Four Band Digital Imagery

INFORMATION SHEET
April 2010

What is four band imagery?

Four band imagery is multispectral, which means that it is collected from several parts of the electromagnetic spectrum. The spectrum is the entire range of light radiation, from gamma rays to radio waves, including X-rays, microwaves, and visible light. Four band imagery, when delivered to a customer, typically contains red, green, blue, and near infrared bands. Only three bands can be viewed at one time in most software applications in use at present. A user can choose to display an image as either natural color (red, green, and blue bands) or color infrared (infrared, red, and green bands).

What is color infrared imagery?

Color infrared (CIR) film is a three layer product, with individual layers being sensitive to red, green, and near infrared wavelengths. Near infrared (NIR) wavelengths are slightly longer than red, and they are outside of the range visible to the human eye. Blue wavelengths, a part of natural color film, are filtered out of CIR.

Digital imagery acquisition uses charge coupled devices (CCDs) which are sensitive to different wavelengths in the electromagnetic spectrum. All four bands are routinely collected in digital acquisition. A CIR product can be created from the raw digital data, or all four bands can be delivered to the customer.

How does a color infrared display differ from natural color?

A natural color image displays the colors as they would appear to human eyes under normal conditions. Conventionally, a CIR image is set up to display the infrared band data with a red tone. Red wavelengths will appear green, and green wavelengths will appear blue. Blue wavelengths are not displayed. Because the healthy green vegetation will appear to be bright red, a CIR image is also known as a "false color" image.

How can a user change from natural color to CIR in the display?

The user must have software which will recognize all four bands. The software will usually have some type of interface where the band assignments can be changed.

If an image is set up with the red (wavelength) band as band 1, green as band 2, blue as band 3, and near infrared as band 4, a natural color display on the computer screen would be set up with the red (display) channel as band 1 (red), green channel as band 2 (green), and blue channel as band 3 (blue). CIR would be set up with the red channel as band 4 (NIR), the green channel as band 1 (red) and the blue channel as band 2 (green). Band 3 (blue) is omitted.

Why was color infrared developed?

CIR film was developed during World War II by Eastman Kodak to assist in detecting camouflage, because it can distinguish a plant cover from other materials. It has since been used for many other applications involving vegetation; the primary purpose being to monitor the health of crops or forests. Trained analysts can sometimes distinguish different plant species from their tone in the image, known as the "spectral signature."

What is the advantage of CIR?

Color infrared is especially useful because the internal cell structure of healthy plants reflects near infrared wavelengths. Chlorophyll in plants reflects green wavelengths; this is why healthy plants appear green to humans. In addition, the reflected infrared is more reliable in monitoring plant health than the reflected green wavelengths.

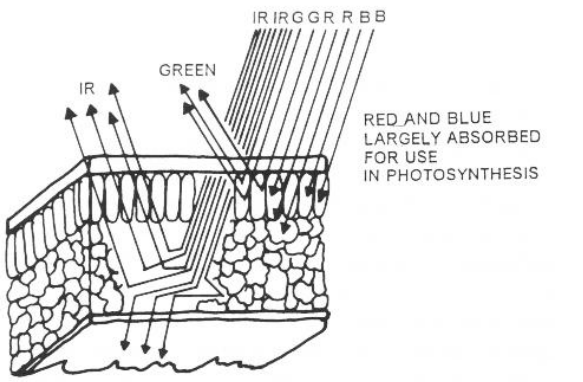
CIR tends to penetrate atmospheric haze better than natural color, and it provides sharper imagery. This makes CIR especially valuable in areas of the country which are hot and humid in the summer.

How is four band imagery used in agriculture?

Four band imagery is useful in agriculture because a bright red color is an indication of healthy vegetation. Variations in the red color can indicate stressed vegetation. These stresses can include a lack of fertility, insect infestation, soil deficiencies, and over or under watering.

CIR can be used for such purposes as crop inventory and analysis, crop stresses, monitoring fertilizer applications, and yield estimates. CIR can also help analyze soil properties, such as permeability, salinity, and erosion. The Normalized Difference Vegetation Index (NDVI), can be derived from digital CIR data, and is key indicator in plant analysis. (Source: Crook)

- **How does a leaf react to solar radiation?**



Green wavelengths are reflected off the outer palisade tissue, while infrared is reflected off the inner mesophyll tissue. (Source: Campbell, 1996).

- **What is the NDVI?**

The NDVI is one of several indexes mentioned in literature dealing with plant health. The Forest Service uses it in assessing wildfire risk. This index is "derived from a mathematical normalization technique that utilizes only the red and near-infrared energy measurements…

The NDVI measurement takes into account the amount of red energy that is absorbed by chlorophyll and the amount of near-infrared energy that is reflected by the cellular structure of the leaf (because the red and near-infrared measurements are normalized in an indirect measure of vegetation health)." (Source: Servilla).

The formula is (NIR – Red)/ (NIR + Red), where NIR is the Near Infrared channel, and Red is the Red channel.

- **How is four band imagery used in precision agriculture?**

Precision agriculture uses technological advances, such as GIS, GPS, and Remote Sensing, to assist with agricultural operations. Four band imagery gives the farmer two views of the fields, with CIR providing a clearer picture of plant health, as well as the data for calculating the NDVI.

Ground level sensors owned by a farmer can be mounted on a vehicle or be handheld, and will remotely sense and/or map the field while driving through it. They can output raw imagery or index values calculated from the data capture. The output can be used with four band imagery to provide greater temporal resolution for indexes such as the NDVI. (Source: Casady & Palm)

- **How does four band imagery benefit FSA's agricultural programs?**

CIR provides more detail in the imagery than natural color, and the vegetative and cropping boundaries are more distinct in the image. Crop health and soil moisture variations are more apparent with CIR.

Data analysis (uncompressed data) benefits from CIR, as supervised, or automated unsupervised, classifications can identify crops and characteristics not evident to the naked eye. CIR provides the county offices with the opportunity for greater visual interpretation and digital analysis. The continued option for a natural color image allows FSA personnel the opportunity to print out color maps for farmers with the fields appearing in their natural tones. (Source: Crook)

- **How many NAIP projects have been flown in CIR?**

Natural color is the default for NAIP projects. CIR is available on request by the states or partners, and four band imagery is a "buy-up" product. Missouri was flown with CIR in 2003, and Illinois, Pennsylvania and Texas received CIR in 2004. Michigan received CIR in 2005, and Texas again received CIR in 2006.

- **Have there been any other CIR acquisitions?**

Some of the imagery from earlier film photography programs were flown as CIR. Some of this film was scanned and orthorectified as part of the National Digital Orthophotography Program (NDOP).

- **What states are available in four band?**

In 2007 Arizona was the pilot state for the first four band imagery acquisition through the NAIP program. In 2008, eight states received four band imagery. They were: CN, IN, KS, MN, TN, TX, VT, and VA. In 2009, fifteen states received four band imagery. They were: WA, OR, MT, CA, CO. WY, ID, ND, NE, AL, GA, SC, NC, MD, DE. This trend will likely continue in 2010

Sources:

Casady, William and Harlan Palm. *Precision Agriculture: Remote Sensing and Ground Truthing*. University of Missouri Extension.
Crook, Brian. FSA GIS Coordinator, Texas. 2008.
Servilla, Mark. *The First Steps to Understanding Agriculture Remote Sensing*: Modern Agriculture, 1999.
Campbell, James. *Introduction to Remote Sensing*, 1996.

- **Who do I contact for more information?**

1. For sales information, contact USDA-FSA-APFO at 2222 W 2300 S, Salt Lake City UT, 84119-2020, call 801-844-2922, or visit http://www.apfo.usda.gov.
2. For further information contact GIS Specialist Nathan Pugh at 801-844-2927, or GIS Specialist Louise Mathews at 801-844-2934.