

Assessing Nitrate Deficiency in Corn in Southern Minnesota

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## Objective

Nitrate is a common fertilizer that is applied to agricultural fields throughout the Midwest. However, excessive amounts of this nutrient can negatively impact streams, rivers, and lakes. The surface waters within the Mississippi River Basin contribute to hypoxia in the Gulf of Mexico. Nitrate and phosphate fuel algae growth, which, when it decomposes, consumes dissolved oxygen within the coastal waters. Without oxygen, aquatic organisms such as fish and shrimp cannot survive.

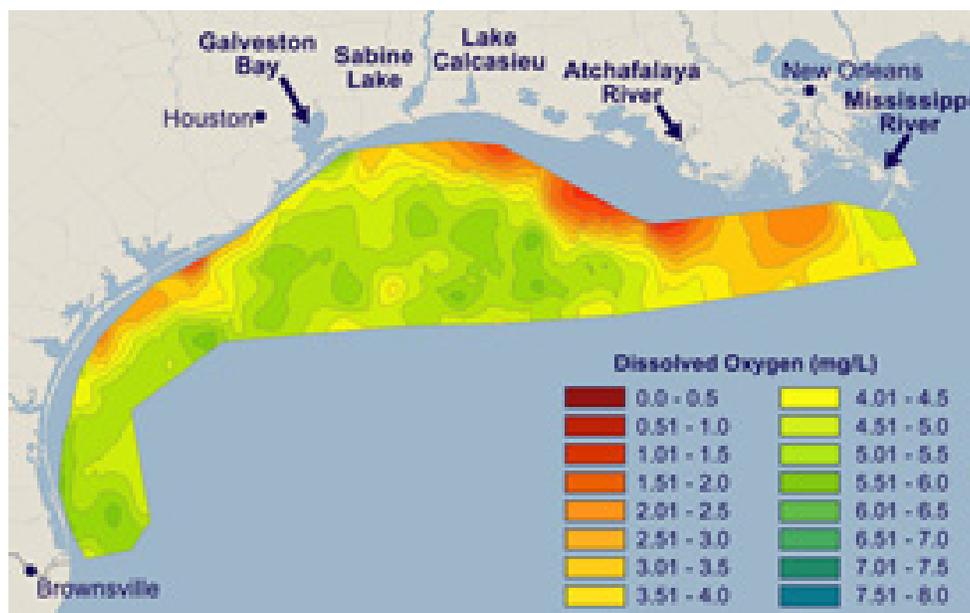


Figure 1: 2013 map of the hypoxic zone in the Gulf of Mexico (EPA, 2013).

With the use of precision agriculture, the amount of nitrate applied can be closely managed for monetary, crop, and environmental impact. By monitoring corn health throughout the growing season, nitrate can be applied to the field when the corn needs it, rather than applied to the entire field early in the growing season. Careful timing of fertilizer application not only minimizes fertilizer runoff, but can improve crop productivity and farm profitability.

By using remote sensing, nitrate deficiencies in corn plants can be quickly identified. These plots can then be fertilized with the necessary amount of fertilizer, when the corn needs it. To determine

areas of corn stress within a field, multispectral data gathered by an unmanned aerial vehicle (UAV) and Tetracam device were used to capture images of the field. This multispectral data was compared to ground data gathered on the same day as the aerial images.

The Tetracam has six cameras, allowing for six images at different wavelengths to be gathered simultaneously. These wavelengths were: 443 nm and 482.5 nm (blue), 565 nm (green), 660 nm (red), 790 nm (red edge), and 867.5 nm (near-infrared).

Large folding tables were set up in the field to coincide with previously gathered GPS points marking the boundaries of the field.

### Methods

Aerial imagery was gathered from the Tetracam and organized into different flights. This image would be rectified using GPS points gathered for the test site. The Normalized Difference Vegetative Index (NDVI) for the image would then be calculated and compared to data gathered by the Soil Plant Analysis Development (SPAD) meters.

### Results

Both ERDAS Imagine 2013 and ArcMap 10 were utilized to examine the aerial images. After attempting to georectify an image from the Theilman site in southern Minnesota in ERDAS, I called upon Joel Nelson to help me with the rectification. Using MNGeo's statewide imagery, we were able to determine that the images from the Tetracam were not properly oriented. It was a simple fix to re-orient the image and successfully georectify it. We attempted to use a polynomial order of 2, but with only four GPS coordinates we were able to use a polynomial order of 1. The georectified image had an RMSE of 0.0018.

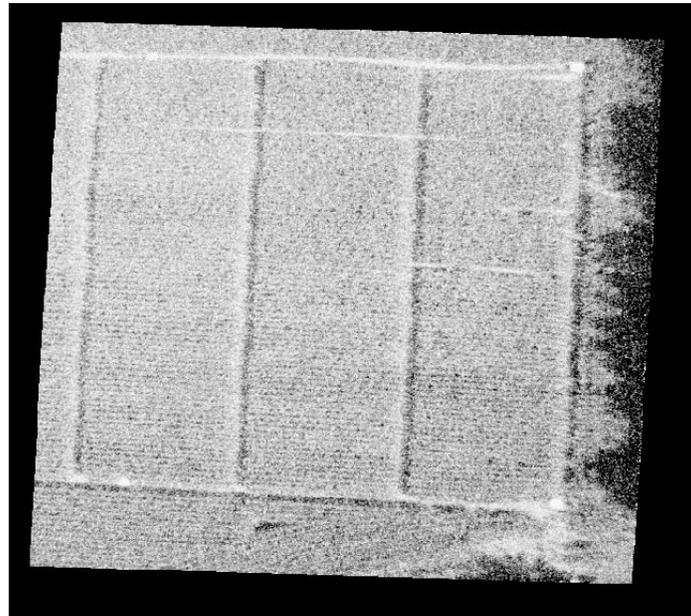
However, after georectifying the image, I realized that most of the spectral information had been confused within the new image. I thought I could split the TIFF file into its six sub-images and georectify them independently, but quickly realized that the process would not only be time-consuming, but would also prove difficult with some of the 'washed-out' images. After reading the ERDAS Imagine help guide, I attempted to create a virtual stack of images within the program. This process proved difficult, as the program continually stopped working and quit abruptly. This went on for quite some time, until I was successfully able to load the image as a virtual stack. From there, I was able to georectify all 6 layers of the TIFF file at once, and not lose any spectral information.

From there, I began the process of determining NDVI for the image. However, an image that was supposed to have just 6 bands suddenly had 9 bands. ERDAS Imagine had a total of four bands that fell within the near-infrared range, if the values detected by the program were indeed correct. I chose to use the default selected NIR and Red bands, as they appeared to line up with the information I had.



*Figure 2: The first NDVI image created by ERDAS and default bands (660 nm and 790 nm).*

The image above is the result of using the 660nm and 790 nm bands to calculate NDVI. Obviously no useful information could be derived from it. I next created an NDVI image using the 660 nm and 867.5 nm bands, which yielded an image that looked a little more promising, but still didn't show the difference I was expecting.



*Figure 3: NDVI output using 660 nm and 867.5 nm bands.*

NDVI images created using the higher near-infrared bands (1250, 1650, 2215 nm) were not created, as they would not be helpful in assessing nitrate stress.

After inquiring after SPAD meter data, I realized that I would be unable to generate the logarithmic curve to determine the average chlorophyll values of each plot. I had thought the data gathered in the field could be directly compared to the NDVI produced from the image. Needless to say, I was mistaken.

### Discussion

The breadth of the proposed project turned out to be too much to accomplish within a two month period. I realize now I was essentially attempting to complete my two-year research proposal for

this project—which was ambitious but foolish of me. In hindsight, I should have created a project that was much more obtainable within the time frame.

However, I have determined what I need to do to move forward with my own research. Dr. Mulla and I need to discuss my results, and how I can obtain usable information. I also need more complete data for the ‘ground truth’ information, and to know how to use the SPAD meter readings.

### Conclusions

Overall, this appears to be a failed project. My optimistic timeline was due to not realizing the sheer magnitude of what I had proposed, compounded by data accessibility. Despite my lack of definable results, I have gained a great deal of knowledge regarding ERDAS Imagine, ArcMap, and all of the little pieces of information that I need to know before I get started on a large project. I feel that I have a better idea of what the next year and a half of research will entail for me, and have the resources and tools to successfully complete my research.