

The Feasibility of Converting a Corn Monoculture into a Three Sisters Polyculture in the Midwestern United States

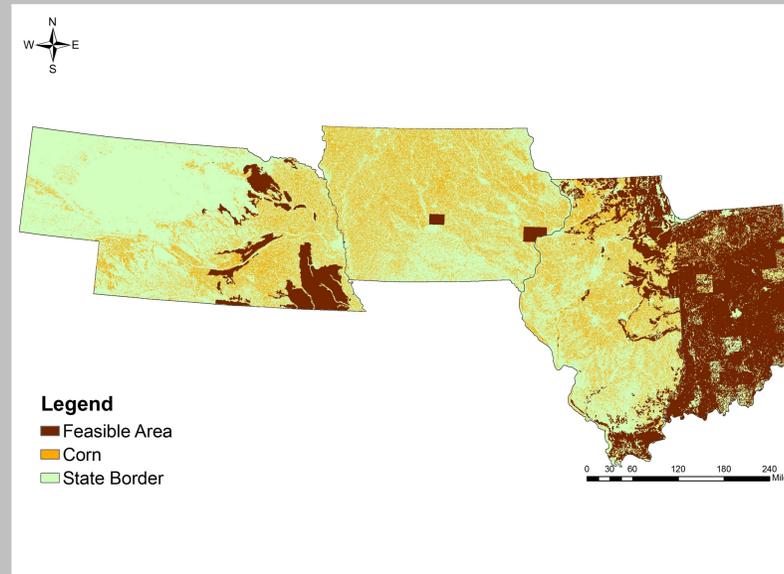
Introduction

American agriculture is dominated by monoculture—a system of agriculture where only one type of crop is grown on a large scale. Monoculture cropping is widely considered to be an unsustainable form of agriculture because of the extensive resources that are required to maintain it and because of its negative environmental effects. Polyculture cropping is a system of agriculture where multiple types of crops are grown in the same area. Polyculture cropping is preferable to monoculture cropping because it is more sustainable.

The Three Sisters Polyculture—corn, squash, and beans—has a long history in the United States: this polyculture was originally practiced by the Iroquois tribe (Mt. Pleasant, 2006). However, as farming demands increased and more emphasis was placed on yields, polyculture gave way to monoculture. Now, monoculture is coming under increased scrutiny because of its unsustainable nature. Therefore, systems like the Three Sisters polyculture have since been examined and proven to be beneficial to the environment. The Three Sisters polyculture results in a mutualistic relationship between the three crops (Mt. Pleasant, 2006).

While more research is needed on the potential yields of polyculture systems, exchanging monoculture for polyculture is a promising, more sustainable solution to the negative effects monoculture cropping has on the environment.

Feasible Area of Three Sisters Polyculture Compared to Current Corn Monoculture Extent

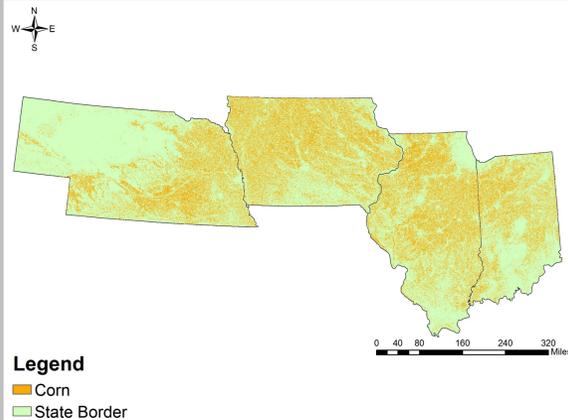


Limitations and Future Work

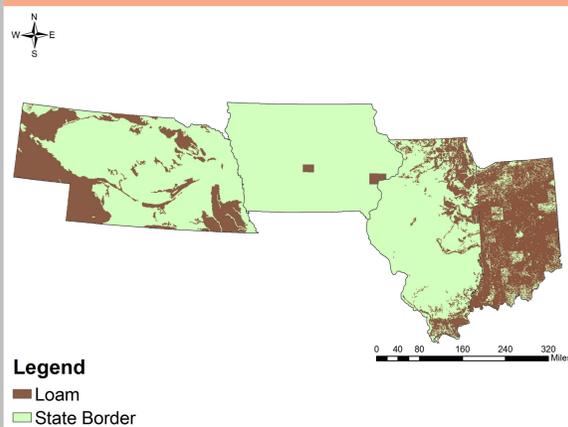
This feasibility analysis was limited primarily by data availability and the complexity of soil chemistry and climatic conditions that result in successful plant growth. To make the analysis more complex, original soil chemistry conditions are obscured by the intensive farming practices inherent in monoculture agriculture such as soil compaction and the introduction of pesticides and fertilizers into the natural environment. A major assumption in this project was that humans would have little to no involvement in altering the natural environment. Realistically, humans would have moderate involvement in agriculture, at a more sustainable level than the one currently seen in monoculture cropping, but higher than the one assumed in this project.

This feasibility analysis would be more effective and comprehensive if it were restricted to a smaller area, perhaps a single county in any of the four states. If the analysis were done on a smaller scale, more complete soil data sets, including nutrient levels, pH, and moisture content might be available. Restricting future analysis to a smaller geographic area may also allow this type of analysis to apply to a type of farming called “precision agriculture.” In precision agriculture, farmers adjust their practices based on the unique soil chemistry and climatic conditions of their farm or field. Applications of fertilizer or pesticides would be smaller and less frequent because the farmers respond to actual, measureable indicators, rather than preventatively applying unnecessary chemicals.

Corn Crop Extent



Soil Loam Extent



Methods

The goal of this project was to determine the feasibility of converting the corn monocultures of Iowa, Illinois, Indiana, and Nebraska to a Three Sisters polyculture, which includes corn, squash, and bean crops. The analysis was based on the extent of current corn crops, soil type, and annual precipitation.

Due to limited data availability and the complexity of crop growing conditions, the feasibility analysis was restricted to an “ideal” agricultural situation. This situation assumed no human interference other than planting the crops. This is to say that the soil was not modified in any way and that the crops did not receive additional water beyond natural precipitation.

The water requirements for corn were used in determining suitable areas because corn had the most stringent watering requirements of the Three Sisters crops. Each crop required the same type of soil characteristics (loam, well-drained).

The crop data, downloaded from the National Agricultural Statistics Service CropScape tool, was already in a raster. The precipitation data for each state, downloaded from the United States Geological Survey Geospatial Data Gateway, was converted from polygon data into a raster for each state. The soil data from each state was converted from point data (using Spline) or from polygon data to a raster. Basic polygon to raster conversion was performed with the Conversion tool.

Once everything was in a raster, the Raster Math tool was used to evaluate where precipitation was over 25 inches per year, where there was loam-like soil, and where corn crops already existed. Areas that fulfilled these three criteria resulted in the areas of each state where it would be feasible to convert corn monoculture into a corn, squash, and bean polyculture.

Results

The state with the greatest feasible area for conversion of corn monoculture to Three Sisters polyculture is Indiana, followed by Illinois, Nebraska, and Iowa.

Based on calculations that compared the feasible area to the total land area of the state, 84.10% of land in Indiana, 18.90% of land in Illinois, 9.41% of land in Nebraska, and 0.10% of land in Iowa are suitable to be converted into a Three Sisters polyculture.

Soil type affected the results the most while precipitation was the least limiting factor in the analysis. The effect of the combination of these factors is seen most clearly in Nebraska, resulting in a small percentage of the total area that would be feasible for conversion into the Three Sisters polyculture.

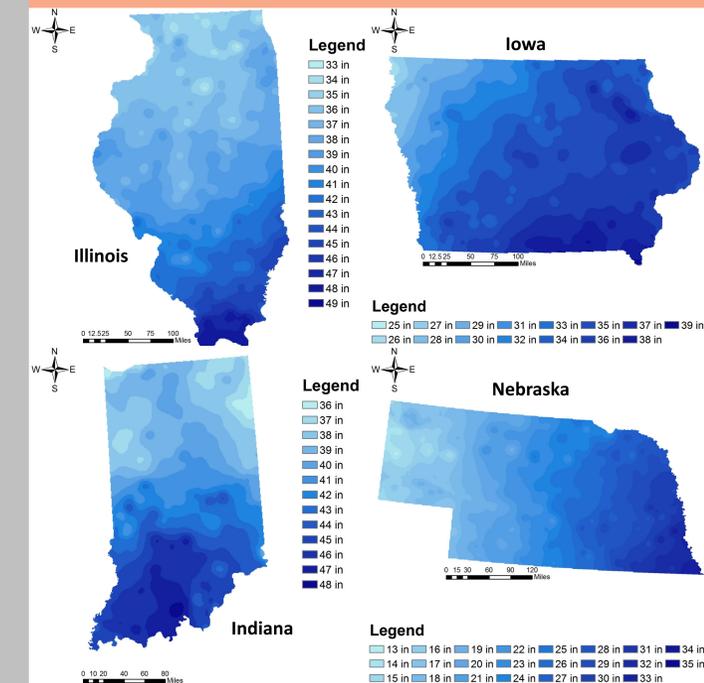
Conclusions

This feasibility analysis showed that most of the corn monoculture area is not suitable to be converted into a Three Sisters polyculture area. The limiting factor in this analysis was soil type. Corn, squash, and beans grow well in loamy, well-drained soil. This type of soil was not common in Nebraska, Illinois, or Indiana.

The limitation of soil type was made more restrictive by the assumption that no additional modifications to the soil were made by humans to make the soil more suitable to grow crops.

The stark difference in area between corn monoculture and Three Sisters polyculture is explained by the proposed lack of human involvement. Humans modify the land with agriculture in order to make a greater area more suitable to grow crops. The effect of human involvement can be seen when comparing the large corn monoculture area to the relatively small Three Sisters polyculture area.

Annual Precipitation in Inches



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