Normalized Difference Vegetation Index (NDVI) Analysis for Forestry and Crop Management
Normalized Difference Vegetation Index (NDVI)

- **How NDVI Works**

  - Live green plants absorb solar radiation in the photosynthetically active radiation (PAR) spectral region, which they use as a source of energy in the process of photosynthesis.

  - NDVI is calculated from the visible and near-infrared light reflected by vegetation. Leaf cells scatter (i.e., reflect and transmit) solar radiation in near-infrared spectral region strong absorption would overheat the plant possibly damaging the tissues.

  - Live green plants appear relatively dark in the PAR and relatively bright in the near-infrared (Gates 1980). Clouds and snow tend to be rather bright in the red (as well as other visible wavelengths) and quite dark in the near-infrared.

  - NDVI is calculated from these individual measurements as follows:
    - \[ \text{NDVI} = \frac{(\text{NIR} - \text{Red})}{(\text{NIR} + \text{Red})} \]
    - where RED and NIR stand for the spectral reflectance measurements acquired in the red and near-infrared regions, respectively. NDVI itself thus varies between -1.0 and +1.0.

Healthy vegetation (left) absorbs most of the visible light that hits it, and reflects a large portion of the near-infrared light. Unhealthy or sparse vegetation (right) reflects more visible light and less near-infrared light. The numbers on the figure above are representative of actual values, but real vegetation is much more varied. (Illustration by Robert Simmon)
NDVI Applications for Forestry and Crop Management

• Stress assessment (droughts, fertilizing stripes (uneven) etc.)

• Species Delineation

• Leaf Area Index, biomass, chlorophyll concentration in leaves, plant productivity, fractional vegetation cover, accumulated rainfall, etc.

• Moisture problems detecting and measuring areas of crop stress caused by too much or too little precipitation or by inadequate drainage

• Fertilizer, insect, disease weed and herbicide problems

Three NDVI applications (Top) biomass and (Middle) fraction of absorbed photosynthetically active radiation (FPAR) (Bottom) leaf area index (LAI), Great-Plains grasslands - 1995.

Characteristic NDVI Signatures

- NDVI of dense vegetation canopy will tend to positive values (say 0.3 to 0.8). Clouds and snow fields will be characterized by negative values of this index.

- Free standing water (e.g., oceans, seas, lakes and rivers) which have a rather low reflectance in both spectral bands (at least away from shores) and thus result in very low positive or even slightly negative NDVI values.

- Soils generally exhibit a near-infrared spectral reflectance somewhat larger than the red, and thus tend to also generate rather small positive NDVI values (say 0.1 to 0.2).

- Very low values of NDVI (0.1 and below) correspond to barren areas of rock, sand, or snow.

- Moderate values represent shrub and grassland (0.2 to 0.3),

- High values indicate temperate and tropical rainforests (0.6 to 0.8).
Conducting NDVI Analysis with our Sensor

- **Our sensor could also provide data for Wetland Delineation**
  - Using Remote Sensing classification techniques and by integrating existing datasets into suitable geospatial processing models to develop expert systems for identification
  - Imagery of existing wetlands provides a source of "a priori" knowledge of wetland characteristics that can be used to locate potential wetlands areas that have not been delineated.
  - Our data used in combination with existing historical field data can be used to create a cumulative knowledge base that improves the accuracy and efficiency of wetlands delineation with each use.
  - As we improve the capability we could integrate historical field data, and species data as input for supervised classification. We could develop an expert system to classify plant species from imagery.

- **Benefits of Our Camera System and Process**
  - Can employ custom narrow band filter combinations for specific vegetation types.
  - Our data is collected at 12-bits. That's 1600% more pixel values collected for each channel, critical for classification.
  - A simple NDVI type map can give field technicians a quick and easy way to know where to look and where not to look.
  - Imagery is a very good QA tool for data collected in the field.
  - Processing techniques can work with USGS or other data for digital terrain data suitable for hydrological analysis
NDVI Analysis

1. Raw image
2. A simple equalization helps pull out contrast.
3. An NDVI layer is calculated for the cotton field. Dark areas have low chlorophyll and light areas have more. The NDVI is an index ranging from -1.0 to 1.0.
4. NDVI layer was color coded to better visualize vegetation coverage.

Actual NDVI Data
Basic Image in Visible Spectrum (R, G, B)

Color Image Using Three Bands (Red, Green, Blue)
Basic Image in Near IR

True Color Near IR Image Georegistered with the Visible (R, G, B) Image Prior to NDVI Calculations
Standard NDVI Calculation

\[ \text{NDVI} = \frac{\text{NIR} - \text{Red}}{\text{NIR} + \text{Red}} \]
Examples of IR Analysis

NDVI Index Indicating Water

Soil Adjusted NDVI
Examples of IR Analysis

Map delineating Grass, Small Trees/Foliage and Pine Canopy
NDVI Delineating Roads, Water from Biomass Characterizing Stress Areas

More detailed analysis could further characterize sources of stress.

NDVI Demonstrating Roads, Grass, and Pine Canopy Identifying Areas of Potential Stress