Navigating Urbanization: The Impact on Crop Diversity and Agricultural Productivity in Indianapolis

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Abstract

This project aims to study the agricultural operations, crop diversity, and population dynamics in Indiana, with a focus on Marion County. Home to Indiana's capital, Indianapolis, this county represents the most densely populated and rapidly urbanizing area in the state; its growth correlates to a variety of broader trends stemming from urban expansion, such as impacts on agricultural land use. Utilizing data from 1997 to 2022, combined with census figures, we explore changes in agricultural productivity (operations, sales, acreage) and population trends at both the county and state levels. Corn, Indiana's most significant crop and a focal point of the region's economic and agricultural output, plays a critical role in the nation's food supply chain.

We situate Marion County's agricultural productivity within the context of state trends, noting how the pressures of urbanization on the region have led to a marked decline in corn grain acres harvested in the county over the study period. By comparing the agricultural activity in this county with that of surrounding rural counties and the state as a whole, the analysis demonstrates a shift in land use patterns. The surrounding counties have experienced population growth as a result of spillover urbanization from Indianapolis. This has led to a reduction in agricultural output from this region, primarily in corn, and a concentration of agricultural output in the northeastern counties of Indiana.

This shift suggests a need for careful land-use planning to balance out development with agricultural sustainability.

1. Introduction

Indiana is a large farming hub in the United States, and is ranked in the top five states for corn and soybean production. These crops are used in many of the commodities and products we use today, such as popcorn, bio-diesel, and consumer goods like shoes and tires. Marion County sits at the center of Indiana, and is home to Indianapolis, the capital of Indiana, which is one of the fastest growing cities in the United States; the population increased by over than 150,000 people within the last 20 years.

To accommodate this many people, the land dedicated to farming has been reduced, leading to less crop output in the county. However, much of agricultural production is dependent on land availability. This change in farm land use sparked questions about how urban expansion affects crop production and crop diversification, or if other counties' farming infrastructure felt the effects of rapidly growing population size. We sought to investigate how Indianapolis' population change impacted the crop production and overall agricultural productivity of the crop types in Marion County and surrounding counties in Indiana. To do address these tasks, we aggregated census data from the population and land use to analyze the largest crop productions in scatter plots and map visualizations.

2. Data and Methods

For this project, census data about the population of Marion County and Indiana was pulled dating back to 1900 to view the change in population over time. We then used data about the crop land usage, crop types, and crop sales for counties and states in the United States. Python libraries (e.g. pandas, matplotlib, plotly) were used to handle data cleansing, processing, and visualizing.

2.1. Data Preparation:

Before analyzing this crop data, we cleaned it to only contain data for Indiana and Marion County based on the

state code (18) and county code (97). We also took into account the county code 999, which refers to accumulated values for the whole state. There were 3 datasets: one with land use data, one with sales data, and one that dove more into specific crops.

We adjusted our crop sales data to adjust it for the base year 2017, as well as narrowed our focus on major crop productions in Indiana.

$$\text{Prices Adjusted to Base Year} = \left(\frac{\text{Current Dollars}}{\text{Current Price Index}}\right) \times 100 \quad (1)$$

The top performing commodity crops in Indiana were corn, soybeans, wheat, veggies, fruit and nuts, and berries. All other crop production columns were either non commodities or were negligible in the scope of land usage and sales compared to the major crops.

2.2. Methods

1. **Map Visualization:** The distribution of agricultural operations was visualized across Indiana counties using a geographic information systems-based approach. FIPS codes were used to map the number of agricultural operations per county. This spatial visualization displayed the concentration of farming activities by percentage of state activity, showing a shift of operations surrounding Marion County towards the northeastern region of the state. See figure 3,4,5 below.

2. **Time Series Analysis:** Analysis of population growth over time, along with the change in crop sales, crop operations, and cropland usage.

   (a) Total Farm Operations and Marion Co. Population: Analysis of population growth and the reduction in total farm operations for Marion county.

   (b) Crop Diversification: Comparing the number of operations in Marion county for a selection of key crops (berries, corn, soybeans, and more.

   (c) Corn Grain and Population Relationship: This analysis examines the relationship between corn grain acres harvested and population change during the study duration. Population data for Marion County and the state of Indiana was merged with corn production data using the `YEAR` and `COUNTY_CODE` fields. Using 1997 as the base year, the percentage changes in both corn grain production and population were calculated using the following formula:

$$\text{Percent Change} = \left(\frac{\text{Current} - 1997}{1997}\right) \times 100$$

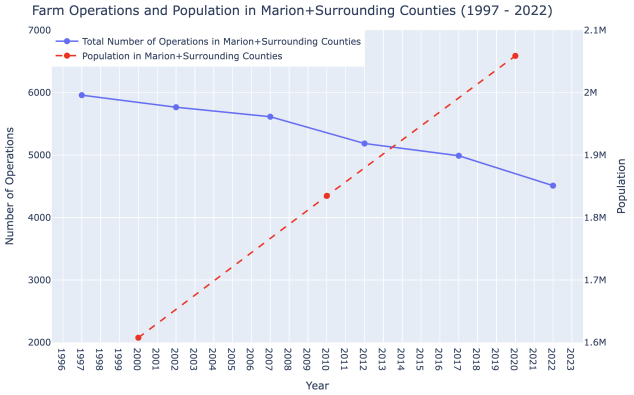

Figure 1: Marion County Operations and Population Growth

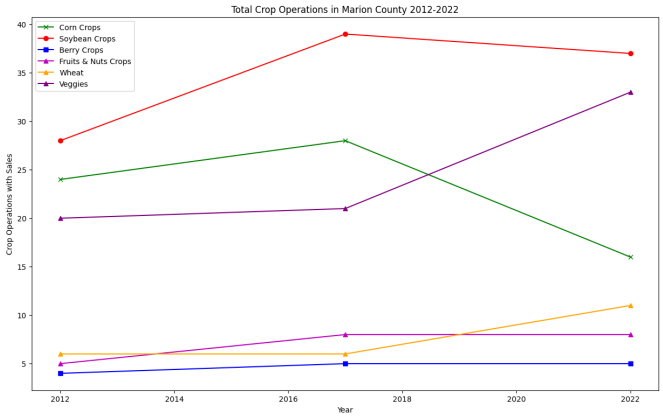

Figure 2: *Crop Diversification:* Change in crop operations in Marion County from 2012-2022.

The resulting trends were visualized to compare population growth against the decline in corn production, revealing how urbanization in Marion County has led to reduced agricultural land use.

3. Results

Marion county and it's surrounding counties have seen a significant decline in their percent of statewide agricultural operations. Marion county and the 8 surrounding counties have decreased from 10.79% to 8.38% of statewide agriculture operations (Figure 2).

From 1997 to present-day, the amount of corn grain acres harvested in Marion County has shown a significant decline, while population growth in the region has steadily increased.

The percentage of corn grain acres harvested has dropped about 60% compared to 1997 levels. This reduction is particularly shown in the years of increased popula-

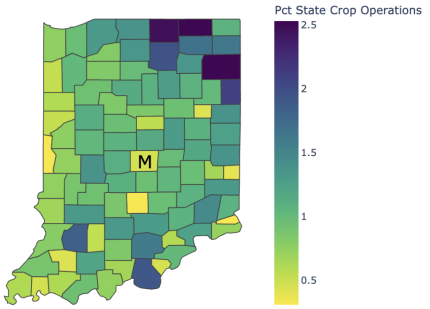

Figure 3: Indiana Crop Operation Distribution by County 2002

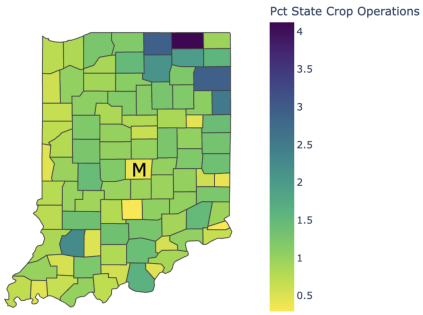

Figure 4: Indiana Crop Operation Distribution by County 2012

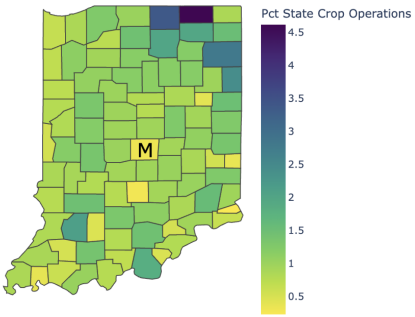

Figure 5: Indiana Crop Operation Distribution by County 2022

tion growth, where urban sprawl has seeped into previously rural areas. We also find that as Marion County has experienced a 13% population increase since 1997.

In contrast, the state of Indiana as a whole has not seen such drastic reductions in corn production. The rate of corn production has been relatively steady, with certain rural counties even maintaining or increasing their production levels. The state has also had a population increase of about 13%.

Our analysis supports a connection between urban population increases and reductions in agricultural output in surrounding areas. The crop diversity also experiences a marked shift from 2012 to 2022, with soybean and berry crops increases in the number of operations while corn production decreases significantly. It is unclear whether market shifts, climate shifts, or urban expansion led to this change.

4. Conclusion

These results further support the idea that there has been a concentrating shift in agricultural production towards the northeastern counties of the state. The decreasing populations in Marion County and the surrounding regions indicate a growing shift in land use from agricultural production to urban development. This could support a broader hypothesis about suburban sprawl, suggesting that farmland is being increasingly pushed away from the outskirts of growing urban areas and centralized in more rural less populated regions. As cities like Indianapolis expand, they consume not only the land for housing and commercial development but also the natural buffer zone that once existed between living centers and agricultural zones. What we observe is an gradual shift where farming, which historically thrived near cities to easily supply food to growing populations, is now being relegated to distant, concentrated areas. This can arise logistical challenges and places a heavier reliance on transportation and infrastructure to bring produce from more remote farming communities into urban markets, which of course is not sustainable.

This trend seen in Indiana is emblematic of a larger national pattern of the displacement of agricultural operations. As farms become more centralized in specific regions, they lose their geographical diversity which can be crucial for resilience considering the challenges of climate change, soil depletion, and market fluctuations.

A further analysis could utilize more historical data on crop sales and land usage. Much of the data revolving these was from the years of 2007 to 2022, with 5 year increments between the data points. Expanding this timeline would allow for a deeper exploration of how crop production—particularly corn and soybeans—has evolved alongside urban expansion. Such an investigation could also shed light on the growing role of ethanol production. Indiana ranks as the 5th largest ethanol producer in the United States, generating over 1.1 billion gallons annually. This industry consumes more than 40% of the state's corn crop, making it a crucial asset of both the agricultural and renewable energy sectors. Examining how this biofuel demand influences land use decisions could provide valuable insights into the balance between agricultural sustainability, urban growth, and environmental impact.

Please see this link to our Submission Video.
Please see this link to our Google Colab Notebook.