TRACKING NDVI IN TIME AND SPACE: KNOW THE PHYSIOLOGY BEHIND THE NUMBER

Jacob Nederend, B.Sc. (Agr.)

DEVERON
A New Level of Farming

TRACKING NDVI IN TIME AND SPACE: KNOW THE PHYSIOLOGY BEHIND THE NUMBER

Jacob Nederend, B.Sc. (Agr.)
Research Agronomist, UAS Agriculture
jnederend@deveronuas.com

Managing farm tasks around the weather is a perpetual struggle, and as UAVs integrate into the cropping toolbox, the weather poses similar issues due to variable conditions. Differences in sunlight levels are particularly concerning because sensors respond to the amount of light striking the imaging array. Deveron uses the latest sensor technology to eliminate this variability by calibrating images against incoming light and a target of known reflectivity. This calibrated imagery enables growers to monitor their crops using measurements that are stable through time. By standardizing each flight to the conditions on that day, the resulting maps can be compared at regular intervals or targeted timings during the growing season. The Normalized Difference Vegetation Index (NDVI) is one representation of the collected data that provides an overview of the size and greenness of the crop canopy.

$$\mathbf{NDVI} = \frac{NIR - RED}{NIR + RED}$$

Equation 1

The NDVI formula (*Equation 1*) takes the difference of near infrared and red reflectances and divides it by their sum to provide an index scaled from -1 to 1. But what do these values really mean?

The Micasense Rededge is one of the calibrated sensors we use. The bottom-mounted sensor measures reflectance, while the top-mounted sensor simultaneously records the incoming sunlight in the same wavebands.

NDVI IS BOTH A *"LEAFINESS"* AND *"GREENNESS"* INDEX

Reflectance values in agricultural fields have distinct seasonal patterns (*Fig. 1*) that follow the growth and development of a crop. Since red and blue light provide the energy to drive photosynthesis, the reflectance of those wavelengths decreases as the leaf canopy becomes larger and more chlorophyll absorbs the intercepted light. At the same time, NIR reflectance largely depends on the size of the crop canopy, and continues to increase until around the time of flowering in many crops. The result of these two factors on NDVI is increased sensitivity to leaf area early in the season, and a shift to sensitivity to chlorophyll content as the canopy matures.

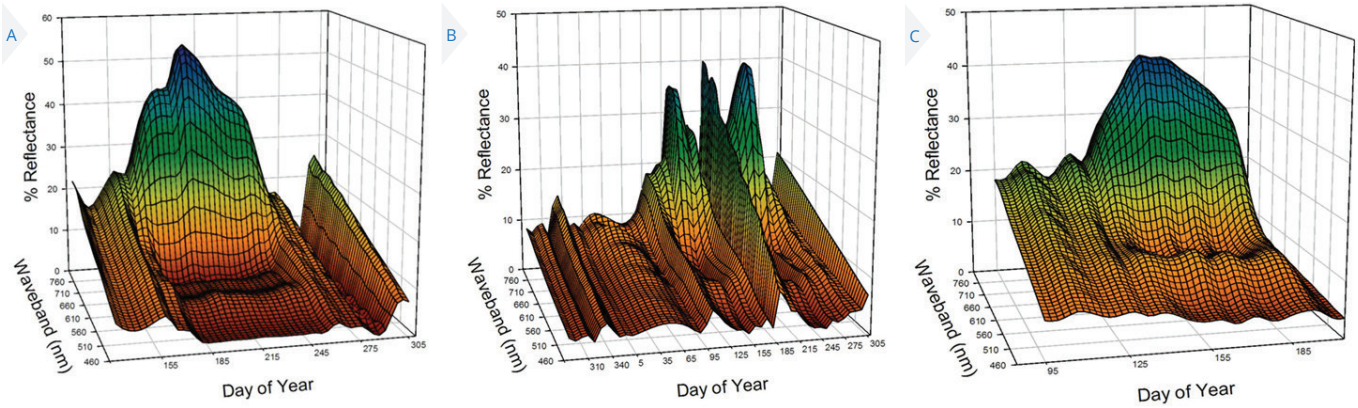

*Figure 1: Seasonal reflectance values for corn **(a)**, winter wheat (DOY < 180) and double-crop soybean (DOY > 180) **(b)** and spring canola **(c)** collected in Iowa in 2007 for an experiment conducted by Hatfield and Prueger (2010)*

TIMING UAV SURVERYS
EARLY SEASON IMAGERY SHOWS YOU WHAT'S THERE (AND WHAT ISN'T)

When planning UAV operations for the season, think about how crop growth and development will affect the goals you can achieve. Early in the season, a lack of leaf area makes NDVI a poor candidate for problems related to greenness. In addition to having less vegetation than at more developed stages, most young crops do not express nutrient deficiencies until they enter the steep parts of their uptake curves (*Fig. 2*). Differences in nutrient status will also be masked by starter fertilizer. Instead, use early-season imagery to assess issues related to the presence and uniformity of vegetation identified by the NDVI. These opportunities are numerous but some of the common use cases include:

- Assessing winter survival of wheat and forages
- Emergence counts
- Determining post-emergent stand reductions

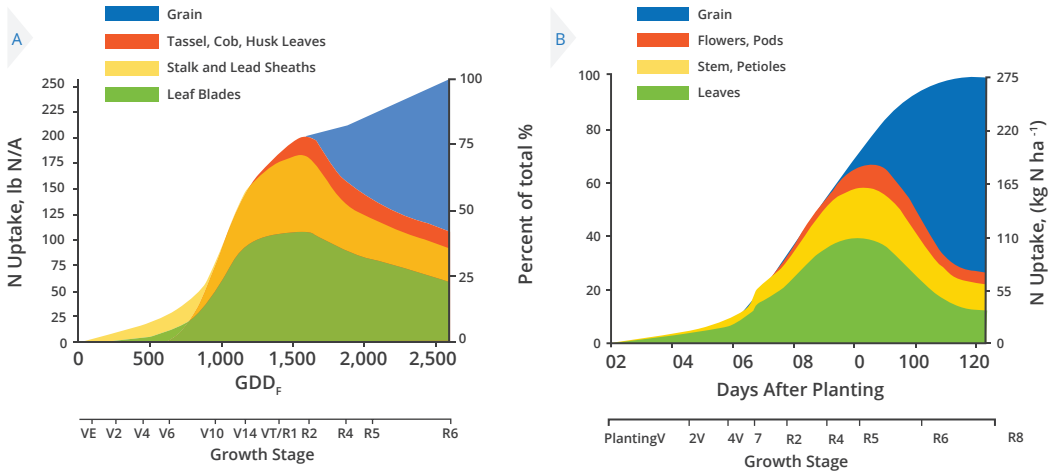

*Figure 2: Nitrogen deficiency is a common reason for reduced leaf greenness. The uptake curves for corn 2 **(a)** and soybean 3 **(b)** show that very little nitrogen is taken up in the early stages, but that rapidly changes as the slope of the curves becomes steeper*

The above applications rely on the NDVI's ability to identify if there is (or isn't) crop where you would expect it. The earlier that growers can identify problems in their crop stands, the greater the opportunity to rectify the problem. The aerial perspective and high detail of UAV imagery is ideal for supporting re-plant decisions while there is still enough growing season left to produce a profitable crop.

MID-SEASON IMAGERY

The crop will reach a point where leaf area will be large and uniform enough to be an insignificant contributor to variation in the NDVI. At the same time, the crop will be in an explosive stage of growth where stress factors begin to influence the reflectance of leaves. Using NDVI to delineate zones of stress, and on-the-ground data to identify the causes, growers can apply variable rate prescriptions of fertilizer or pesticides without the need for historical yield data. Surveys can be targeted for specific management goals, like sidedressing nitrogen into corn, or conducted at regular intervals to monitor for sudden changes in crop growth that may warrant intervention outside of the usual product application timings. Calibrated imagery is important at this timing because it ensures that the variability observed by the NDVI is related to biophysical parameters like nutrient deficiency or disease development. Uncalibrated imagery is suitable for detecting general variation, but without accounting for the incoming light, the measured NDVI might be biased up or down, which means any relationships between the index and actual crop biophysical characteristics will be inaccurate.

TRACKING NDVI WITHIN AND BETWEEN FIELDS

Aerial imagery as a digital notebook

Record keeping is a key part of learning and improving as a farmer. Pen and paper may have turned to spreadsheets and word processors, but using past experiences to support decisions in the current year remains important. With calibrated imagery collected by Deveron, growers can track observations of every acre and compare the progress of crops both past and present.

NDVI cross comparisons—it's not just the number

Using NDVI to compare the health of several fields in the same year, or of the same field over many years, is not as basic as looking at the pixel values. For the former, be aware that varietal differences in reflectance do exist. This means that, all else being equal, the same growth patterns would be identified by different magnitudes of NDVI for different varieties. Always keep the two underlying factors in mind when comparing NDVI as well. Discrepancies in NDVI between fields or years will be explained by one or both factors, making unbiased comparisons a challenge if no additional information accompanies the index. For example, two corn plants can have low NDVIs, but in one plant the low NDVI is related to stunted growth due to early-season frost damage, and in the other plant it is due to a nitrogen deficiency. Extrapolating this situation to the field scale demonstrates that comparisons of the general progress of a crop are valid, but supporting information is mandatory to draw any deeper conclusions.

*Variability of NDVI in poorly performing crops will be driven mostly by the amount of leaf area **(a)**, whereas greenness is likely to be a more significant contributor in healthier parts of the field **(b)***

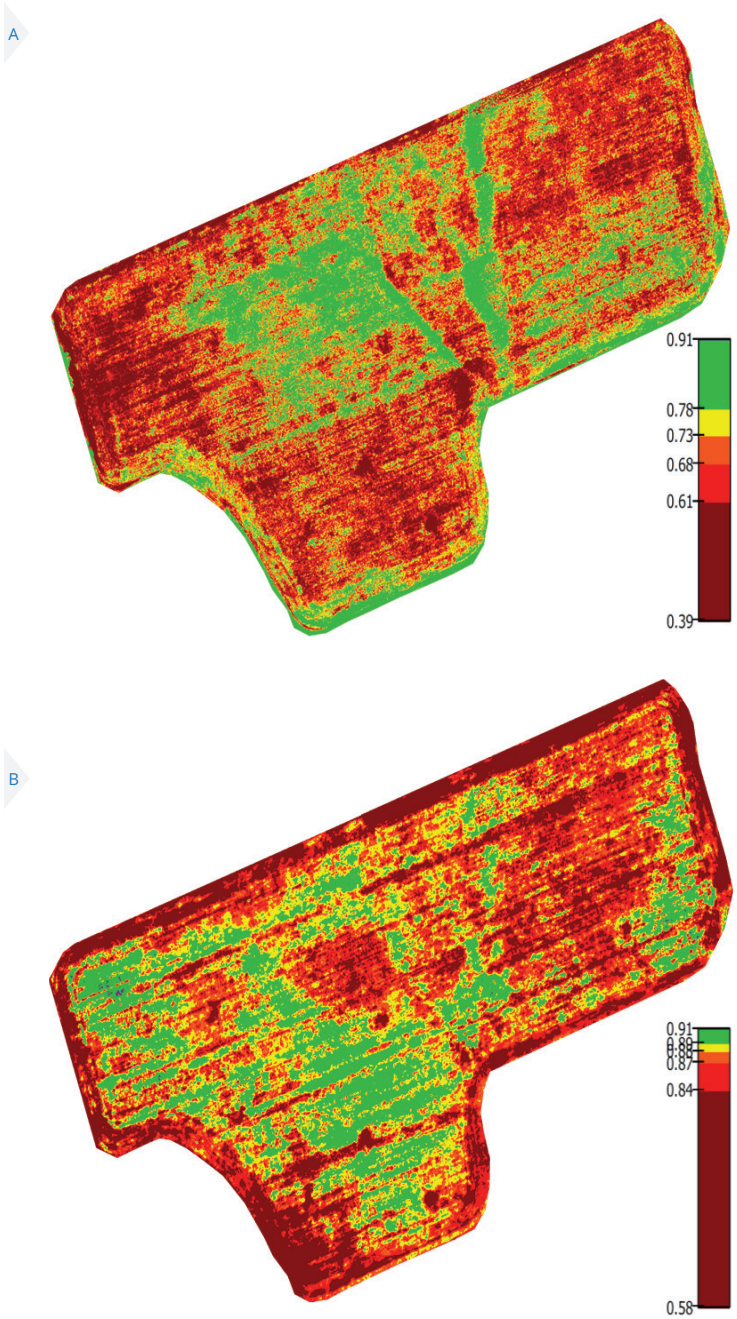

Figure 3: *The above NDVI maps of a soybean field were acquired on 2017 on August 20* ***(a)*** *and September 19* ***(b)****. The symbology emphasizes a shift in the distribution of NDVI over 4 weeks. Each colour interval on the scales covers an equal area of the field, rather than defining intervals by fixed values, to maximize visibility of variability.*

Scales are visual, not numerical

When comparing NDVI maps, remember that the colours are just a visual representation of the data and do not impact the actual values. Altering the visualization (known as symbology in the remote sensing world) can reveal or hide variability in NDVI. If the goal is to find the top performing regions of a field over time, using a uniform scale might eliminate the ability to see variation because the distribution of NDVI values early in the season will be drastically different from that of mid-season imagery [Fig. 3]. Scaling the colours by the maximum and minimum NDVIs across all the surveys in a time series will provide the best compromise between visibility of variation and ease of comparisons between dates.

REFERENCES

1. Hatfield, J.L., and J.H. Prueger. 2010. Value of using different vegetative indices to quantify agricultural crop characteristics at different growth stages under varying management practices. Remote Sens. 2(2): 562–578.

2. Bender, R.R., J.W. Haegele, M.L. Ruffo, and F.R. Below. 2013. Modern Corn Hybrids' Nutrient Uptake Patterns. Better Crops. 97(1): 7–10.

3. Bender, R.R., J.W. Haegele, and F.E. Below. 2015. Nutrient uptake, partitioning, and remobilization in modern soybean varieties. Agron. J. 107(2): 563–573.

For more information or to discuss this article, please contact:

Jacob Nederend
jnederend@deveronuas.com
519-722-6026