (Whitefish, MT) Image Source: ADAR 5500

Figures 1 and 2 are examples of a CIR image (Figure 1) transformed into an NDVI image (Figure 2). Figure 1 was stitched together from 12 different images taken from a fly over on the same day. Figure 2 is the resultant NDVI image. The yellowish areas indicate lower biomass, while the more green areas indicate higher biomass. Note that the NDVI conversion helped take out splicing variance seen in the original CIR image (Figure 1).

Another example is shown in Figure 3. The left side (A) is a CIR image of a grass field taken with an airborne CIR camera. The resultant NDVI image is shown on the right side (B) and was converted with Labview[®] IMAQ (National Instruments Corp., Austin, Texas) software into an NDVI image. Note that some of the color depth was lost because of the monochrome image storage format¹. The less grey areas (B) and more pinkish areas (A) correspond to locations of higher biomass and healthier plants.

¹Loss of definition can sometimes occur in an NDVI image conversion when the image is saved to a monochrome image type file such as 8 or 16-bit that has less bandwidth than the original.

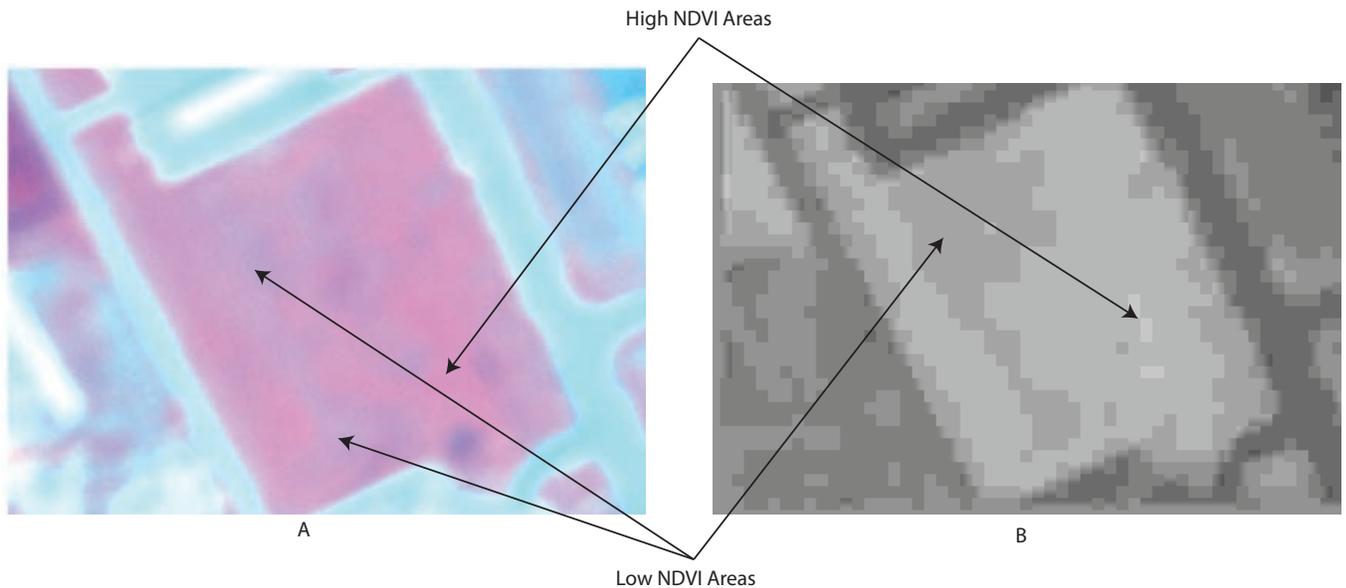


Figure 3: CIR image of a grass field (A) and the corresponding NDVI image (B).

When performing an NDVI conversion:

- a. The ratio must be calculated for each pixel in the image and then written back to either the original image (in one of the RGB spots) or a second image (usually monochrome).
- b. The NDVI ratio returns a real number between - 1 and +1 (such as 0.89), but the number must be rescaled to correctly display on a computer monitor. Most computers only use integers for displaying screen values which range from 0 and 255 for each color band, or more depending upon the file type, so the NDVI value must be rescaled to fit this range. Depending on the software, this process can be done by adding 2 (to make the range positive) and then multiplying by 127 to rescale to the 0 to 255 range. Other methods may be employed. Note that when storing back into a monochrome image, many different monochrome formats exist, such as 8-bit (0-255), 16-bit (0-65535), 32-bit, and floating point file types. Select one that can be viewed with your software and will still give you the color depth desired.
- c. Although the NDVI calculation will take out some image variations, cloud spots and other overly dark areas in an image will not return a good NDVI value that can be compared with other areas in the image.

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