EVALUATING CHANGES IN AGRICULTURAL PRODUCTIVITY FOR CENTRAL KENTUCKY USING LANDSAT AND sUAS DERIVED VEGETATION INDICES: 1988 TO 2018

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ABSTRACT

In 2015, Kentucky agriculture contributed indirectly to $50 billion in economic stimulus and 250,000 jobs in the state. Yearly estimates vary, particularly for small operations (the bulk of farms in the state), but the 2017 Agricultural Census reported almost 1 million acres removed from agriculture activity during the previous 5 years, including 100,000 acres lost permanently to development. Given the macro scale changes in the agricultural industry, how has the distribution and magnitude of agricultural productivity for the growing season (June to October) changed during the period 1988 to 2018? Peak production of the agricultural season in Kentucky falls between the month of June (latest planting) and the month of October (end of harvest) and covers a wide array of crops and environmental conditions. This project utilizes data from the Landsat Mission Archive (TM, OLI) to derive normalized difference vegetation indices (NDVI) for estimating the productivity of farmland and to calculate annualized productivity as the magnitude of change in NDVI between June to October of each year. Preliminary results indicate that 1) the spatial distribution of productivity changed (decreased in area) and 2) the mean productivity, in contrast, has increased significantly, in some cases doubling overall productivity means. These contrasting trends highlight expected changes, such as, 1) decrease in number of farms, 2) decrease in the overall land dedicated to farming, and 3) significant increases in overall productivity for remaining farms. Lastly, preliminary results are presented that incorporate (sUAS) small unmanned aerial systems-based mulit-spectral imagery for validation of NDVI estimates.

INTRODUCTION

The overall goal of this research is to understand how productivity has changed over the last 30 years in central Kentucky (Figure A) in order to understand the major types of change taking place in this region. Here, normalized difference vegetation indices (NDVI) are used as proxy for productivity.

The objectives presented for this discussion include:

1. Utilize machine learning for summarizing the major productivity changes between the years 1988 and 2018.
2. Identify counties with large shifts in productivity potential (+/-).
3. Compare directly Landsat 8 NDVI to SENTERA NDVI imagery at 30 meters for multiple organic crop types.

A

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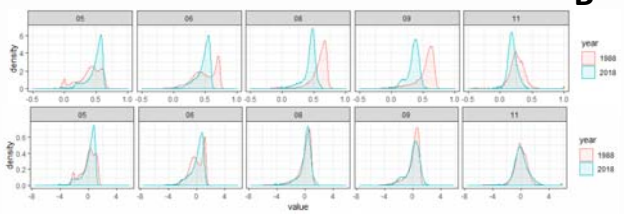
METHODS

1. Download level 1 TM and OLI for path 020 row 034.
   - *May, June, August, September, November (1988 & 2018)*
2. For each image date, calculate NDVI time series in R
3. Stack NDVI images and scale on image means
4. Random point samples for extraction of NDVI values (N=25,000)
5. Unsupervised classification
   - K-Means clustering for feature extraction (dis-similarity)
   - Generate temporal signatures to interpret features
6. Random Forest "response" prediction on NDVI stack
7. Summarize by meaningful unit area (central KY counties)
8. Directly compare Landsat to Sentera NDVI (*preliminary*)
   - June and August 2018

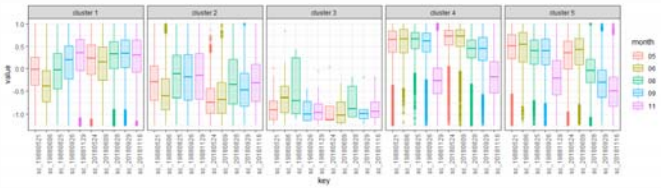
RESULTS



B

Value Distributions by Month

The tendency for Landsat 5 to produce NDVI values that are artificially higher than comparable values from Landsat 8 is well documented and shown in Figure B. To compensate, we simply scale all values using the image mean. No additional normalizations were performed.

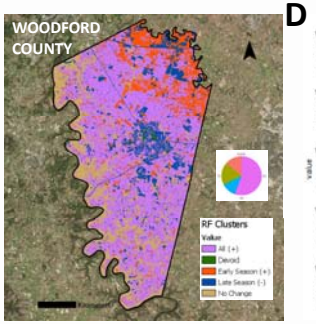


C

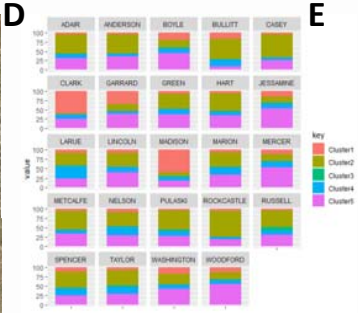
Feature Interpretation

The temporal signatures (Figure C) were used to understand how productivity patterns are distributed in 2018, relative to 1988.

1. **Overall (+):** These clusters have experienced increases in productivity values overall, in line with finding globally that suggest a greener landscape.
2. **Early Season (+):** These clusters are generating higher productivity values early in the growing season, particularly in June and August.
3. **Devoid:** These clusters are devoid of productivity both time steps.
4. **No Change:** These clusters are consistent in productivity over time.
5. **Late Season (-):** These clusters have a reduction in productivity values later in season, particularly August and September.



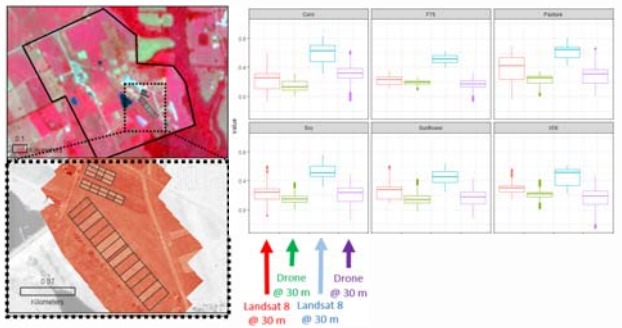
D



E

Random Forest Classification and Summary

Classification results highlight the distribution of productivity changes in Woodford County (Figure D) as an example. All other counties in study area are summarized in Figure E and show the proportional distribution of each cluster type.



F

Landsat 8 NDVI vs. SENTERA NDVI (June and Aug 2018)

Direct comparisons were made between the OLI and drone based NDVI values. Drone values are consistently lower than those derived from satellite data and also have more variation, as shown in Figure F. Results are mostly consistent across crop types.

CONCLUSIONS

Key Takeaways

1. Overall productivity is up, as expected (cluster 1).
2. Productivity is highly dynamic in central KY, with multiple distinct change types identified.
3. There exist some evidence of land being removed from productive endeavoring. Lack of tillage activities results in early season gains (cluster 2).
4. There exist some evidence of land now free from intensive crop cultivation that show up as late season decrease (cluster 5).
5. Real change in productivity from 1988 to 2018 is undecided, though the spatial distribution of change is very clear. Work is ongoing for precise values of productivity change during this time.