# Analyzing the Impact of Wind Turbines on Crop Condition in Story County, Iowa Using Airborne Hyperspectral Imaging

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## Abstract

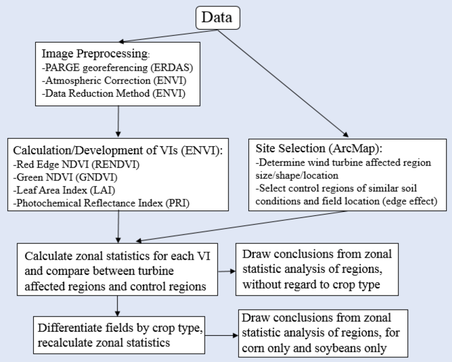
The number of wind turbines in Iowa is rapidly increasing. Many of these wind turbines are built on agricultural land, yet the effects they have on crop condition are poorly understood. If wind turbines affect crop condition, it could impact agriculture in the United States. Through calculation and comparison of four vegetation indices derived from hyperspectral data, this study sought to quantify this impact. Airborne hyperspectral data of corn and soybean fields in Story County, Iowa were collected, providing 332 bands between 398.35 – 1001.04 nm. Four vegetation indices (red-edge NDVI, green absorption NDVI, leaf area index, and photochemical reflectance index) were calculated in regions near the turbines, which were compared to control regions away from the turbines. In general, the presence of turbines negatively affected crop condition; however, the effect varied by crop type. Specifically, the presence of turbines tended to benefit corn crops but negatively impact soybean crops.

## Research Goal and Objectives

Determine the impact of wind turbine presence on local crop condition using vegetation indices indicative of different crop properties

1) Calculate four vegetation indices: red edge NDVI (RENDVI); green NDVI (GNDVI); leaf area index (LAI); photochemical reflectance index (PRI) using selected hyperspectral bands
2) Determine size/shape/direction of wind turbine affected wake regions and control regions
3) Compare vegetation indices in wind turbine affected wake regions and control regions to determine if significant variability exists between the two using zonal statistics
4) Determine whether the effect of wind turbines differs between corn and soybean fields

## Methods




## Data Sources

- Airborne Hyperspectral Data acquired by Headwall Photonics A Series Hyperspectral Imager, acquired July 22, 2015 (3 flight paths), includes 332 spectral bands (398.35 – 1001.04 nm)
- SSURGO Soils maps via Iowa Department of Natural Resources joined with CSR2 tables from Iowa State University to determine corn suitability ratings
- Prevailing wind data acquired from Ames Municipal Airport (July 1 - 23, 2015)
- CropScape data for crop discrimination via United States Department of Agriculture (NASS)

## Results

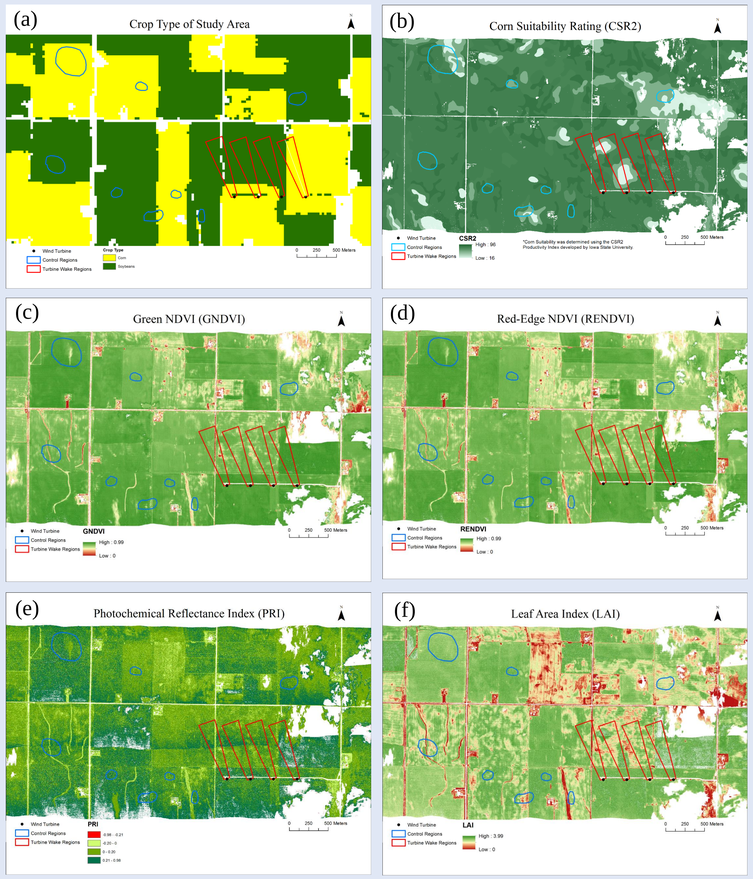



**Fig. 1** Maps of the study areas depicting measures of crop type (a), corn suitability rating (b), and the four calculated vegetation indices (c-f). The red shapes represent regions in the wake of wind turbines and blue circles represent control regions used in this study.

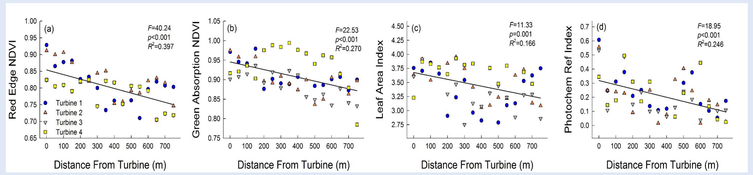



**Fig. 2** Linear regressions of the four vegetation indices against distance from a wind turbine. One measure was made at 50m intervals (0-750m) within the wake region of the four wind turbines. The values of all four vegetation indices declined as distance from the wind turbine increased.

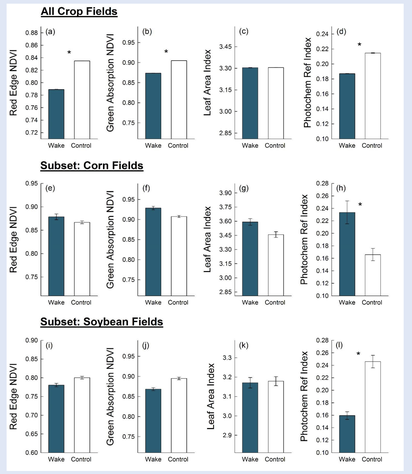



**Fig. 3** Variation in four vegetation indices between regions in the wake of turbines (wake) vs. regions away from turbines (control). Data was divided into all fields (a-d), corn fields (e-h) and soybean fields (i-l). * indicates a significant ($p<0.05$) difference between the wake and control regions based on two-tailed pooled t-tests.

### Summary of Results

- There was significant variability in the four vegetation indices across the study area (**Fig. 1**).
- All vegetation indices declined as distance from the turbine increased (**Fig. 2**).
- In general, the presence of turbines negatively affected crop condition (**Fig. 3a-d**); however, the effect varied by crop type.
- The presence of wind turbines tended to improve crop condition for corn plants (**Fig. 3e-h**) and negatively impact crop condition for soybean plants (**Fig. 3i-l**).
- PRI (**Fig. 3h,l**) showed the most pronounced difference between wake and control regions.

## Conclusions

- The linear regressions suggest that wind turbines actually improve crop condition. Nevertheless, this analysis may have been biased by the shift from corn to soybean across the wake area and the differential effect of turbines on these crops.
- The negative impact of wind turbines overall is a disappointing result for American agriculture; however, this effect could be due to a higher % of soybean in wake vs. control areas and general differences in spectral signatures between these crops.
- The differential impact of turbines on corn (positive) vs. soybeans (negative) could be related to cooling, especially for PRI, which is a measure of light stress. The differing impact of turbines on corn vs. soybean could also be due to differences in crop height.
- Future analyses should also:
    1. Quantify biomass to supplement measured parameters
    2. Ensure consistent farming practices across study area
    3. Ensure full range of spectral data collection (i.e. red wavelength)

## Acknowledgments

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