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In Search of a Sustainable Future

Barriers to Organic Food Production in the Rock River Basin

Organic is fast becoming a buzzword on the lips of everyone from politicians and scientists to weekend grocery shoppers. Defining organic, however, is challenging without comparison to conventional production methods. In the field of agriculture, the federal government has taken steps to define and regulate the organic industry; yet this has not signaled a change in paradigm. In fact, conventional farming, including industrial and factory farming, is still the dominant form of agricultural production. In the state of Wisconsin, one of the most productive agricultural states in the union, organic agriculture is beginning to establish itself among the plethora of conventional farming and livestock operations. Yet the shear number of organic operations still dwindles in the state, especially in the Rock River Basin. This area encompasses the population triangle of Wisconsin, ranging from Madison to the outskirts of Milwaukee and the Fox River Valley, and includes some of the most fertile soils in the state. The natural richness of this tract of land has attracted many competing uses, including city-building, agriculture, recreation, and industry to name but a few. The interaction of these different forces, and their effect on the land itself, has created a specific geographic distribution of organic farming in the basin. Thus, different social and environmental factors have become barriers to, and generally explain the geographic distribution of, organic food production within the Rock River Basin.

Study Area

The Rock River Basin is located in southern Wisconsin and falls within 10 counties: Dane, Green Lake, Fond du Lac, Walworth, Washington, Waukesha, Jefferson, Rock, Columbia, and Dodge. The basin itself is approximately 9,600km^2. The region boasts some of the state's most fertile farmland, which comprises 64% of the counties that make up the region; however, it is also deemed the third most threatened agricultural area in the United States by the American Farmland Trust (Rock River Coalition, 2006, p i). One reason for this status is the basin's proximity to many rapidly-growing metropolitan areas such as Madison, Milwaukee, Janesville, Beloit, and even Chicago.

Literature Review

Organic agriculture is different from conventional agriculture by definition, including both social and environmental aspects. In order for farmers to be certified organic through the USDA, they must wait a mandatory three years before being able to sell certified organic food. The farmer can not apply synthetic fertilizers or pesticides during those three years, nor can they after the land has been certified organic (Smukler 2008:169). Thus, organic agriculture requires skill in recreating a natural ecosystem that provides healthy pasture and/or feed for livestock, nutrients and pest protection for crops. (Gabriel 2009:327). Research conducted by the Institute of Integrated and Comparative Biology, at the University of Leeds in England found that the suitability of the land for organic farming can be determined on the topography, soil quality, and pest management system utilized on the farm.

Topographical factors such as altitude and slope had a direct effect on the location and type of organic farm in a specific area. The upland hilly areas in England were found to be less conducive to crop farming because they offered less arable land, but more conducive to small scale dairy farming due to the grass species that grow in those regions (Gabriel 2009:329). Topography plays an important role in the spatial distribution of organic farms in the state of Wisconsin as well. Many small scale dairy farms in Wisconsin have an average herd size of sixty five cows, and apply a grazing method known as Management Intensive Rotational Grazing (M.I.R.G). The highest rates of M.I.R.G. adoption practices are located in the drift-less area of Wisconsin where hills and valleys dominate the landscape (Brock 2008:27). Topography also has a direct effect on the quantity and quality of the soil that is found in a specific location.

Soil is a very fragile ecosystem, and farmers must be very knowledgeable in terms of how the soil forms, and also how susceptible it is to degradation. Soil texture and hydrology were two of the most important factors in determining the spatial distribution of organic farms in England. Geographic locations with soils high in silt and clay had the most organic farms. Loam soils have the highest potential yields of any soil texture. While organic farming in England is mainly concentrated in areas where the soils contain high silt and clay content, organic farms are also located in regions with sandy soil that are shallow, well aerated and drained (Gabriel 2009:329-31). Wisconsin, thanks to rich soils is home to some very fertile agricultural lands. In Southeastern Wisconsin most of the landscape is composed of glacial moraines and till plains with soils that are high in coarse glacial till and covered by loess (wind- blown silt). The quality of the soil in this region has led to the removal of much of the native vegetation in the area for the use of agricultural production. Today only ten percent of the region is covered by forest (www.dnr.wi.us/landscape.com). The health and maintenance of the soil is vital for the health and future of the farm, and the farmer also must implement an appropriate pest management system in order to naturally control insects, and other pests.

The organic farms in England used crop rotations and natural enemies to control the pests that attacked the crops. Crop rotations promote temporal and spatial heterogeneity on organic farms, and help maintain small scale agricultural field units. Borders around the organic farms that act as field margins may in fact act as reservoirs for natural enemies. Biodiversity is encouraged through these practices (Gabriel 2009:324) In a study on crop rotations and soil quality published in by the American Society of Agronomy it was found that agricultural regions that extended crop rotations for at least three years for forage crops had the highest quality of soil, and that a more diverse and extended crop rotation strategy would greatly improve a regions suitability to organic agricultural production (Karlen 2009:494).

Organic farmers often rely on insect management practices that are biologically based. The farmer has to know what type of biological control agent will work the best for their crops. Many farmers struggle in this area because there has not been much research done to clarify which techniques are considered the best (Lohr 2002:91). The three most commonly used integrated pest management systems are crop rotations, beneficial insects, and Bt treatments. Many of the organic farmers do not just rely on one technique. It is common for an organic farm to implement three or four techniques of biological controls (Lohr 2002:97). Other forms of biological control agents exist, but are used on a case by case basis. Many techniques are used depending on the farm size and production type. Wisconsin organic crop production is a very large contributor to the organic industry in the Midwest, and the organic dairy production in Wisconsin also largely contributes to that market.

There are many types of dairy production systems in the state of Wisconsin. Certified organic dairy farms produce milk free of synthetic hormones and agrochemicals. Thus, the farmer faces the challenge of keeping the animal healthy without the use of antibiotics or growth hormones. Pastures must also be "improved" if they are not suitable for raising livestock. There may also not be enough pasture land to support the herd, which may lead the farmer to convert more land to pasture or to find an alternative organic feeding source for the herd (Brock 2008:26).

Thus, organic farmers have to overcome environment barriers such as recreating a natural ecosystem on the farm, retaining soil nutrients and overall quality without synthetic fertilizers, adapting to the topography of the land, matching the best appropriate insect management plan to the farm size and crop types, and maintaining a healthy herd of cattle without using antibiotics or growth hormones. Wisconsin has many small scale dairy and vegetable farms, and the correlation between these environmental barriers and the spatial characteristics of those farms has yet to be analyzed. Further, agriculture itself is a point of human-environment interactions and thus requires both social and environmental factors to be assessed in order to tease out possible barriers to, or opportunities for, concentrated areas of production. This spatial analysis would thus not be complete without the incorporation of social factors in which such farms are located and conduct their business.

Organic agriculture is thus different from conventional agriculture by definition – a socially constructed definition. The USDA has developed National Organic Standards through its National Organic Program for organically produced agricultural products under the 1990 Organic Foods Production Act. These standards "require that agricultural products labeled as organic originate from farms certified by a State or private entity that has been accredited by USDA" (MOSES 2008:online). The certification process, which takes three months on average, involves an application, inspection, and review and can cost between $400 and $1,000 per year, or more for livestock operations (MOSES 2008:online). This definition offers the first social barrier to organic production, in that the State places limits on who can sell organic products by requiring a strict certification process. Organic farming is thus at a disadvantage since conventional farming does not require such regulations, at least in the view of the State. It is telling that the number one concern of organic farmers here in Wisconsin is the integrity of organic standards, with certification coming in at number four (Paine 2007:online).

Economic reasons are perhaps the most important in the decision-making process of individual farmers. Previous research has focused on marketing as a central concern, including the need for diversification, direct marketing, and withstanding the powers of organic agri-business (Duram 2006: online). Further, in the Southern US a lack of marketing infrastructure has been found to be a barrier (Rodriguez et al. 2008:65). Another barrier may be the perceived increased economic risk or reduction in yields associated with organic production, although yield ratios from organic practices have been demonstrated to be as high as, or in some cases higher than, their conventional counterparts in most cases (Badgley et al. 2007:92). Subsequently, a study in southern Wisconsin found that "the management practices associated with lower input or organic systems are, overall, no less effective than those associated with high input systems." The study also concludes that, "if organic price premiums remain high, the spread among grain systems will increase to the advantage of organic grain and organic forage production" (Chavas et. al. 2009:294). Farmers, however, perceived "an economic environment that generally favors conventional agriculture" (Rodriguez et al. 2008:67), including falling commodity prices and income support programs, to be barriers to organic agriculture. Consequently, the influence of large farms and corporations was the second most important issue of concern for Wisconsin organic farmers (Paine 2007:online).

This concern also shows that social infrastructure can be a barrier to the adoption of organic methods. Most literature focuses on the large issues of information generation and dissemination in relation to technology adoption (Rodriguez et al. 2008, D'Souza et al. 1993, Duram 2006). D'Souza et al. quantify this through looking at participation in farm commodity programs (D'Souza et al. 1993: 161), while Rodriguez et al. find that farmers "think poor connections between producers and information sources is a central problem" (Rodriguez et al. 2008:69). This becomes especially important because of the relative complexity of organic production practices. Another aspect of the social infrastructure is the ownership and use arrangements of land parcels. The same study also suggests that some "government programs are ineffective or even detrimental" to the adoption of organic methods (Rodriguez et al. 2008:69). The lack of farmer examples and peer pressure, to balance weak government support, is also a barrier to adoption of organic methods (Rodriguez et al. 2008:68) – but one that begins to tread into the category of personal traits.

Previous research, however, has proven inconclusive on the importance of personal traits to adoption of organic agriculture. While D'Souza et al. found that "human capital characteristics such as a producer's age and education were found to be significant determinants of the adoption [of organic methods] decision," (D'Souza et al. 1993:164) other research found these same characteristics to not be significant (Salamon 1995:online). The study by Salamon did, however, find that families "had an environmental or health event linked to adoption, traditions of environmentalism, systematically do on-farm experimentation, and are generally prudent about resources in homes as well as in farming" (Salamon 1995:online). Rodriguez et al. found that "lack of knowledge and training is the most significant barrier to adoption," along with reluctance to change, socially held beliefs and perceptions, and the traditional production paradigm to be important in the adoption decision in the US South (Rodriguez et al. 2008:70). Brock and Barham also found that organic dairy farmers in Wisconsin were "progressive in their adoption of modern technologies," and viewed their work as a way to live out values on health and environment (Brock and Barham 2008:30). Taken together with the environmental barriers discussed earlier, these social barriers to organic farming provide a starting point to explain the spatial distribution of such production in the landscape of the Rock River Basin.

The use of a Geographic Information System (GIS) significantly aides landscape analysis in many ways. First, a GIS can be used to develop an information database allowing for coordination and access to a plethora of geographic data. Second, the use of GIS as an analytical tool facilitates the specification of logical and mathematical relationships among the data yielding new derivative maps. Derivative mapping and simulation modeling combine existing data with knowledge of relations and process resulting in new data used for powerful analysis. Finally, advancements in technology validate the use of a GIS as a decision support system or a means for deciding how to act upon the analyses produced (Eastman 1995:539).

Salam, Khatun, and Ali utilize all three of the aforementioned applications of a GIS in their attempt to locate potential sites for carp farming in Barhatta Upazilla, Bangladesh. Though the study area is vastly different from the Rock River Basin, the concepts and methodology used in developing a suitability map were very similar. Before running their model, the authors assessed the study area and began data collection. They used GIS when gathering data by specifying physical parameters for carp farming development, compiling a database, and analyzing the data to determine whether or not it could be included in the model (Salam 2005:76).

According to J. Ronald Eastman, criterion provides some basis for a decision that can be measured and evaluated. The criterion, or data, is the evidence upon which a decision is based and comes in two forms: factors and constraints. Factors either enhance or detract from the suitability of a specific alternative for the activity being considered. Constraints, on the other hand, limit alternatives being considered (Eastman 1995:540). In the case of the Salam paper, 20 criteria were selected and included in the model (Salam 2005:79).

Before inputting the factors in a model, they must be standardized. Each factor usually is scaled individually depending on the nature of the data. In order for all of the factors to be combined, they must possess the same scale. Transforming a factor’s scale can be done a variety of ways; however, the simplest transformation is a linear stretch. The resulting scale can fall within any range specified by the user, but generally takes the form of a 0 to 255, 8-bit integer range (Eastman 1995:541). The authors of the carp farming article used an alternative scale. The factors were reclassified on a scale from 1 to 4, 1 being not suitable and 4 being very suitable (Salam 2005:79). When standardizing factors, empirical information is generally referenced to determine how the values fall within the specified range. Subjectivity is often introduced when standardization does not take the form of a simple linear stretch.

The next step after the factors have all been standardized is to apply weights to the factors. One frequently used weighting technique is Saaty's pairwise comparison matrix. Weights are derived by entering all of the factors into a matrix and comparing them concerning the relative importance of the two criteria involved in determining suitability for the stated objective. The comparisons are based on a nine-point continuous scale (Figure 1). A rating is applied in the matrix by addressing the importance of the row factor relative to the column factor (Eastman 1995:542).

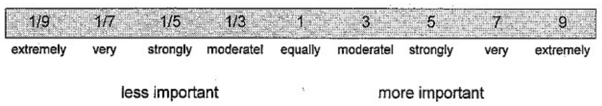


Figure 1. The continuous rating scale used for the pair-wise comparison of factors in the multi-criteria evaluation.

Due to the subjectivity of applying factor weights, consistency among weights can be addressed using a consistency ratio. This ratio indicates the probability that the matrix ratings were randomly generated so the lower the ratio's value, the more consistent the weights are. Saaty indicates that a matrix should be re-evaluated if the consistency ratio is 0.10 or higher (Eastman 1995:542). The authors of the carp farming paper utilized Saaty's pairwise comparison weighting technique. They achieved a consistency ratio of 0.07 which is considered acceptable (Salam 2005:79).

After all of the prior steps have been taken, the model can finally be run. Salam, Khatun, and Ali use a Multi-Criteria Evaluation (MCE) model with Weighted Linear Combination (WLC) (Salam 2005:75). WLC is considered to be the most common procedure for MCE. The factors are combined by applying the designated weights to each followed by a summation of the results to yield a suitability map. IDRISI software has a specific module called *MCE* which performs the weighted linear combination very efficiently (Eastman 1995:541). Salam et al. use the IDRISI software to perform the

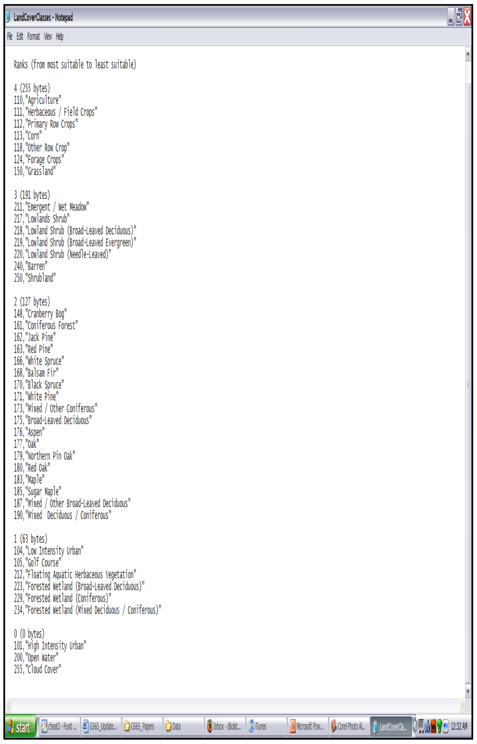
WLC when identifying probable sites for carp farming. The authors determined via a Multi-Criteria Evaluation model that "[t]he best areas for carp culture potential are those where most of the variables coincide with each other and have a high potential for carp production and sustainable yield year after year" (Salam 2005:82). Salam et al. do indicate that their results are subjective. They deem that an important advantage of a GIS is that when new or better information becomes available, the database they used could be updated and a more accurate suitability map could be produced in very little time. "…GIS used in a discriminating fashion is a powerful tool for site-selection decision making. By providing unbiased methodology and the ability to optimize and change relevant variables, GIS can be a valuable tool in solving problems in a regional and continental forum" (Salam 2005:86).

Methods

The GIS model that was run utilized a variety of data. Included in the model were a total of four factors and one constraint. The four factors were Land Cover, Percent of Organic Material within Soil, Soil Texture and Permeability, and Slope (derived from a digital elevation model). A Land Cover map, an ESRI shapefile containing soil texture and permeability information, and a digital elevation model were all obtained from the Wisconsin Department of Natural Resources. Each of the aforementioned data encompassed the entire state of Wisconsin and needed to be clipped to the Rock River Basin. The final factor, Organic Material within Soil, was retrieved as an ESRI shapefile from the Natural Resource Conservation Service. This data was also clipped to the Rock River Basin. After the model was run, it was compared to the locations of existing organic farms. The layer of farm locations was acquired from the Department of Agriculture, Trade, and Consumer Protection; they also provided a layer of organic processing and manufacturing businesses. All of the data used the Transverse Mercator projection with the geographic coordinate system North American Datum 1983 High Accuracy Reference Network (NAD 1983 HARN).

The factors were chosen based upon empirical information pertaining to their relevance to organic food production. Detailed information on why these factors were chosen is found in the literature review section. Due to data availability, time constraints, and the nature of the study area, the data included in the model were primarily environmental data. Social data would have been desirable, however, was not included.

Due to the nature of the model and the modeling software (IDRISI Andes Edition produced by Clark Labs), the data were all used in raster format. The resulting suitability map is a continuous surface which is why raster format is ideal. The cell size used for all of the data was 30 meters by 30 meters. This size was chosen because the Wisconsin DNR data originally had this same cell size. Other than for ease, the cell size makes sense based on the overall size of the study area (approximately 9,600 km^2) as well as the modeling objective – to find areas suitable for organic farms.



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Ranks (from most suitable to least suitable)

4 (255 bytes)
110,"Agriculture"
111,"Herbaceous / Field Crops"
112,"Primary Row Crops"
113,"Corn"
118,"Other Row Crop"
124,"Forage Crops"
150,"Grassland"

3 (191 bytes)
211,"Emergent / Wet Meadow"
217,"Lowlands Shrub"
218,"Lowland Shrub (Broad-Leaved Deciduous)"
219,"Lowland Shrub (Broad-Leaved Evergreen)"
220,"Lowland Shrub (Needle-Leaved)"
240,"Barren"
250,"Shrubland"

2 (127 bytes)
148,"Cranberry Bog"
161,"Coniferous Forest"
162,"Jack Pine"
163,"Red Pine"
166,"White Spruce"
168,"Balsam Fir"
170,"Black Spruce"
171,"White Pine"
173,"Mixed / Other Coniferous"
175,"Broad-Leaved Deciduous"
176,"Aspen"
177,"Oak"
179,"Northern Pin Oak"
180,"Red Oak"
183,"Maple"
185,"Sugar Maple"
187,"Mixed / Other Broad-Leaved Deciduous"
190,"Mixed  Deciduous / Coniferous"

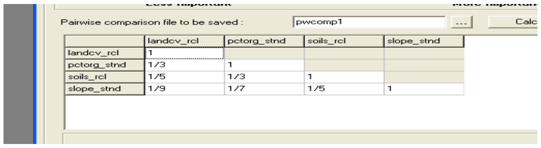
1 (63 bytes)
104,"Low Intensity Urban"
105,"Golf Course"
212,"Floating Aquatic Herbaceous Vegetation"
223,"Forested Wetland (Broad-Leaved Deciduous)"
229,"Forested Wetland (Coniferous)"
234,"Forested Wetland (Mixed Deciduous / Coniferous)"

0 (0 bytes)
101,"High Intensity Urban"
200,"Open Water"
255,"Cloud Cover"
```

Figure 2. Land Cover Classification Scheme

As far as standardizing the factors, two different methods were used. Both methods result in a standardized scale taking the form of a 0-255, 8-bit integer range. The first method was to manually scale the land cover data as well as the percent of organic material within soil data. This was done based upon the non-linear nature of these data. The land cover data was separated into five classes (0-4). Class 4 included all of the land cover types that were most suitable for organic farming while Class 1 included all of the classes that were least suitable. Classes 3 and 2 contained land covers of intermediate suitability. Class 0 included land cover classes that were not suitable for organic farming at all. The classification scheme is identified in Figure 2. Since four of these classes have value and the final scale has 256 values, 256 was divided by 4 which resulted in 64 byte intervals (Class 1 = 63, Class 2 = 127, Class 3 = 191, and Class 4 = 255). Class 0 was naturally assigned to 0 on the final scale. As far as soil texture and permeability, the data was originally organized as 1 = course texture/high permeability, 3 = medium-coarse texture/high-medium permeability, 6 = medium texture/medium permeability, 10 = fine texture/low permeability, and 99 = water body. Based on empirical information, we reorganized the data as 3, 6, 1, and 10 (from highest suitability to lowest for organic farming). As with the land cover data, we then assigned each of the classes a byte value using 64 byte intervals. The original 99 value was assigned a 0 on the final scale.

The second method used to standardize the remaining two factors was a linear transformation using the *FUZZY* module in IDRISI. For the slope data, a monotonically decreasing linear transformation was used to standardize the data to a 0-255 scale. Monotonically decreasing means that as slope increases, it negatively affects the suitability for organic farming. The original slope data had a minimum of 0% to a maximum value of 55%. The same module was used to standardize the data for percent of organic material in soil. The original data ranged from 2% - 5.5%. According to empirical research, the more organic material that is in the soil results in higher suitability for organic farming. This lends itself to a monotonically increasing relationship.



Pairwise comparison file to be saved : pwcomp1

	landcv_rcl	pctorg_stnd	soils_rcl	slope_stnd
landcv_rcl	1			
pctorg_stnd	1/3	1		
soils_rcl	1/5	1/3	1	
slope_stnd	1/9	1/7	1/5	1

Figure 3. Pairwise comparison matrix depicting the values assigned to each factor – should be interpreted as the importance of the row factor relative to the column factor.

Once the factors were all standardized to a 0-255 scale, they needed to be weighted. The weighting technique used was a pairwise comparison and was performed via the *WEIGHT* module in IDRISI. The matrix containing the factors and the values assigned to them can be seen in Figure 3. The values assigned to each factor were also based on empirical research. The resulting weights for each factor were as follows: land cover = 0.5660; percent organic material in soil = 0.2674; soil texture/permeability = 0.1267; and finally, slope = 0.0399. The consistency ratio was 0.06 which is considered to be acceptable.

Once the weights were obtained, the Multi-Criteria Evaluation model using Weighted Linear Combination was ready to be run. Using the *MCE* module in IDRISI, the four standardized factors along with their weights were entered in. The next step was to incorporate the one constraint which was briefly mentioned earlier. The constraint used was a simple Boolean reclassification of the land cover map where 1 = all land and 0 = any open water. This way, the model will not analyze any of the water bodies in the Rock River Basin for organic farm suitability. Once the constraint was entered, the model was run.

Aside from the model, other methods were used to gain an understanding of the environmental and social elements facing organic agriculture in the Rock River Basin. These included a survey of information from the USDA National Agricultural Statistics Service relating to the situation of organic agriculture in the region, practices being used on farms including MIRG operations and acreage, and the present relationship of organic and conventional agriculture. Pest management data was provided by the U.S.D.A. Pest Management Practices Summary from the year 2000, while the Wisconsin DNR provided information about Wisconsin's ecological regions and soil characteristic. An ESRI shapefile was obtained from GeoCommons (www.geocommons.com) under a Creative Commons License, originally compiled from data available from the USDA, to showcase local farmers markets. A distance analysis was employed to tease out the relationship between organic farmers and local farmers' markets; a separate distance analysis also looked at organic farms and organic processing and manufacturing businesses. The nature of farmers markets, usually located in large and small towns alike, made the use of the classical von Thunen analysis of little value to explaining the spatial distribution of organic agriculture in the relatively small Rock River Basin containing only one large urban center. Further, information about the various resources for organic farmers was obtained from the Midwest Organic and Sustainable Education Service (MOSES).

Results and Discussion

The results of the Multi-Criteria Evaluation model yielded a site suitability surface for organic food production in the Rock River Basin (Figure 4). The surface was scaled from 0 – 255 as a result of each factor that went into the model having that scale. The linear scale begins with 0 which is deemed unsuitable for organic farming based on the constraint that no farm can be located in open water. From there, the first value after 0 is when the suitability of organic farm is at its lowest point. The suitability then gradually increases until the highest suitability is reached at 255. At the value of 255, each land cover type is optimal, the soil's organic matter is the highest in the region, the soil's texture is medium-coarse resulting in medium-high permeability, and the slope is very minimal. All of the factors are at the maximum suitability for organic farming.

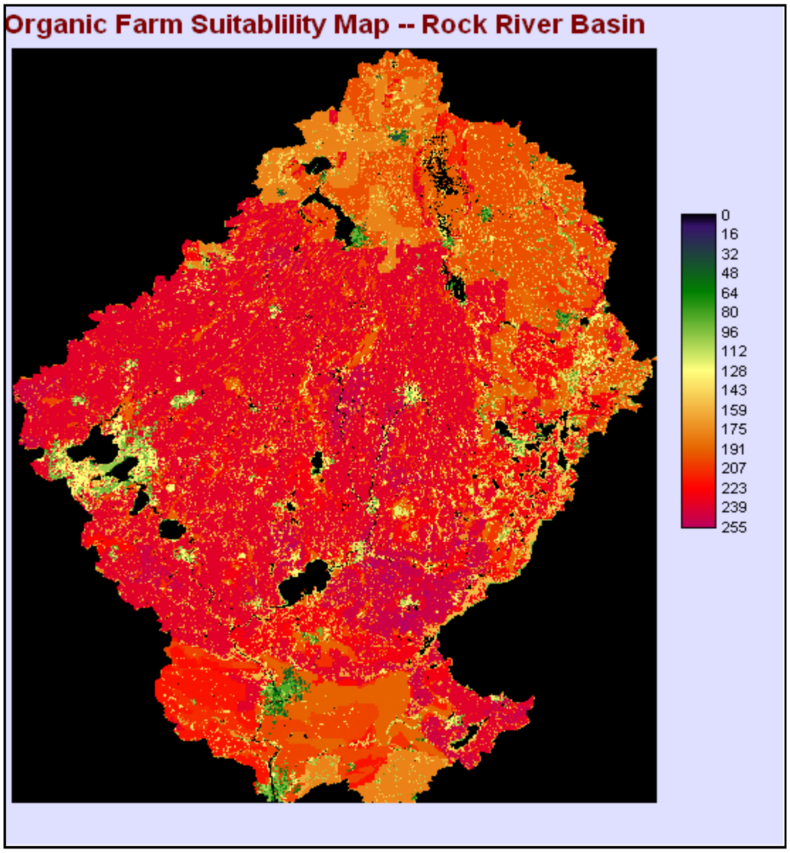


Figure 4. Site suitability surface for organic farms in the Rock River Basin

A visual analysis of the suitability surface revealed that the majority of the Rock River Basin falls into the moderate to high suitability range for organic food production. The areas of low suitability, however, were generally found near urban areas. For example, the city of Madison is located on the west side of the Rock River Basin near the series of lakes seen in Figure 4. This area has below average to minimal suitability. Another example of urban areas resulting in low suitability was seen in the southern section of the Rock River Basin. The two large areas that are colored green (very low suitability) are two moderately-sized cities: Janesville and Beloit. Urban areas most likely possess low suitability due to the incompatible land cover types and poor soil properties that are characteristic of a developed setting.

Beyond a basic analysis of the original suitability map, a comparison was made between areas of moderate to high suitability and locations of existing organic farms in the Rock River Basin. Before the layer of existing farms was overlaid on top of the suitability surface, the surface was reclassified into quartiles: 1 = barely suitable, 2 = somewhat suitable, 3 = moderately suitable, and 4 = highly suitable. This was done to more easily discern the level of suitability at a given point. Once the surface was reclassified, the point layer of organic farms was overlaid (Figure 5).

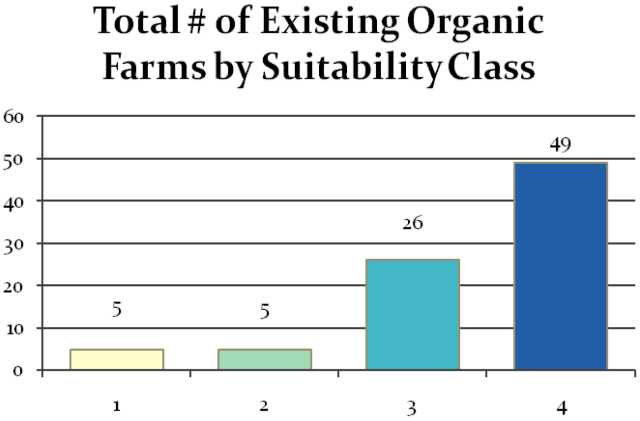


Figure 6.

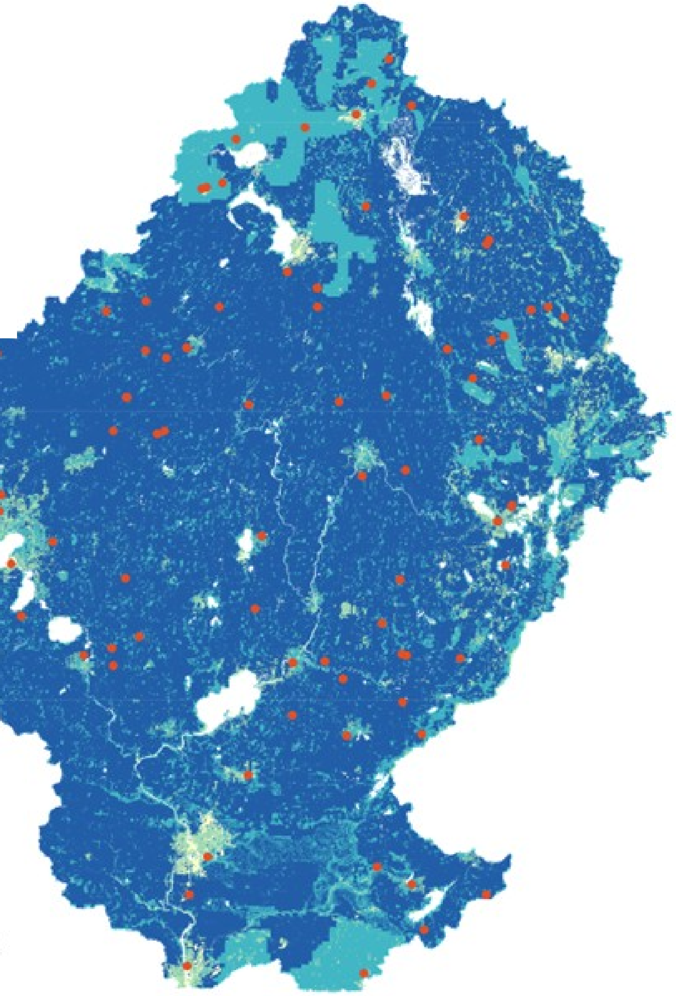


Figure 5. Reclassification of organic farm site suitability surface including locations of existing farms in the Rock River Basin. The solid white areas represent the constraint regarding open water. Data for farm locations provided by the Department of Agriculture, Trade, and Consumer Protection

There are a total of 85 certified organic farms located within the boundary of the Rock River Basin. Each location was assigned to the appropriate suitability class that it belongs to. The result was a graph showing the distribution of organic farms by suitability class (Figure 6). The results of the analysis did not go against expectations. This analysis served as a validation method for the Multi-Criteria Evaluation model. An accurate suitability surface for organic food production should contain the greatest number of existing sites in the classes of highest suitability. Overall, the site suitability surface produced anticipated results and displayed a high level of accuracy based on the four factors that were incorporated into the model.

Though the model produced desirable results, there are many considerations to be discussed. The first one concerns the factors that were included in the model. The inclusion of many more factors would have resulted in a more precise suitability surface. No social factors were included into the model due to the nature of the data as well as the limited amount of data collection time. Transitioning to or beginning an organic farm is a very personalized decision and none of the factors that may influence that decision were included into the model. Ideally, a survey would have been conducted to assess any factors that may have played a role in each individual's decisions. On the other end of the data spectrum, more environmental factors could also have been included to increase the model's overall legitimacy. Such factors may have been ground water quality, proximity to pollution sites, proximity to conventional farms, etc. The four factors that were included are certainly pertinent to the success of an organic farm; however, more factors could have been included. The suitability surface could be misleading due to the limited number of factors included. This may explain why the class of highest suitability dominates that map.

The second issue to be considered is the subjectivity involved in the modeling process. The two areas that contain the most subjectivity are the standardization and weighting of the factors used in the model. The standardization could be considered subjective in the model used for this research when the land cover data was reclassified so that the data was scaled from 0 – 255. This reclassification was based upon logical land cover types that would be suitable for organic farming. The land cover types were broken down into 5 classes (4 = most suitable, 2 and 3 = intermediate levels, 1 = least suitable, and 0 = unsuitable). The classification scheme can be seen in the methods section. Since the data was not classified based upon empirical research, subjectivity was largely involved. This may have affected the outcome of the model; however, the affect would have most likely been minor. Assigning weights to each factor was also somewhat subjective. Though the factors were ranked in order of importance for organic farming based upon empirical research, the point values assigned to each factor in the pairwise comparison was subjective. Slightly different weights could have resulted in a different suitability surface.

One other concern to be addressed is the random spatial distribution of organic farms in the Rock River Basin. This distribution resulted in few explanations being developed to address the question of why organic farms are located where they are. Regardless of this issue, the approach to trying to formulate an explanation of the spatial distribution of farms was very sound. Using extensive empirical research to drive data collection ensured the consideration of a wide variety of factors. Though for this research not many factors were included; however, given more time, many more factors could easily be fitted to the Multi-Criteria Evaluation model. The use of a GIS-based model was an excellent tool for analysis and would certainly be used again in future research.

One factor that may address the above concern is the distance analysis of organic farms to farmers' markets and organic production and manufacturing businesses. A distance between one and eleven miles from the nearest farmers' market and/or organic business was found to be ideal for the location of an organic farm (Figure 7). While this does not necessarily imply a causal relationship between the location of farms and markets/businesses – avoidance of the fallacy of affirming the consequent, in which the cause of an event has nothing to do with the number of times the event was observed to occur, is pertinent (Wainwright, 218) – it does suggest that organic farms are more likely to be located within this range of markets/businesses and vice-versa. Distances of less than one mile were also present in the data, yet are not included in Figure 7 due to the spatial and area requirements of farms (i.e. most farms do not have a farmers' market on their land).

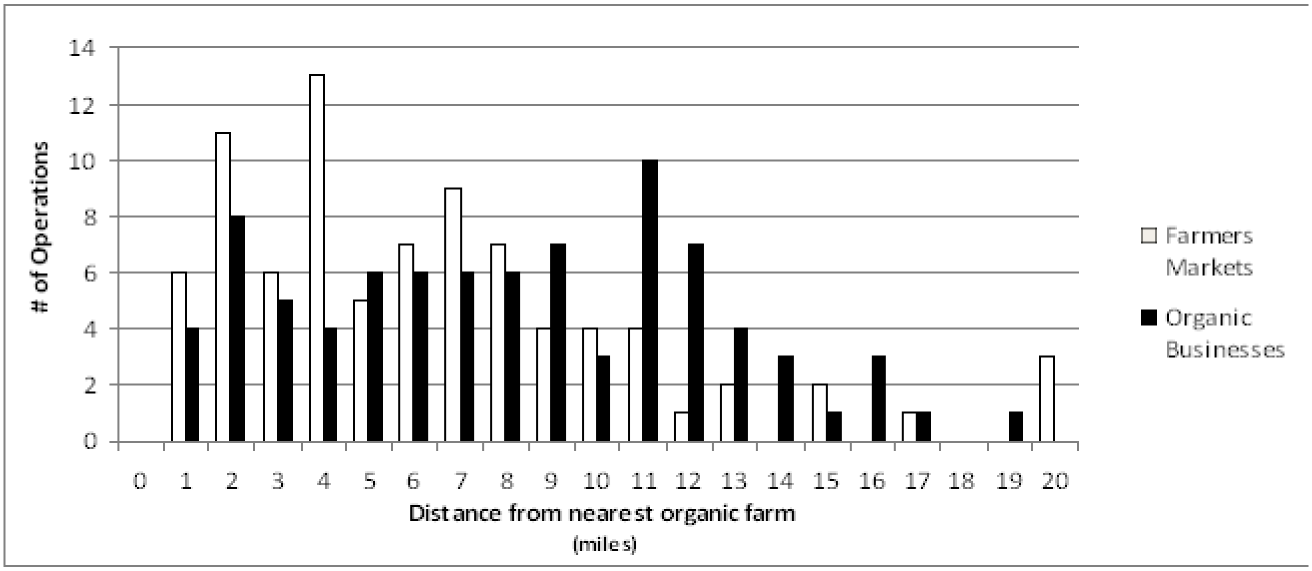
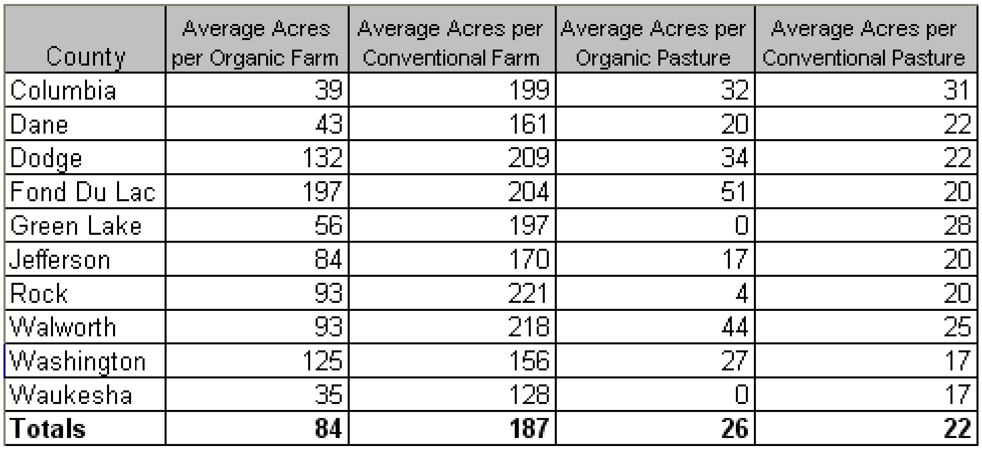


Figure 7. Shows the number of farmers' markets and organic businesses (processing and manufacturing) that are located within one mile increments from the nearest certified organic farm.

An analysis of several other social elements believed to be important to organic agriculture proved inconclusive. A look at personal traits in the Rock River Basin is a good example. In the counties that comprise the basin, there was not a large discrepancy in age, affluence, or education – despite the outlying counties of Dane and Waukesha. These outliers, however, did not have above normal concentrations of organic farms when compared to the rest of the basin. Additionally, the relatively small size of the basin meant that the location and distribution of educational resources about organic production methods were likely not major factors in the location of organic farms. In this region, however, farmers do have plenty of these educational resources. MOSES offers resources on organic methods in print, online, and many other formats that are easily attainable, including a farmer-to-farmer mentoring program and an organic farming conference. Their website also includes links to over sixty regional organizations (eleven in Wisconsin), sixty government agencies (eleven in Wisconsin), thirty-five university programs (five in Wisconsin), and thirty certification agencies (four in Wisconsin).

Certified organic farming is a very strong industry in the Rock River Basin in Southeast Wisconsin, and is continuing to grow. Organic farmers have to rely on natural strategies to raise their crops and or livestock instead of using chemical pesticides and fertilizers. The most important aspects of organic farming that connects the farm operation to the natural ecosystem are the quality of the soil, the type of pest management system used, and the system that the farmer uses to feed his livestock.

The Rock River Basin is located in the Southeast Glacial Plains ecological region in southeast Wisconsin. The fertile alfisols and mollisols dominate the region, and aid to the productivity of the agricultural landscape. Most of the soils were deposited during the Pleistocene Glaciation. Silt loam loess covers lime rich glacial till throughout much of the region, creating soil with a high cat-ion exchange capacity , and also a medium to high level of permeability to aid water percolation and root growth (Wisconsin D.N.R., Southeast Glacial Plains Landscape. 2009: 1). The agricultural land in the Rock River Basin on average contains three to five percent organic matter, which is more than enough for organic farming (National Resource Conservation Service 2009). The quality of the soil is also affected by other practices used on the farm



County	Average Acres per Organic Farm	Average Acres per Conventional Farm	Average Acres per Organic Pasture	Average Acres per Conventional Pasture
Columbia	39	199	32	31
Dane	43	161	20	22
Dodge	132	209	34	22
Fond Du Lac	197	204	51	20
Green Lake	56	197	0	28
Jefferson	84	170	17	20
Rock	93	221	4	20
Walworth	93	218	44	25
Washington	125	156	27	17
Waukesha	35	128	0	17
Totals	**84**	**187**	**26**	**22**

Figure 8. Shows the average number of acres per organic farm and pasture versus their conventional counterparts in the counties that make up the Rock River Basin. Values of 0 signify incomplete data, and were not used in calculating totals. Source: USDA NASS, 2007.

Many organic dairy operations implement a feeding strategy known as Managed Intensive Rotational Grazing (M.I.R.G.) in order to recreate a natural food supply offered by the landscape ecosystem. Of the counties that comprise the Rock River Basin there are 6,896 pasture land operations with 1,674 of them as M.I.R.G. systems, and of these operations 208 were on certified organic pastures. The counties that make up the Rock River Basin had a total of 2,445 acres of organic pasture land (U.S.D.A. NASS 2007). The counties that make up the Rock River Basin implement M.I.R.G. into their farming industry for both the organic and non organic pastures. Organic pasture land used for M.I.R.G. operations requires more acres than do non organic farms. This may be due to the fact that organically raised livestock simply need more land to access greater amounts of fresh pasture (Figure 8). The organic farming industry utilizes natural techniques in order to manage insect pest, but these methods are not just limited to organic farms. Many conventional farms practice these techniques because they are less detrimental to the land, and less expensive, but they may however be more labor intensive to implement.

The most common techniques were crop rotations, tillage, and creating physical barriers to prevent the spread of insects. Farms that are both organic and conventional implement these strategies of pest control. Wisconsin is in the north central region of the country, and eighty-two percent of the conventional farms that grow corn in this region practice crop rotations to control pest, twenty-five percent of these farms use physical barriers to stop pest migration, and fifty-three percent of these farms used tillage to manage pest. Chemical pesticides account for fifty-one percent of the pest management techniques utilized on these corn farms. (U.S.D.A. Pest Management Practices Summary. 2000:12). These numbers are not specific to the Rock River Basin or to Wisconsin as a whole, but rather reflect the characteristics of the entire northern region that Wisconsin is in. We can see an overall trend in the techniques used to biologically control pest on a much larger scale by the conventional corn farms, and this gives a good idea of the more common biological approaches to pest management by both conventional farms and organic farms. There are many challenges faced by the organic farmer, and the most important aspects of an organic farm are the soil quality, Animal feeding system, and the type of pest management system used.

The Rock River basin is a very fertile region in Wisconsin thanks to its rich geological history. The organic matter content of the soil is around three to five percent. This is more than enough for an organic farmer. The Basin provides agricultural land for dairy operations that use M.I.R.G. on certified organic pastures, as well as organic crop producing operations that are certified organic by the U.S.D.A. The most common technique organic farmers used to biologically control pest were crop rotations, tillage, and creating physical barriers to disrupt the insect migration. The Rock River Basin is the proud home of eighty-five U.S.D.A. certified organic farms, and hopefully that number will continue to grow.

Works Cited

Altieri, Nicholls. "Soil fertility management and insect pests: harmonizing soil and plant health in agroecosystems." *Journal of Soil and Tillage Research*. 2003: 204.

Badgley, Catherine, Jeremy Moghtader, Eileen Quintero, Emily Zakem, M. Jahi Chappell, Katia Aviles-Vazquez, Andrea Samulon, and Ivette Perfecto. "Organic agriculture and the global food supply." *Journal of Renewable Agriculture and Food Systems.* 22(2): 86-108.

Brock, Caroline and Bradford Barham. "Farm structural change of a different kind: Alternative dairy farms in Wisconsin- graziers, organic and Amish." *Journal of Renewable Agriculture and Food Systems*. 2008: 25-31.

Chavas, Jean-Paul and Joshua Posner, Janet Hedtcke. "Organic and Conventional Production Systems in the Wisconsin Integrated Cropping Systems Trial: II. Economic and Risk Analysis 1993-2006." *Agronomy Journal* 101 (2009):288-95

D'Souza, Gerard, Douglas Cyphers, and Tim Phipps. "Factors Affecting the Adoption of Sustainable Agriculture Practices." *Agriculture and Resource Economics Review.* October 1993: 159-165.

Duram, Leslie. "Organic Farmers in the US: Opportunities, Realities, and Barriers." *Crop Management* doi: 10.1094. Plant Management Network: 2006

Eastman, J. Ronald, Jin, Weigen, Kyem, Peter A.K., and Toledano, James. "Raster Procedures for Multi-Criteria/Multi-Objective Decisions." *Photogrammetric Engineering & Remote Sensing* 61.5 (1995): 539-47

Karlen, Douglas and Eric Hurley, Susan Andrews, Cynthia Cambardella, David Meek, Michael Duffy, Antonio Mallarino. "Rotation Effects on Soil Quality at Three Northern Corn/Soybean Belt Locations." *Agronomy Journal* 2006: 484-495

Lohr, Park. "Choice of insect Management portfolios by organic farmers: lessons and comparative analysis." *Journal of Ecological Economics*. 2002: 91, 97.

MOSES. "Funds for Farmers." June 2009. http://www.mosesorganic.org/fundsforfarmers.html

MOSES, "Guidebook for Organic Certification." Midwest Organic and Sustainable Education Service. June 2008. http://www.mosesorganic.org/guidebook.pdf

Paine, Laura. "A Survey of Organic Farmers in Wisconsin." *Wisconsin Department of Agriculture, Trade, & Consumer Protection – Division of Agricultural Development*. 2007. Online.

Pfeifer, Catherine, Roel A. Jongeneel, Marthijn P.W. Sonneveld, and Jetse J. Stoorvogel. “Landscape Properties as Drivers for Farm Diversification: A Dutch Case Study.” *Land Use Policy* 26 (2009): 1106-115.

Rock River Coalition. *Rural Development Guidelines and Policies*. Publication. 2nd ed. 2006.

Rodriguez, Joysee M., Joseph Molnar, Robin Fazio, Emily Sydnor, and Mecca Lowe. “Barriers to adoption of sustainable agriculture practices: Change agent perspectives.” *Renewable Agriculture and Food Systems*: 24:1 (2008): 60-71.

Salam, M.A., N.A. Khatun, and M.M. Ali. “Carp Farming Potential in Barhatta Upazilla, Bangladesh: A GIS Methodological Perspective.” *Aquaculture* 245 (2005): 75-87.

Salamon, Sonya. “Social and Cultural Factors Affecting Sustainable Farming Systems and Barriers to Adoption.” *SARE*: 1995. http://www.sare.org/reporting/report_viewer.asp?pn=LNC92-050&ry=1995&rf=1

Smukler, Jackson, Murphree, Yokota, Koikr, Smith. “Transition to large-scale organic vegetable production in the Salinas Valley, California.” Journal of Agriculture Ecosystems and Environment. 2008: 169-70

USDA. “Pest Management Practices: 2000 Summary.” 2001. Online.

Wainwright, John. “Models, Modelling, and Geography.” In *Questioning Geography Fundamental Debates*. By Douglas Sherman, Alisdair Rogers, Noel Castree, and David Demeritt. Grand Rapids: Blackwell Limited, 2005: 206-25.