# MULTI-SPECIES PASTURE ROTATION SYSTEMS: AN EXAMINATION OF THE ACREAGE AND FARM REQUIREMENTS TO FEED MICHIGAN

By

Daimon C. Meeh

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**ABSTRACT**

MULTI-SPECIES PASTURE ROTATION SYSTEMS: AN EXAMINATION OF THE ACREAGE AND FARM REQUIREMENTS TO FEED MICHIGAN

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In the past 10 years there has been a large growth of literature, in academia and the popular press, that evaluates the current agriculture and food production systems with suggested strategies for improving systemic sustainability. A number of works express the general idea of a return to massive smaller scale diversified production as a strategy to feed America. One of the most noted and influential non-academic books in this vein is *The Omnivore's Dilemma* by Michael Pollan. In his book Pollan heavily critiques current agricultural practices and discusses the ways in which it has made the environment and the American population unhealthy. The third section of the book provides an antidote to this critique as it profiles Polyface Inc., a Virginia farm that produces a variety of animal products using a multi-species pasture rotation system. The study reported here uses this as a starting point to understand the land footprint and number of farms required to produce beef, chicken and eggs for the state of Michigan using similar production strategies. It is my intention that this illustration of the system's requirements will spark more academic investigations in order to better understand the system requirements and potential evolutionary steps if such products are to be widely available in the marketplace.

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# INTRODUCTIONAND LITERATURE REVIEW

Using extreme conditions for testing the limits of any system is a way of exaggerating and identifying where problems might arise within the system. However when this type of analysis is done it must not be conflated with endorsement that the system should operate at the exaggerated levels. Rather, it is an examination of the feasibility of the system in general, but not in regard to the functioning of the system at the extreme conditions. In the study reported herein, it was assumed that all the beef, chicken and eggs could be produced within Michigan using a multi-species pasture rotation (MSPR) system. This assumption was based on the premise that the MSPR system is radically different from the dominant animal production systems of today and may embed attributes unavailable in other production systems. The use of the extreme conditions was done in order to analyze the required changes in the agricultural landscape regarding acreage and number of farms if product availability from MSPR systems were to expand beyond the niche market it commonly supplies. By comparison the number of acres that would be required if the confinement/grain finished production system were used to produce all of Michigan's beef, chicken and eggs was also calculated. This was done to provide a benchmark to compare with the MSPR system.

This study follows a large base of literature in the academic and popular press. The first chapter of this thesis is to familiarize the reader with the background literature. Chapter 1 begins with the background of alternative agriculture and critiques of industrial agriculture that led to *The Omnivore's Dilemma* by Michael Pollan (Pollan, 2006). It was Pollan's uneven treatment of various agricultural systems in *The Omnivore's Dilemma* as well as its influence that inspired this study. Following the background literature I proceed to detail the intricacies of the MSPR system. It is important to understand the specific production practices in order to fully know what is involved. Following the first chapter is the methods, results, and discussion as I examine our research questions: How many acres would it take to produce enough beef, chicken and eggs for the state of Michigan using multi-species pasture rotation systems? How many farms the size of Polyface would it take to meet the demand?

## SCIENTIFIC BACKGROUND OF POPULAR CRITIQUE

Any current scientific journal related to agricultural production reports research being done to reduce or mitigate the environmental effects of agricultural production. For example, the product of this research can be seen in the development of Best Management Practices that were developed to protect water quality. It can also be seen in much of the reasoning and strategy behind the Conservation Reserve Program of the USDA.

With that in mind, many argue that more drastic steps than mitigating the effects of current practices are required; they feel that the current practices must be changed. The critiques range from examining the social to environmental problems related to current predominant production systems.

Animal agriculture is discussed in a wide range of disciplines in relation to animal welfare issues (e.g. Siegford *et al*., 2008), the environmental impacts of production (e.g. Subak, 1999, McMichael *et al.*, 2007), the human health risks related to the current animal agriculture system (e.g. McMichael *et al.*, 2007, Leibler *et al.*, 2009) and new methods of production (e.g. Oltjen and Beckett, 1996, Wilkins, 2007), among others. There has also been a recent increase in studies discussing grass-finished beef production and studies regarding the pasture-based production of broilers and laying hens. Many of the grass-finished beef production studies are surveys or analyses of the current conditions of the producers as well as the potential for growth in marketing and production (e.g. Martin and Rogers, 2004, Comerford*et al.*, 2005, Lozier *et al.*, 2005, Lozier *et al.*, 2006). While there are studies regarding pasture-based poultry systems, they are relatively few and many are limited in scale or scope. Most focus on feed consumption of the poultry when on pasture (eg. Fanatico *et al.*, 2008, Anderson, 2008, Anderson, 2009). An area not researched to date concerns the characteristics of a MSPR system when animals are combined on the landscape. This gap in the literature is one that needs to be filled in order to understand the effects of using MSPR systems on a larger scale and makes it difficult to truly analyze the veracity of claims for this system.

Many of the social arguments against agribusiness as it has evolved trace their roots to Walter Goldschmidt's study (Goldschmidt, 1947) showing the social and political consequences of agricultural consolidation on the small Californian farming towns of Arvin and Dinuba. Since the reprinting of Goldschmidt's study there have been a variety of studies that have continued this academic discussion on the characteristics of a community's agriculture. Some studies suggest the repetition of Goldschmidt's study in order to make the data more applicable to the current markets and agricultural landscape (Durrenberger and Thu, 1996, Welsh, 2008). Others discuss the benefits, if any, sustainable agriculture and civic agriculture provide rural communities when compared to large scale agriculture (Lasley*et al.*, 1993, Lyson and Guptil, 2004). These discussions critiquing large scale agriculture, encouraging smaller farms and profiling alternative production have been used in the popular press literature and documentaries to bring the discussion about agricultural systems to the non-academic community.

In the past 20 years there has been a growth in the popularity of alternative agriculture production systems, such as organic and pasture-based animal production (Dimitri and Greene, 2002, Weber *et al.*, 2008, O.T.A., 2010). Out of this consumer movement has grown a body of literature and documentaries that scrutinize conventional agriculture practices (Nestle and

McIntosh 2010). These books and documentaries also profile proposed alternatives, often without an equally detailed look at their sustainability and implications for a system-wide shift to these production strategies.

A practical example of one of these alternative production systems would be Polyface farm in Swope, VA run by Joel Salatin and his family. Mr. Salatin has been promoting his grass-based animal production systems for many years through his self-published books, but had not achieved nationwide recognition. They were thrust into the national spotlight when Michael Pollan wrote about his experience visiting Polyface in *The Omnivore's Dilemma* (Pollan, 2006).

In *The Omnivore's Dilemma* Pollan critically depicts the problems in the United States agricultural system both in the "conventional" system and the consolidated organic industry. His critique is in-depth and harsh. Next he describes the system at Polyface as one of pastoral beauty and a sense of agrarian idealism. He stops just short of recommending that the meat for this country's population should be produced using Polyface as a model. The analysis of potential negative environmental impacts, number of people it could feed, land requirements to feed significant numbers of people, etc. are noticeably weak or missing from his argument.

Pollan is not alone in his critiques of so-called "conventional" agriculture. Many of the issues that he raises are not new. In the early 1940s J. I. Rodale, considered one of the founders of the organic agriculture movement in the US, began experimenting with farming based on the production practices that Sir Albert Howard had developed (Belasco, 2007). However there was little attention paid to Rodale and his organic production and theories until the late 1960s when, spurred by the events at Peoples Park the counterculture latched onto ideas of ecology and healthy food (Belasco, 2007). Not only did organic agriculture fit with many of the natural ideals of the late sixties and early seventies counterculture, the agrarian philosophies that accompanied it provided another way of defying authority.

Thomas Jefferson is credited as originator of the agrarian philosophy in the U.S. (Thompson, 2010). Jefferson wrote: "Cultivators of the earth are the most valuable citizens. They are the most vigorous, the most independent, the most virtuous, & they are tied to their country & wedded to its liberty & interests by the most lasting bonds" (quoted in Thompson, 1990). This was part of his argument against moving towards industrialization and greater Federalization of power espoused by Alexander Hamilton. Resistance to industrialization and Federalization as well as the appreciation for farmers that are connected to the land was adopted by the 60's counterculture (Belasco, 2007). This growth in the interest in ecology, agrarian philosophy and healthy food led to the publication of a wide variety of books and papers, in both the popular media as well as academia. Some of the seminal works during this time were: Walter Goldschmidt's 1978 republication of *As You Sow: Three Studies in the Social Consequences of Agribuisness* (Goldschmidt, 1978)*, The Unsettling of America* (Berry, 1977), and *Diet for a Small Planet* (Lappé, 1975).

The importance of Goldschmidt's study has already been discussed. *The Unsettling of America* by Wendell Berry, published in 1978, discusses the losses to community and culture caused by agribusiness in a poetic manner that resonated with the counterculture (Feenstra, 1997, Belasco, 2007). Frances Moore Lappé's book *Diet for a Small Planet*, published in 1975, called into question the eating habits of people and the effects it has on the world's resources. Although the popularity of these books and many others, including the 40 percent growth in subscribers to Rodale's *Organic Gardening and Farming* publication, is easily documented; this movement was confined to the counterculture and had not reached a majority of the people in the

United States (Belasco, 2007). Organic farming and support of smaller, local farms continued to grow slowly and remained out of mainstream American culture. There were developments, such as the Organic Foods Production Act of 1990 and more books that continued to criticize the consolidating farm system.

Pollan draws on many sources to form the framework for the critique of large scale agriculture in *The Omnivores Dilemma*. An example would be Wes Jackson's *New Roots For Agriculture* (Jackson, 1980), a harsh critique of industrial agriculture. He makes the distinction that his book is a discussion about the problem *of* agriculture not just problems in agriculture. He argues that "the plowshare may have destroyed more options for future generations than the sword"(Jackson, 1980, p.2). In this book he discusses the problems of erosion, over fertilization, pesticides, narrowing the genetic base, increased debt load for farmers, costs and over dependence on energy inputs. Jackson argues that these problems cannot be fixed by changing production practices in agriculture, but rather a whole new way of agriculture needs to be developed. This is followed by suggestions about what it might take to create a sustainable agricultural system. Jackson's book is a similar format to *The Omnivore's Dilemma* and it is easy to see how it laid much of the groundwork for Pollan when he was writing his own critique of agriculture.

Joan Dye Gussow has also been influential in the sustainable agriculture movement . Her book *Chicken Little, Tomato Sauce and Agriculture* published in 1991 is also a precursor to more recent books. Michael Pollan credits her as a large influence on his thinking and understanding about the problems with our modern food system (Pollan, 2006). It is evident that this new food movement has drawn on writers such as Gussow when one looks at the content of books such as *Chicken Little, Tomato Sauce and Agriculture*. In the book Gussow describes the public confusion by the health claims from producers of processed foods, as well as all of the problems with industrial agriculture described in *New Roots For Agriculture* (Jackson, 1980). Gussow also includes an excerpt from a paper by Kevin Danaher called *The Real Cost of Our Cheap Food* from 1988, in which he discusses the social and environmental costs of cheap food. This has become a very common phrase used by Pollan and others when promoting local, sustainable food production.

The literature continued through the 90s with relatively slow growth of public interest, but was far from mainstream until 2001. Marion Nestle, another important author in the food movement, credits *Fast Food Nation* (Schlosser, 2001) as the book that brought the discussion about problems with agriculture and food to the national publics' attention (Nestle and McIntosh, 2010). Eric Schlosser provides a history of the fast food industry, primarily focusing on McDonald's, and casts light on problems in the industry, including the targeting of children in advertising, the low wages of workers, and the health and environmental problems attributed to fast food. "His account turned masses of readers into food advocates eager to transform the current food system into something healthier for people, food animals and farm worker, as well as for the environment" (Nestle and McIntosh, 2010). *Fast Food Nation* was followed in 2004 by Morgan Spurlock's documentary, *Supersize Me*. In the documentary Spurlock tracks his health over the course of a month while he eats McDonalds for each meal of the day. During his month long experiment he also includes a discussion on advertisement targeted at children, unhealthy food choices and nutrition information availability at fast food restaurants. This movie continued to keep the issues of the health and environmental effects of the U.S. food system in the minds of the general public (Belasco, 2007). *Supersize Me* was followed by other popular documentaries about the food system such as *The Future of Food* (2004) and in 2005 *Our Daily Bread* (Nestle and McIntosh, 2010)

In 2006 Michael Pollan caught this wave of concern with *The Omnivore's Dilemma*. Schlosser did gain some celebrity after the publication of *Fast Food Nation* but it paled in comparison to the attention that Pollan received for *The Omnivore's Dilemma*, becoming one of the leading advocates for reform in the food system (Nestle and McIntosh, 2010). While the ideas, critiques and information included in *The Omnivores Dilemma* has been written about before, Pollan seems to have published his book at just the right time with just the right tone to capture the market. It was followed by a deluge of books including, *Stuffed and Starved* (Patel, 2008), *The End of Food* (Roberts, 2008), *In Defense of Food* (Pollan, 2008), *Food Rules* (Pollan, 2009), *The Omnivore's Dilemma for Kids* (Pollan, 2009) and documentaries such as, *King Corn* in 2007, *Food Inc.* in 2008, and *Fresh* in 2008. These critiques of the food system have bombarded the public with information and suggestions about how and why the food system should be different.

These popular press books and documentaries have received exposure and promotion in the media. As well as many cover stories in *Time*, the *New York Times Magazine* and making the *New York Times* bestseller list (Sexton, 2009), these books and documentaries have captured the attention of television and radio shows. Pollan has been especially popular with appearances on television[1] and many speaking engagements per year.[2] One of the most telling television

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[1] *The Colbert Report,* (6/15/2006 and 5/13/2009), *Bill Moyers Journal* (11/28/2008), *Bill Maher* (5/29/2009), *The Daily Show* (1/4/2010), *NBC Nightly News* (6/24/2010), *CNN's Anderson Cooper 360°* (8/23/2010), *Oprah* (2/1/2011).

[2] Past speaking schedule can be seen on http://michaelpollan.com/appearances/

appearances of Pollan's rise was on the Oprah show,[3] which has a large cultural influence on public opinion (Miller, 2004). This indicates that people with large amounts of influence and marketing power are promoting these types of critiques of agriculture. All this promotion without asking the not-so-simple question: what would it look like if a large portion of this country got their beef, chicken and eggs from Polyface-type farms? The goal of this study is to begin examination of this question as an examination of MSPR systems in order to define its production potential in relation to both acreage and farm numbers. This study focused on Michigan in order to geographically bound the study with a manageable scale of population and a relatively uniform climate. The question then was posed: how much acreage and how many Polyface-type farms would it take to produce enough beef, chicken, and eggs locally for the state of Michigan? Polyface produces more products than listed in the research question but the beef, chicken, and eggs on the farm share the most acreage. To complement this question, the acreage that it would take to produce these same products from grain-based systems for Michigan was also calculated.

In order to accurately understand this analysis it is important to know the details of the management systems. These pasture-based systems are promoted because of their perceived benefits to society, environment, health, and quality of life of farmers (Martin and Rogers, 2005, Weber *et al.*, 2008, Undersander *et al.,* 2002, Gwin, 2009). However these issues will not be discussed in this paper. The purpose of this paper is not to argue for or against pasture-based production but to analyze this MSPR system to see what scale of change might be necessary if it became a large part of the meat production market.

[3] Appearance on *Oprah* 2/1/2011

## GRAZING SYSTEMS

There are many different pasture management strategies (Hancock and Andrae, 2009a) used by cattle grazers. The strategy profiled in this paper is a subset of rotational grazing called Management Intensive Grazing (MiG) (Gerrish, 2004, Beetz and Rinehart, 2004). Rotational grazing is the general term for a pasture management strategy where the livestock are moved from pasture to pasture on a regular basis. In this type of system the animals are moved anywhere from every two weeks to multiple times per day, depending on the producer (Hancock and Andrae, 2009a). The goal of these movements is to allow the forage a period of regrowth before it is grazed again (Rinehart, 2006, Undersander *et al.* 2002). Often rotational grazing is used in conjunction with stockpiling forage, where some pastures are left to grow in the fall, in order to extend the grazing season for as long as possible, reducing winter hay requirements (Lalman, 2000). Properly managed, rotational grazing can increase the production per acre when compared to the most common strategy called continuous stocking (Beetz and Rinehart, 2004) where the livestock are on the same pasture for most of the year (Hancock and Andrae, 2009a).

On the rotational grazing spectrum MiG is one of the most highly managed systems, but it magnifies the benefits associated with rotational grazing. With MiG the livestock are in smaller paddocks for a short duration. Many times proponents of this strategy say that it is an attempt to mimic how the buffalo used to graze the great plains of America or how wildebeests and other herbivores graze the savannas of the Serengeti (DeRamus, 2004, Frank and McNaughton 1993). These wild grazing systems have been shown to increase the production and nutritive quality of the available forage in those ecosystems (Frank and McNaughton 2002). Therefore it would be reasonable to hypothesize that if domestic herbivores were properly managed to simulate wild grazing systems, it would stimulate more forage growth and an increase in forage quality. The goal is to have a high stocking density, i.e. the amount of animal liveweight per acre at a given time (Gerrish, 2006). This is done to quickly utilize the forage in a given area and move off before the livestock begin to damage the plants. This strategy keeps the grass in a highly productive, vegetative stage (Lane, 2010). As with rotational grazing, MiG increases the animal production per acre compared to continuous grazing, but it also results in higher production than longer cycle rotational grazing. These increases in efficiency come about through a number of different avenues. The first and most straightforward reason is because the stocking rate, or livestock per acre over the course of a year (Gerrish, 2006), of livestock can be increased from continuous grazing rates by as much as 35-60% (Hancock and Andrae, 2009b).

The other benefits that increase the production per acre are related to changes in the pasture quality and performance. Oates *et al.* (2010) found, when comparing MiG to continuous grazing and harvesting forage, that not only did MiG create higher biomass production, but the forage quality was superior as well. In this study, the MiG system produced significantly more biomass per year than the other systems in below average rainfall summers. In the summer and fall of the second year of the study, the MiG system forage quality was significantly ($p<0.05$) higher when compared to forage from the continuous grazing or harvested forage treatments groups. This finding is important because the late summer and fall are typically difficult seasons for producers to grow good quality forages.

The findings of Hamilton and Frank (2001) help shed light on why the production of grazing resistant forages would increase as a result of grazing pressure. They found that the grasses respond to grazing by encouraging rhizobia microbes to break down organic matter in the soil to make more nutrients, such as nitrogen, and minerals available for plant regrowth. With a greater uptake of nutrients the grasses are more nutrient rich and as a result the forage quality is greater. They proposed that this stimulation of microbes promotes nutrient cycling on a landscape basis and therefore makes nitrogen more available to all the plants in the area. Holland *et al.* (1992) found that the nutrient cycling process initiated by grazing was more important to nutrient and mineral cycling than the deposition of urine and feces while the animals are grazing the area.

In order to produce MIG's full benefits to forage quality and production, the forages need time to recover. Since MiG systems base a large portion of the decision for moving livestock on the stage of grass growth, a properly managed system would allow the forages to have adequate time to re-grow and promote nutrient cycling (Derner *et al.* 1994). In continuous grazing systems there is not enough time for the forages to recover before they are grazed again, especially in the patches of forages that are more desirable to the livestock (Teague and Dowhower, 2003). Increased nutrient cycling in turn adds to the potential number of animals that the pasture can support, therefore the potential carrying capacity of the pastures increase when the MiG strategy is used.

However, these studies join many other studies in this area. Some research supports the benefits of short duration grazing like MiG, but there are also many studies that do not show any benefit to production when grazing is managed intensively (Norton, 1998). Holechek *et al.* (2008) argues that when Allan Savory introduced the idea of more concentrated, short duration grazing systems, there was an unreasonable amount of support from the government and other communities without scientific proof that it was truly a beneficial system. They explain that that enthusiasm was encouraged by an increase in cattle prices and average yearly rainfall shortly after the introduction by Savory, which created "Wondrous tales [that] were told regarding the effects of short-duration grazing on vegetation and livestock productivity"(Holechek *et al.*, 2008,

p. 21). They note that since the decline of the above average rainfall, there has been a large amount of scientific literature that proves short duration grazing does not produce the advertised results. Briske *et al.* (2008) and Holechek *et al.* (2000) provide a synthesis on many of the academic articles that have examined some of the impacts of short duration high stocking rate on pasture and criticize the promotion of this system when there is scientific evidence showing that there is little to no benefit. According to Teague *et al.* (2008) these compiled studies could be misleading for the following reasons:

> (1) The manner in which researchers have managed multi-paddock grazing treatments has been sub-optimal for providing the best possible vegetation or animal production results; (2) The notion that rotational grazing can control frequency of defoliation within a grazing period is flawed *at the scale of rotations employed in research trials* (Norton 1998); (3) Grazing systems comparisons in small-paddock trials fail to address the problem that continuous grazing in large paddocks causes patch grazing and localized pasture degradation and underuse elsewhere, resulting in low growth rate relative to moderately and more uniformly grazed vegetation; and (4) The omissions in grazing research of a spatial dimension and consideration of the effect of grazing management on animal activities have created a communication gap between scientists and commercial producers, for whom landscape features and herd behavior are a prominent aspect of their production system.(p.24)

With all these differences in the scientific community it is difficult to develop a conclusion. Outside of scholarly research there is a growing community of farmers, ranchers and some university extension agents who maintain that the improvements in pasture production and quality are very noticeable.[4] Joel Salatin is one of those proponents of MiG and uses the strategy at Polyface farm and is the type of system being examined in this analysis.

In this thesis the discussion of multi-species grazing is based on the interaction between cattle and poultry utilizing the same land. However there is no scientific research exploring the relationship between grazing cattle and any sort of pasture-based poultry production. The

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[4] Personal communication, Dr. Jason Rowntree, Michigan State University Extension Beef Cattle & Forage Utilization, Faculty Coordinator Lake City Experiment Station.

primary source for literature discussing the benefits of MSPR systems that involve the interrelationship of cattle and poultry, (e.g. Pollan, 2006, Fanatico, 2006) cite Joel Salatin's books (Salatin, 1999, Salatin 1995), or personal communication. In his books about the poultry and cattle production on pasture, Salatin discusses the many benefits of rotating poultry on pasture that has recently been grazed by cattle. This use of anecdotal evidence in publications and an extensive literature search yielding no academic papers directly about poultry and cattle multi-species grazing shows a gap in the literature. It would be advantageous for the academic community to begin looking at what, if any, positive or negative relationships there are between poultry and cattle when utilized within the same system.

Multi-species pasture research has primarily looked at the relationship in grazing between cattle, sheep and goats. While including sheep and goat in the management plan is very different from including poultry, the research has shown that including goats or sheep can change the pasture quality such that it increases the production per acre. (Baker and Jones, 1985, Glimp, 1988, Coffey, 2001). The production gains were primarily based on the improvement of rangeland from an environment that has some grass mixed with encroaching small bushes and young trees, often encouraged by continuous single species grazing (Walker *et al*., 1981). The rangeland would be improved to a range pasture composed of primarily grass and a few small bushes and young trees. By including other species that prefer different plants as feed, the rangeland in the trials mentioned turned from increasing takeover of sagebrush and small trees to a more stable system where grasses predominated. It predicted that keeping multi-species grazing as a production strategy on the land studied would maintain the land in a predominantly grass state.

This example of mixing several species to create a more beneficial pasture ecosystem leads to the question: are there any benefits when poultry and cattle are used in the same system? There are indications that might point to potential benefits, such as the use of specific management techniques to use grazing cattle as 'ecosystem engineers' for rangeland birds (Derner *et al.* 2009). These investigators discuss fourteen studies that identify the best conditions for different endangered rangeland birds. They then relate those conditions to potential techniques or practices for grazing cattle that would benefit each bird. This indicates that cattle potentially create a beneficial environment for poultry. This is supported by anecdotal evidence that chickens prefer the grazed pasture to the tall grass of a non-grazed pasture (Salatin, 1999). Other anecdotal benefits mentioned by Salatin (1999) include chicken manure deposition fertilizing the pasture and chickens scratching through the cowpats which disperses the nutrients and disturbs insect larvae. Poultry manure is also high in nitrogen (Sloan *et al.* N.D.) and is a good source of nutrients to improve the soil and production. This would be especially true with Salatin's method of broiler production where they are in pens that are lined up across pastures and are moved once daily. Salatin sets up the system so that around 1000 broilers cover one acre per year and does not return to that pasture for three years with the broiler production in order to not build up excess nutrients[5]. The manure from the hens is also beneficial but less concentrated than the broiler manure where they have each 600 hen group cover about 50 acres per year.[5] All these benefits in relation to the acreage needed for production are believable, but since there are no scientific studies that have studied this type of system there is no way of knowing for sure what the actual benefits are and what potential problems might arise.

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[5] Personal communication, Mr. Daniel Salatin, interview 01/30/2010

## BENEFITS OF MULTIPLE ENTERPRISES

Diversifying the production on a farm can also have a benefit to its economic resilience (Coffey, 2001). While there has been a trend towards specialization, many farms remain diversified to some degree due the risk reduction associated with diversification (Chavas, 2008). Another difficulty experienced in specialized farming is that there are often long periods of little or no income between harvest times. Having a diversified farm can help even out the cash flow of the farm because there is a wider variety of products to sell at different times (Glimp, 1988). Diversification and the risk reduction and somewhat steadier income flow that usually accompany it, occur much more often in smaller farms and is seen as an important contributor to a farm's success (Chavas, 2008).

## PASTURE-BASED POULTRY

Salatin is commonly used as an example of pasture-based production of broilers and laying hens in books (Pollan, 2006), recent research (Chisholm *et al.* 2003, Fukumoto, 2009) and bulletins from government and non-profit organizations (Berton, 2002, Fanatico, 2006). The laying hens are housed in coops on wheels called "Eggmobiles" which are surrounded by electric net fencing and moved behind the cattle every three to four days (Salatin 1999). The broiler pens are low 10' by 12' structures that house on average 80 broilers[6] per pen and are moved daily (1999).

A claim that has often been questioned is Salatin's assertion that his birds consume 15-30% less feed as a result of being on pasture (Salatin, 1999). Academic studies in this area are

[6] Personal communication, Mr. Daniel Salatin, interview 01/30/2010

not abundant but those available are mixed on the effect. None have data to support a 15-30% feed reduction.

Egg laying production studies that have begun to look at the effects of pasture on feed consumption, have found the extra feed available from the pasture is offset by the extra energy needs during foraging.[7] The result is that pasture-based laying hens require slightly more feed to produce a dozen eggs than do confined laying hens (Anderson, 2009).

Studies of pasture-based broiler production are inconclusive. Some show that the average final body weight of the pasture-based broilers is higher than the confined birds (Ponte *et al.*, 2008b). In that study they also found the feed conversion ratio, pounds of feed per pound of gain, of the pasture-based broilers to be significantly different than the feed conversion ratio of the confined birds, in favor of less feed for the pasture-based broilers. Other studies found that a higher final body weight of pasture-based broilers; in some cases 75-150g higher (Ponte *et al.,* 2008a), but no significant difference in the feed conversion ratio (Chisholm *et al.* 2003, Ponte *et al.,* 2008a). In Fanatico *et al.* (2005) there was no significant difference in weight gain, feed intake, feed conversion or yield between broilers with outdoor access and broilers raised indoors. Another study had different values that indicated there was no significant difference in the final bodyweight, but the feed conversion was worse for the pasture-based broilers and they consumed more feed overall (Fanatico *et al.*, 2008). Another study reported that both the final bodyweight and the feed conversion of pasture-based broilers were significantly less than broilers raised indoors (Castellini *et al.*, 2002). In these studies the pasture-based poultry was expected to have lower performance. The reasons given for this expectation were that when the broilers were outside they expend more energy through foraging behavior, higher activity levels and exposure

[7] Personal communication, Dr. Kenneth Anderson, Extension Specialist and Pullet/Layer Management, 8/13/2010

to lower temperatures. One possible explanation for the amount of variability in the research findings is that they all had different housing and pasture setups. The quality and appropriateness of the pasture may make a difference in the feed efficiency (Fanatico *et al.*, 2005).

**RESEARCH UNIQUENESS**

I am not aware of anyone to date estimating the land and number of farms required to feed a population in relation to a particular production system; however there are a number of studies that attempt to estimate land requirements relative to food consumption patterns. Most studies investigate the effect of different food consumption patterns on the agricultural land requirements –in the framework of ecological footprint studies. As described in Hoekstra (2008), an ecological footprint calculation commonly has six components to it to analyze the impacts of people, houses, cities or countries based on the consumption patterns of the subject. Because the study described herein is directed on different production systems, it only uses two of the six components, use of arable land and use of pasture.

Conner *et al.* (2008) incorporated an estimation of land into their economic analysis of the effects of developing more local fruit and vegetable production in Michigan. There are also a variety of papers that look at current consumption patterns or a range of consumption patterns and relate those to the acres that would be required to produce the dietary food (Peters *et al.*, 2008, Wilkins *et al.,* 2008, Peters *et al.*, 2006, Gerbens-Leenes *et al.*, 2002). In these papers there are no calculations based on different production systems; rather the emphasis is on different dietary patterns with a generic production system. These papers are quite similar in concept to the following analysis, however consumption levels were held constant and the potential production per acre of two different production systems were examined.

## GOAL OF RESEARCH

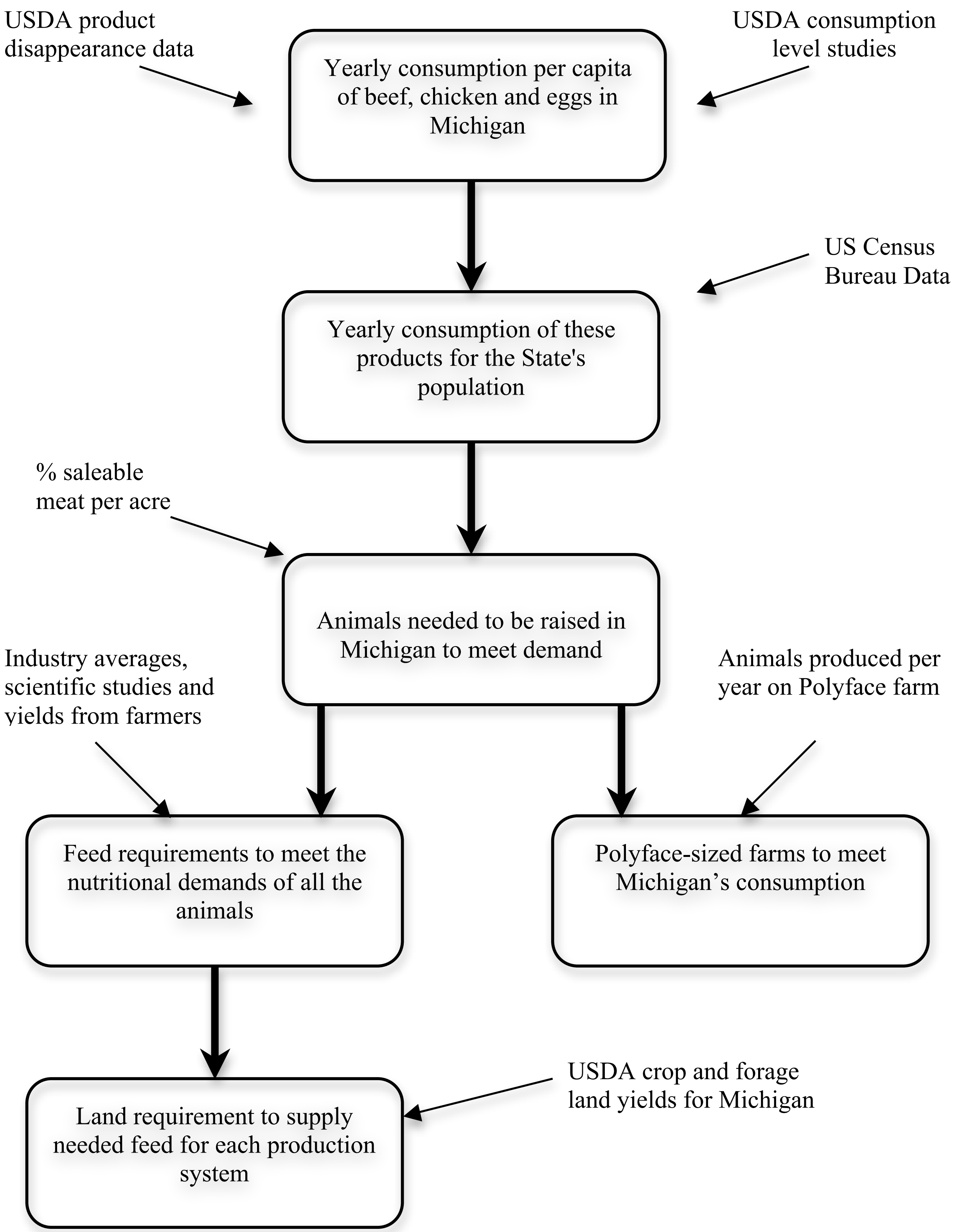
The goal of this research is to take an analytic view of the MSPR system in order to start laying the academic groundwork for a critical analysis of the system similar to the critique of conventional agriculture and large scale organic in *The Omnivore's Dilemma* (Pollan, 2006). There are a number of farms practicing all different types of MSPR in the United States. Polyface farm was chosen as the template farm for the MSPR system because that is the particular system that is so heavily described by Mr. Pollan in his writing. Because this type of system is relatively unexplored it is important to understand what would have to change in the agricultural landscape if MSPR systems provided beef, chicken and eggs for more than just niche markets. More specifically to this study seeks to find how many acres and how many Polyface-type sized farms would be required to produce these products to meet Michigan's demand?

# CHAPTER 2:
# METHODS

## INTRODUCTION

A variety of sources were used to estimate the amount of land and number of farms required to produce enough beef, chicken, and eggs for the state of Michigan. For this study it was assumed that MSPR production levels similar to Polyface in northern Virginia could be achieved in Michigan. To determine if this assumption would provide accurate results for Michigan production, I consulted USDA averages, industry specialists and a local farmer. Because it was confirmed that similar production levels could be achieved in Michigan, this assumption was used. Since Michigan is further north and has a colder climate there would be small changes to management to accommodate the differences, but the overall production per acre would stay the same. Through a sequential analysis I estimated: the yearly consumption levels of these products by Michigan's population, the nutritional/feed requirements of the animals raised in both pasture and grain-based systems to produce beef, chicken and eggs, and the acreage required to grow the feed for the animals. Data sources included peer reviewed publications, reports, as well as personal communication with extension specialists and local producers. The use of non-peer reviewed data was limited to the extent possible. The analytical sequence used is illustrated in Figure 2.1.

**Figure 2.1 Steps of the Analysis of the Research Question**



## MICHIGAN'S YEARLY CONSUMPTION

Yearly consumption data for 2009 were taken from the 'product disappearance section' of the USDA ERS Red Meat and Poultry Forecast (USDA ERS, 2010) and was the source for the beef, chicken and egg average national consumption per capita. The product disappearance is defined by the USDA ERS as "...the data represent the resulting food supply after food "disappears" into the food marketing system"(USDA ERS, 2010) The beef average consumption was modified to reflect a Midwest regional difference (USDA ERS, 2005).

Total consumption was then calculated using Michigan population data (U.S Census Bureau, 2010); yielding the total pounds of chicken and beef and the number of eggs consumed annually (Table 3.1). This was used as the annual population demand.

These consumption levels assume a year round supply of beef for the consumer. It may be problematic for non-frozen beef to be available off-season (Lozier, Rayburn and Shaw, 2006) as there are difficulties finishing cattle throughout the year on grass.

## ANIMALS NEEDED

### *Cattle*

The number of cattle needed was determined from the average slaughter liveweights and converted to average pounds of saleable meat per head of cattle (see Table 2.1 for terminology definitions). The average slaughter liveweight for the grass-finished system was taken from a survey of grass-finished beef producers (Steinberg and Comerford, 2009). This value was slightly different than the average slaughter liveweight on Polyface Farm,[8] but was chosen because it came from a larger pool of producers. 56% of the slaughter liveweight was used to

[8] Personal communication, Mr. Daniel Salatin, interview 01/30/2010

calculate the carcass weight[9] as that percentage is the industry average for grass-finished beef. Of studies found most were old and were testing the effect of different forage types or supplemental grain on carcass yield. The carcass yield used was 75.5% of the carcass weight; the average carcass yield in two studies was used (Bowling *et al.*, 1978, Hedrick *et al.*, 1983).

**Table 2.1 Terminology Definitions**

| Definition of Terms | Beef | Broiler |
|---|---|---|
| Slaughter Liveweight | Weight of the animal just prior to slaughter. Not the shrunk liveweight. | Weight of broiler before it is slaughtered |
| Carcass Weight | Weight of animal carcass when hide, head, internal organs and blood are removed. | Weight of animal carcass when head, feathers, internal organs and blood are removed. |
| Carcass Yield | The percentage of the carcass weight remaining after deboning and trimming the carcass. | Not used for Broilers |

The average slaughter liveweight for grain-based production came from the federally inspected category of the USDA Livestock Slaughter report for the time period of January-December 2010. Average carcass weight was found to be 60.3% of the average slaughter liveweight. This percentage was calculated by dividing the January-November 2010 average of cattle carcass weight, by the January-November 2010 average of federally inspected slaughter liveweight (USDA Livestock Slaughter report, 2010). 72.8% of the carcass weight yields the saleable meat assuming an average of Yield Grade 3 (Ray, 2007). These figures were used to find the average pounds of saleable meat per animal. In order to find the number of animals needed to meet Michigan's consumption (discussed above), the yearly beef consumption was

[9] Personal communication, Dr. Allen Williams, COO Tallgrass Beef 02/25/2011

divided by the pounds of saleable meat per animal. No allowance was made for lost animals and there was also no accounting for the contribution of culled dairy cattle to the beef supply.

***Broilers***

The number of broilers needed to meet Michigan's chicken consumption was determined for both pasture-based and confinement systems. The process of calculating the number of broilers required to meet Michigan's consumption is similar to that described for cattle. The average slaughter liveweight of pasture-based broilers was taken from Mr. Daniel Salatin. This was verified with a local producer[10] as well as Dr. Karcher[11] to ensure these production figures were reasonable for Michigan and the production system. The average broiler slaughter liveweight for confinement operations was determined from a national company[12] and is their national average for the time period October 2009-November 2010.

The carcass weight of a broiler is on average 70% of the slaughter liveweight[11] in each production system and was used as the saleable pounds per chicken. This figure was used to determine the total number of broilers needed to meet Michigan's demand. No allowance was made for lost animals.

***Egg Production***

The number of laying hens required for egg production is needed to estimate total pasture usage. The average number of eggs per chicken-day in the pasture-based system was

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[10] Personal Communication, Mr. Patrick Henne 07/07/2010

[11] Personal Communications, Dr. Darrin Karcher, Michigan State University Extension Poultry Specialist, Oct. 2009-Jan. 2011

[12] Personal communication, Anonymous 01/05/2011

determined[13] and verified[14], to ensure a reasonable range for Michigan. Average number of eggs per chicken–year was then calculated. The number of eggs consumed per year in Michigan was divided by the average annual production to determine the number of laying hens needed. No allowance was made for breakage or seasonality.

**FEED AND ACREAGE REQUIREMENT DETERMINATION**

To estimate the amount of acreage needed to meet the animals' nutrient demands through pasture, hayfields or cropland, the feed consumption was determined and then the needed acreage was determined. For pasture-based production the land footprint of the directly-consumed pasture as well as the land required to grow feed and hay was considered. Additional haymaking pasture for cattle, beyond hay harvested from pastureland, is not required at Polyface Farm.[13] The pasture acreage for the broilers and the laying hens was also determined. The land footprint of the buildings and feedlots were not included in the final calculations because the acreage in relation to the total acreage requirement was marginal.

***Cattle***

The first step in estimating the acreage requirements is determining the amount required to grow the young animal prior to its introduction into the pasture or feedlot finishing system. The number of cattle required each year to meet beef demand determines the number of cow calf pairs required each year. It was assumed that the calves would be in this cow-calf grazing system until the "…standard U.S. beef industry age (205 d)…"(Capper, 2010). The average dry

[13] Personal communication, Mr. Daniel Salatin, interview 01/30/2010

[14] Personal Communications, Dr. Darrin Karcher, Michigan State University Extension Poultry Specialist, Oct. 2009-Jan. 2011

matter requirements per cow-calf pair of 36.16 lbs of dry matter per day (Meyer, 2010) was multiplied by 205 days to calculate the dry matter requirements for the cow-calf pair from the birth of the calf until it is moved into either finishing system. To account for the cows the remaining portion of the year, the dry matter requirement per dry cow of 22.93 lbs of dry matter per day (Meyer, 2010) was multiplied by 160 days. For both beef production systems the cow calf acreage was calculated using the same nutritional requirements to reduce variability. The total requirements for the dry cows were added to the pounds of cow-calf dry matter requirement to reach a total for the cow-calf portion of the production system.

The average dry matter production of Michigan's fields was calculated by dividing the total tons forage dry equivalent produced by the total acres harvested in Michigan (USDA ERS, 2007). The weight per acre was then reduced by 13% to convert it to dry matter (USDA New England Statistics Service, 2008). The dry matter production per acre was divided by the total pounds of dry matter required per cow for the cow-calf and dry cow portions of the year. No allowance was made for lost hay due to rain or other factors. This acreage amount was multiplied by the number of calves needed per year for each system to determine a total acreage needed to produce calves for each system.

The acreage requirement for the grass-finished cattle production was based on the weight gain per acre per year given by Mr. Salatin.[15] The production per acre was confirmed to ensure that it was well within the range expected in Michigan.[16] Weight gain per acre was reduced to pounds of saleable meat per acre per year using the dressing and cutting percentages mentioned above. Michigan's beef consumption was divided by the pounds of saleable meat per acre per

[15] Personal communication, Mr. Daniel Salatin, interview 01/30/2010

[16] Personal communication, Dr. Jason Rowntree, Michigan State University Extension Beef Cattle & Forage Utilization, Faculty Coordinator Lake City Experiment Station.

year to determine the number of acres required. To determine the overall pasture requirement, the acreage needed for the cow-calf system was added to the grass-finished total.

There are two commonly used diets for determining the acreage requirements of a feedlot system. Dr. Steven Rust provided the breakdown of these diets and the average daily intake of the cattle on each[17] (Table 2.2). One diet included dried distillers grains (DDGs), a byproduct of

| **Table 2.2 Beef Feedlot Diets** | | |
|---|---|---|
| **Ingredient** | **DDG Diet** | **Non-DDG diet** |
| *DDG Diet* | | |
| Distiller's Grain with Solubles | 29% | --- |
| Corn Silage | 25% | 34% |
| High Moisture Corn | 44% | 60% |
| Soybean Meal | --- | 2% |
| Mineral Supplement with Rumensin | 2% | -- |
| Protein-Mineral Supplement with Rumensin | -- | 4% |
| Source: Dr. Steven Rust Michigan State University Extension, Beef Cattle Nutrition & Management | | |

corn ethanol production, and the other did not. The two diets have different acreage requirements. In order to determine the total acreage requirements I needed an estimate of how often each diet is used. A study of the upper Midwest indicated that 36% of beef producers were using DDGs in their feedlot diets (USDA NASS, 2007a). Therefore it was assumed that 36% of producers in Michigan would use DDGs in their feedlot diet and assumed 36% of the cattle were being fed a diet with DDG. This figure might be somewhat inaccurate as feeding DDGs is more common in larger feedlots thus the percentage cattle might be higher (USDA NASS, 2007a). This is significant because the DDGs diet requires more acreage than the non-DDG diet.

[17] Personal communication, Dr. Steven Rust Michigan State University Extension, Beef Cattle Nutrition & Management 06/16/2010.

However the DDG corn acreage would also be producing ethanol; this issue will be covered in the discussion.

The average number of days on the feedlot was established by subtracting the average entry weight[18] from the average slaughter weight (USDA Livestock Slaughter Report, 2010), then divided by the average weight gain per day.[18] To calculate the pounds of feed consumed per stocker during its lifetime in the feedlot, the average number of days on the feedlot was multiplied by the average daily feed intake. The lifetime feed consumption per cow was separated into pounds of ingredients based on diet formulations from Dr. Rust.[18] The pounds of ingredient per steer lifetime were multiplied by the total number of cattle fed. This calculation resulted in the total tons of each feed ingredient.

To confirm that currently there are enough DDGs to supply feedlot needs based on the above assumptions, the pounds of DDGs produced per year in Michigan were calculated. This number was derived from the Michigan annual production of ethanol and dividing by the pounds of DDGs produced per gallon of ethanol (Stroade *et al.* 2009). Nationally 42% of DDGs produced are used in feedlots (Stroade *et al.* 2009) and it was assumed consistent for Michigan. 42% of the pounds of DDGs produced in Michigan is slightly greater than the total amount needed for the DDG feedlot diet, so if all went to beef cattle production there would be sufficient DDG feed resources in Michigan to supply the production in this analysis.

To convert the feed consumed on the feedlot into acreage requirements, each ingredient's weight total was divided by the average tons of production per acre in Michigan (USDA NASS, 2007b). The acreage totals were then summed to get the cropland needed to grow the feed for

[18] Personal communication, Dr. Steven Rust Michigan State University Extension, Beef Cattle Nutrition & Management 06/16/2010.

each diet. The overall total of the acreage needed for the feedlot finishing system was calculated by adding the cow-calf acreage requirements to the cropland total.

***Broiler***

The feed consumption for the pasture-based broiler production system was calculated based on the feed conversion ratio (Chisholm *et al.,* 2003, Fanatico *et al.,* 2008). This is the pounds of feed used per pound of animal gain. The feed conversion ratio was multiplied by the slaughter liveweight of the broiler[19] to yield the pounds of feed required per bird. I then multiplied the feed per bird by the number of birds required per year and divided by 2000 to calculate the total tons of feed per year needed for the pasture-based broilers. The tons of individual feed ingredients were then determined based on the pasture-based broiler diet (Salatin, 1999). A local Michigan producer[20] was consulted to confirm that the diet is effective in Michigan.

The confinement broiler feed requirements were calculated using the same method as the pasture-based production. The average feed conversion ratio and the average slaughter liveweight were determined.[21] Similar to the feedlot diets, the "average" diet for the confinement birds was determined through consultation with Dr. Karcher.

The process for identifying the cropland acreage needed for growing the feed for broiler production is the same as for the beef feedlot diet crop production described above, using the tons of each ingredient and the production per acre (USDA NASS, 2007b). The acreages required for ingredients were added together to establish acreage totals required to grow the feed.

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[19] Personal communication, Mr. Daniel Salatin, interview 01/30/2010
[20] Personal Communication, Mr. Patrick Henne 07/07/2010
[21] Personal communication, Anonymous 01/05/2011

The pasture acreage requirements for the pasture-based broilers was determined by using the average stocking rate of 1000 broilers per acre per year based on the production practices on Polyface Farm.[22] The number of broilers needed was divided by 1000 to calculate the number of acres required for the pasture needs. This acreage requirement was added to the total needed for growing the feed to determine the land footprint of the production system.

***Egg Production***

The calculation for egg production was also based on feed conversion, which in this case was pounds of feed per dozen eggs. The pasture-based feed conversion was calculated by the average weight of the egg in grams divided by the grams of egg per gram of feed (Anderson, 2009). This yielded the grams of feed per egg, which was then multiplied by 12 to calculate the grams of feed per dozen eggs; this was then converted to pounds of feed per dozen eggs. Michigan's egg consumption, converted into dozens, was multiplied by the pounds of feed per

**Table 2.3 Pasture Diets**

| Ingredient | Laying Hen | Broiler |
|---|---|---|
| Total Corn | 49.7% | 52% |
| Soy Meal | 30.8% | 29% |
| Oats | 10.9% | 11% |
| Minerals and Supplements | 8.5% | 8% |
| Source: Salatin, 1999 | | |

**Table 2.4 Confinement Diets**

| Ingredient | Laying Hen | Broiler |
|---|---|---|
| Corn | 66.50% | 57.5% |
| Soy | 26.50% | 36.5% |
| Minerals and Supplements | 7% | 6% |
| Source: Dr. Darrin Karcher MSU Extension Poultry Specialist | | |

[22] Personal communication, Mr. Daniel Salatin, interview 01/30/2010

dozen eggs to yield the pounds of feed required per year. The pounds of ingredients were calculated from the total feed needed based on the pasture diet percentages (Table 2.3).

The confinement production feed conversion per dozen eggs was determined.[23] The proportions for the confinement layer diet was given by Dr. Karcher as an average industry-wide diet(Table 2.4). The total ingredient weight was calculated from the total feed required and the diet percentages, as described above. From the total tons of each ingredient the acreage was calculated as above.

The pasture requirements for the pasture-based laying hens were based on the number of layers needed to produce the eggs. The laying hens at Polyface Farm are put in groups of 600 and they utilize 50 acres per year.[24] The total number of chickens was divided by 600 to determine the number of groups. That result was multiplied by 50 to yield the number of acres that are required for pasture for the laying hens. This acreage was added to the acreage required for the grain to yield the total acreage for pasture-based egg production.

### *Totals of Each System*

Before finding the total for the MSPR system the total pasture acreage for the broilers and laying hens were summed to determine if those requirements would exceed the acreage requirement for the grass-finished beef (Table 3.3). Since the combined pasture acreage requirement of the broiler and laying hen systems was less than that of the beef, it was not added to the overall total, because it would fit within the land used for beef production and would not add to the total land requirements. The MSPR system total was calculated by adding the total

[23] Personal communication, Anonymous 01/05/2011
[24] Personal communication, Mr. Daniel Salatin, interview 01/30/2010

pasture required for producing beef, and the cropland needed to produce the feed for the broilers and laying hens.

The calculation of the acreage footprint for the confinement operations was straightforward. The total acreage requirements to produce feed for each system were summed to get a grand total. The totals of the two systems were compared to determine the difference in acreage requirements by subtracting the confinement totals from the pasture totals.

***How Many Farms***

This calculation was based on yearly production numbers at Polyface Farm.[25] The number of MSPR produced animals required to meet consumption, discussed above, for beef and broilers was then divided by the number of animals produced on Polyface Farm each year. The number of farms needed for eggs was calculated by dividing Michigan's yearly egg consumption by the number of eggs produced per year on Polyface Farm. These calculations yielded the total number of farms the size of Polyface Farm required for each product. This calculation showed that broiler production would require the most farms of the size of Polyface Farm. Because the beef production was the largest driver of the acreage requirements the question was asked, how many broilers would have to be produced on each farm producing beef to not require extra farms that only produce broilers. To calculate this, the number of broilers required was divided by the number of farms required for beef production. To confirm that this amount of production would fit within the acreage of each farm the acreage requirement for the number of broilers per farm was calculated. This was done by dividing the number of broilers required for each farm every year by the number of broilers that can be housed per acre.

[25] Personal communication, Mr. Daniel Salatin, interview 01/30/2010

In chapter three the results of this analysis are explored.

## CHAPTER 3:
## RESULTS

United States residents on average consumed 79.6 lbs/yr of chicken, 247.7 eggs/yr and 61.20 lbs/yr of beef (USDA ERS, 2011). The consumption for beef was then altered to reflect the consumption habits of the upper Midwest. The beef consumption of the upper Midwest is 109% (USDA ERS, 2005) of the national average. This yields a total of 66.71 lbs/yr/capita. Michigan's population of 9,883,640 (U.S. Census Bureau, 2011) was then multiplied by the per capita consumption to yield total yearly consumption data for the state (Table 3.1).

**Table 3.1 Consumption Data**

| **Product** | Per Capita Yearly Consumption | Michigan Yearly Consumption |
|---|---|---|
| Beef | 66.7 lbs/yr | 659,317,857 lbs/yr |
| Chicken | 79.6 lbs/yr | 786,737,744 lbs/yr |
| Eggs | 247.7 eggs/yr | 2,448,177,628 eggs/yr |

To calculate the number of animals required, the average live weight of beef and chicken (Table 2) were converted to the saleable product per animal as described in Methods. The saleable product per animal was divided into the total pounds of consumption per year, resulting in the number of animals required per year to match the consumption needs of Michigan (Table 3.2).

**Table 3.2 Animal Characteristics**

| **Category** | **Average Live Weight** (lbs) | **Saleable Product per Animal** | **Number of Animals** |
|---|---|---|---|
| Grass Based | | | |
| Beef | 1097 | 463.81 | 1,421,521 |
| Broiler | 5 | 3.5 lbs | 224,782,212.57 |
| Eggs | n/a | 219 eggs/year | 11,178,893 |
| Conventional | | | |
| Beef | 1282 | 563.34lbs | 1,170,378.14 |
| Broiler | 6 | 4.2lbs | 187,318,510.48 |
| Eggs | n/a | 288.35 eggs/year | 8,490,298.7 |

The next step was to calculate the amount of feed that would be consumed per year or per animal lifetime depending on the length of the production system. The dry matter requirements were multiplied by the number of cattle in order to establish the total acreage for the cow calf system (Table 3).

The yearly gain per acre that was used for the grass-finished production was 600 pounds.[26] There are a number of studies that show that this estimate is on the conservative side for managed pastures (Capper, 2010, Steinberg &Comerford, 2009). Dr. Jason Rowntree also confirmed this estimate to be on the lower end of the scale for managed pasture in Michigan.[27] These conservative estimates were used in order to have a solid estimate that would not have the potential to result in artificially low estimates of acreage requirements. The 600lbs per acre was then converted into the saleable meat per acre (Table 3.2) through the dressing percentages detailed in the methods section. The number of acres for the grass-finished production was determined by dividing the pounds of meat consumption by the pounds of saleable meat per acre as seen in Table 3.3.

The average daily gain for cattle in the feedlot system was 3 pounds of gain per day with a daily feed consumption of 35lbs/day of the DDG diet and 33lbs/day of the non-DDG diet.[28] The average number of days on the feedlot was based on how many days it would take to get from the entrance weight of 600lbs to the average finish weight of 1282 lbs. This resulted in 227.3 days on average that a stocker would spend on the feedlot. The acreage was then

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[26] Personal communication, Mr. Daniel Salatin, interview 01/30/2010

[27] Personal communication, Dr. Jason Rowntree, Michigan State University Extension Beef Cattle & Forage Utilization, Faculty Coordinator Lake City Experiment Station.

[28] Personal communication, Dr. Steven Rust Michigan State University Extension, Beef Cattle Nutrition & Management 06/16/2010.

determined based on the per steer consumption as described above. The total acreage for feedlot feed production can be seen in Table 3.3.

| Table 3.3 Feed and Acreage Requirements | | | | | |
|---|---|---|---|---|---|
| | Tons of Feed Needed | Acreage to Grow Feed | Cow-Calf Acreage | Pasture Needed | Total |
| **Pasture** | | | | | |
| *Beef* | 0 | 0 | 3,540,645.26 | 2,500,708 | 6,139,659.20 |
| *Broiler* | 1,404,888.83 | 734,000.95 | 0 | 224,782.21 | 958,783.16 |
| *Eggs* | 349,723.51 | 185,703.78 | 0 | 931,574.44 | 1,117,278.22 |
| Total Acreage Not Including Pasture for Broilers and Eggs | | | | | 7,059,294.62 |
| **Conventional** | | | | | |
| *Beef* | 4,485,872.16 | 1,352,529.60 | 2,915,112.95 | 0 | 4,267,642.6 |
| *Broiler* | 1,078,954.62 | 524,231.20 | 0 | 0 | 524,231.20 |
| *Eggs* | 325,403.61 | 138,811.37 | 0 | 0 | 138,811.37 |
| Total Acreage for Production System | | | | | 4,930,249.98 |

The feed conversions for the broiler production was 2.5lbs of feed per lb of gain (Chisholm *et al.,* 2003) for the pasture-based broilers and 1.92lbs of feed per lb of gain[29] for confinement broilers. The feed conversion for the pasture-based production of eggs was 3.43lbs of feed per dozen eggs (Anderson, 2009) and the confinement production was 3.19lbs of feed per dozen eggs.[29] These feed requirements were used to calculate the acreage needed (Table 3.3) for each production system as mentioned above.

Pasture requirements for the pasture-based production of broilers and eggs were based off of stocking rates used at Polyface farm as described in the methods section. The results of these calculations can be seen in Table 3.3.

The ingredients in each diet influence the acreage requirements for the animals that

[29] Personal communication, Anonymous 01/05/2011

required cropland to grow their feed. All the feed ingredients can be seen in tables above (Tables2.2-2.4). The acreage requirements for pasture or for growing feed were calculated based on the average cropland production per acre in Michigan (Table 3.4).

| **Table 3.4 Average Crop Production in Michigan** | |
|---|---|
| **Crop** | **Tons/Acre** |
| Corn | 3.35 |
| Soy | 1.16 |
| Silage Corn | 14.69 |
| Oats | 0.94 |
| Sources: USDA ERS, 2007b, USDA ERS, 2007f | |

The cropland requirements to produce feed for both confinement and pasture-based broiler and laying hen production systems were added to the total acreage requirements for beef production in their respective systems. This provided an overall total for each system of 4,930,249.98 acres for the confinement system and 7,059,294.62 acres for the MSPR system.

| **Table 3.5 Polyface Sized Farms Needed** | | | |
|---|---|---|---|
| | **Polyface Production Per Year** | **Pastured Animals Needed/Eggs Needed** | **Number of Farms Needed For Production** |
| Beef | 400 Cattle | 1,421,521 Cattle | 3,553.80 |
| Broiler | 30,000 Broilers | 224,782,213 Broilers | 7,492.74 |
| Eggs | 900,000 Eggs | 2,448,177,628 Eggs | 2,720.20 |

If the totals of each MSPR animal production system listed in the table are added together, it will result in a larger total than what is listed as the overall total for MSPR production. The reason for this is, as described above, the pasture usage of these systems stack on top of one another. Therefore the broiler and laying hen pasture requirements are not added to the overall total.

The number of farms the size of Polyface Farm was based on their yearly production.[30] They slaughter 400 cattle, 30,000 chickens and produce 900,000 eggs per year. The number of farms calculated using these numbers can be seen in Table 3.5. The number of farms that are required to raise broilers is drastically higher than the farms required for either of the other production systems. Therefore it was calculated how many broilers per farm would be needed in

| **Table 3.6 Number of Broilers Required** | |
|---|---|
| Broilers Needed per Beef Farm | 63,251 |
| Acres Required for Broilers | 63.25 |

order to have the broiler production fit within the required number of beef farms. The number of broilers needed per beef farm and the acreage their production would require per farm can be seen in Table 3.6.

The significance of these results will be examined in the following discussion section.

[30] Personal communication, Mr. Daniel Salatin, interview 01/30/2010

## CHAPTER 4:
## DISCUSSION

In many of the books and documentaries that have criticized the current agricultural production system there is a solution presented that is portrayed as the antidote. Many times the treatment of the different systems is not equal - the system promoted as an answer is less critically analyzed. In this study I examined MSPR systems in reaction to the uncritical promotion of them as an answer in *The Omnivore's Dilemma* (Pollan, 2006). While this study only directly discusses the implications in relation to the number of acres and farms needed to provide Michigan with beef, chicken and eggs using a MSPR system, along the way it has also exposed some of the influence this switch would have on other segments of the agricultural landscape. Because these areas are outside the focus of this study they will not be discussed, but the reader should acknowledge that there is more to this change than just the land and farm number requirements. In the following I will discuss my results in relation to the goal of this study.

The goal of this study was to closely examine an MSPR system to establish the land base and number of farms needed for a population's beef, chicken and eggs. Because it is a very broad and complicated system it was restricted to an examination of the acreage and farms needed to meet Michigan's needs. This study is not intended to advocate or criticize any type of production. Rather, it is intended to be the first step in performing an examination of a management strategy that is being promoted as a sustainable option. I use the analysis of the MSPR system supplying all the beef, chicken and eggs for the state of Michigan in an attempt to systematize the issues with scaling production to a large population. I also use the confinement/grain-based production estimate as a way to comparatively benchmark.

## ACREAGE REQUIREMENTS

In order to put our findings into context, it is important to get a sense for the type and extent of production currently occurring in Michigan. These production numbers are from the USDA Census of Agriculture and are thus fairly general and not an easy, direct comparison; yet are helpful to gauge the range of expansion or contraction in production needed to meet the demands identified in the analysis.

Our data in this study indicate 1,421,521 grass-finished cattle and 1,170,378 grain-finished cattle to meet Michigan's demand for beef. In 2007 Michigan cattle on feed sold was 176,731 (USDA NASS, 2007c). This number represents cattle sold from feedlots to slaughterhouses. It does not include cattle that are grass-finished or veal; therefore this number could be an underestimate, but probably not by a lot. To produce enough beef within Michigan from grass-finished cattle an eight-fold increase in the state's cattle numbers would be required; while a 6.6 fold increase for grain-finished cattle would be required. Put simply, we currently produce a relatively small percentage of the total beef consumed within the state.

In relation to broilers, I identified that Michigan would require 224,782,212 broilers for pasture-based production, and 187,318,510 broilers for the confinement operations. The 2007 production level for broilers in Michigan was 4,041,902 broilers and other meat-type chickens sold (USDA NASS, 2007d). Hence a 55.6 fold increase in the number of broilers raised in a pasture-based system would be required. In a confinement system it would require a 46.3 fold increase.

In 2007 there were 9,034,335 laying hens in Michigan (USDA NASS, 2007d). This is all laying hens for table eggs as well as layers for broiler and laying hen-hatching eggs. There is no breakdown for table egg production laying hens. Based on the total laying hens, pasture-based production would need to increase 1.2 fold increase to 11,178,893 laying hens. To produce enough eggs for the state of Michigan using confinement operations it would require 8,490,298 laying hens, so there are already enough laying hens assuming they mostly produced table eggs.

These increases in the number of animals produced in Michigan would have many implications. Such large increases in the animal population would require a change in the supporting infrastructure, from farm supply stores to the animal health industry to the acreage and number of farms. Because there are such large increases in the animal populations it requires an increase in the acreage devoted to the production of these animals and a change in the farms producing beef, chicken and eggs.

Beef production is the single largest driver of the acreage needs for both the grass and grain-finished production systems, but it is especially true in the grass-finished system. The beef production requires so much acreage that the pasture requirements for the broiler and laying hens can fit within the beef acreage requirements and still have 4,983,303 acres of pasture that is only utilized by the beef production. Often in the production system each acre of land that has broilers rotated across it will then be rested for 3 years due to concerns of pathogens and overconcentration of nutrients. If this 3 year rest period is taken into account there are still 4,533,738 acres of pasture that are only used by the beef production.

In 2007 there was 811,623 acres of land used for pasture in Michigan (USDA NASS, 2007e). This would only provide 13.2% of the 6,139,659 acres of grazing land needs for the pasture-based system. However a large portion of the current pastureland is probably used for pastured-based dairy and other grazing animals (sheep, goats, horses), therefore in order to assume all of the current pasture land will be in beef production I have to note that it will replace some other grazing production systems. If the total pastureland is subtracted from the total acreage needs for the MSPR production system, the result is 5,327,946 acres that would need to be changed from its current production. There are also 1,160,467 acres that are currently used for harvested forages (USDA NASS, 2007f). This would probably be the first land switched to pasture production because it is already an established forage crop. This would account for 21.8% of the remaining acreage needed for the pasture needs. If the harvested forage land is converted to use in the MSPR production system it would result in 4,167,479 acres that still need to be converted to pasture. As stated earlier, the intent of this study is not to suggest that this conversion be accomplished but to understand the boundary conditions of such a system.

The dairy products category is the largest value commodity that is exported from Michigan (USDA ERS, 2011). Since dairy is such a large percentage of total farmgate receipts in Michigan such a change would dramatically impact them. With both the current harvested forage land and the current pasture land being required for MSPR or grain finished production, the dairy industry would be without a considerable portion of their feed. To take away the land used for dairy cattle harvested forage and grazing would result in drastically reduced production of dairy products in Michigan. The land that would most likely be converted to pasture would be current cropland. If that acreage came out of the 7,803,643 acres of cropland in the state of Michigan (USDA NASS, 2007g) it would require that 53.4% of the cropland be converted to pasture. This would leave 3,636,164 acres of cropland that is not converted to pasture.

When the 919,635 acres needed for producing the grain brought onto the farm for poultry are included, there are 2,716,529 cropland acres remaining for all other agricultural production. To put this in perspective, that is almost one-half a million acres more than the land used to produce corn for grain in 2007 (USDA NASS, 2007f). Overall, this system uses 72.2% of the combined pasture, harvested forage and cropland acres in the state of Michigan. This does not include the potential for using marginal land because an estimate of the marginal land in Michigan suitable for grazing was not available. By not including marginal land a major advantage of this system is removed because grazing is often able to take advantage of land that is unsuitable for harvested crops. In total this system requires just over 11,000 square miles and would cover 19% of the 58,110 (Library of Michigan, 2006) square miles in Michigan. By achieving this estimate it shows that there is reason to be concerned about the effectiveness of this system for producing beef, chicken and eggs for larger markets than the niche markets that it produces for now and/or that our consumption of these products (especially beef) is out-of-alignment with the carrying capacity. When the MSPR systems are promoted in *The Omnivore's Dilemma* (Pollan, 2006) there is no consideration of how the agricultural landscape would have to change if the MSPR system provided a larger portion of the nations food as the author suggests. This criticism can be applied to many of the popular press books and documentaries that promote an alternative to the conventional production system (e.g. Jackson, 1980, Gussow, 1991, Pollan, 2006, Patel, 2008 etc).

The MSPR production system is compared to 4,930,250 total acres required for the confinement/grain-finished system. The cow-calf portion of this production system requires 2,915,113 acres of pasture – a number that represents all of the current pastureland, the land that is currently used for harvested forages and 934,023 acres of cropland converted to pasture. This would represent a production change of 12% of the cropland and a monopolization of land in forage production as in the MSPR system.

The 2,015,137 acres needed for the production of feed for the animals would bring the usage for the confinement/grain-based system to 37.8% of the total cropland. If production acreage of corn for grain, corn silage and soybeans for grain remained the same the production of the feed would require 61.1%, 31.5% and 28.3% respectively of the current production. Overall this system would use 50.4% of the combined pasture, harvested forage and cropland acres in the state of Michigan. This system could also take advantage of marginal land in the cow-calf portion, which would reduce the effect that it has on current production practices.

To feed Michigan's population from internal production using either system explored herein would require a large shift in the current Michigan production profile would monopolize all current pastureland and harvested forage land. This shift would be larger for the MSPR production system but both systems would greatly limit the capability of the state to produce other crops and raise other animal products such as pork, dairy and lamb.

When performing a direct comparison, the MSPR system requires 2,129,044 more acres to provide beef, chicken, and eggs to Michigan than the confinement/grain-finished system. This calculated difference is approximately one and one-half times more acreage. This difference provides a better understanding concerning land-requirement differences between an MSPR system compared to current predominant production practices.

It is not surprising that the confinement/grain-finished system requires fewer acres than the MSPR. The confinement and grain-finished production systems have been developed over many years with a great deal of scientific resources expended to optimize these systems- from crop yields to animal breeds. However there are indications of potential for reduced acreage requirement in the MSPR system based on the conservative nature of our assumptions. The pasture-based and grass-finished systems are based on historic systems with new, emerging strategies incorporating ecological principles. Systems, such as the one used at Polyface farm, are very complex with relatively little land-grant research to aid in their optimization. In this study conservative estimates for production were used in order to be sure that the production potential per acre used would be a minimum. Using conservative estimates would also allow us to say that *at most* there would be a difference of just over two million acres between confinement/grain-finished and MSPR systems with a potential to shrink that difference with highly skilled farmers engaged in the production.

The acreage required for the grass-finished beef was the driver of the overall acreage requirements in the pasture-based system. While the total acreage needs for the grass-finished beef production was calculated at 6,139,659 acres, it is reasonable to expect that that acreage requirement could be reduced. One area where reductions could be seen is in the cow-calf portion of the production system. A middle ground weight was used to estimate the cow-calf acreage requirements of each system. The calculations for the cow-calf portion were based on a dry matter intake for mature cows weighing 1,120lbs. Because this weight was being used for both grain and grass-finished systems, it is higher than the mature weight for grass-finished systems. There is a movement among many grass-finished beef producers to reduce the size of a mature cow to about 1,000lbs, because they are thought to produce stockers that are more suited for grass-finishing production.[31] By reducing the size of the cattle the daily intake per cow would be less and therefore would require fewer acres for the cow-calf portion of this calculation.

Another effect of this middle ground estimate is that the weight of the cows in the cow-calf portion of the grain-finished cattle is low. By underestimating the weight of the cows the feed requirements are also underestimated; thus the acreage requirements would be increased. While the ideal size and weight of a mature beef cow is often debated, the cows producing

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[31] Personal communication, Dr. Jason Rowntree, Michigan State University Extension Beef Cattle & Forage Utilization, Faculty Coordinator Lake City Experiment Station.

stocker cattle headed for feedlots tend to be in the 1,200-1,400lb range. The feed requirements for the animals are commonly calculated by using a percentage of bodyweight. As mentioned above the weight used for estimating the required intake was 1,120lbs. Therefore when the bodyweight is increased to match the common weight of cows producing stockers for the grain-finished system the feed requirement per cow would be higher. This would result in more acres being required for the cow-calf portion of the grain-finished system. An increase in acreage in this system paired with a decrease in acreage in the grass-finished system would bring the acreage requirements closer together.

The acreage requirement for the grass-finished system after the cow-calf section is also a fairly conservative estimate. While 600lbs of gain per acre per year is a good healthy production, there seems to be the potential for more production per acre; for example, research currently underway at the Michigan State University Lake City Experiment Station.[32] It is important to remember that often the quoted production numbers for grass-finished beef production are on range settings in the American West with a very different climate than Michigan. Therefore the potential pounds of gain per acre will be higher in areas with greater rainfall.

Another aspect to consider is that land in Michigan used for grazing is often not the most productive acreage because this is often used for field crops. Therefore if some of the more productive lands were used for grazing increases in the production per acre could be seen.

When comparing the grain-finished and grass-finished acreage needs there is an added complexity to the acreage comparison. The DDG diet acreage requirements are higher than the

[32] Personal communication, Dr. Jason Rowntree, Michigan State University Extension Beef Cattle & Forage Utilization, Faculty Coordinator Lake City Experiment Station.

non-DDG diet because the DDGs are a byproduct of ethanol production. During ethanol production some of the energy is removed from the corn and it thus takes more DDG per weight basis to provide the same amount of energy as high moisture corn. More DDG per cow translates into more acres of corn required. However the fact that there is already a use being extracted from the corn in the form of ethanol should be considered. It is not within the scope of this study to put a value on the ethanol production or argue the merits and problems with feeding DDG, but it is a consideration that should not be overlooked when interpreting this study. The non-DDG diet is probably a reasonable estimation of the land going to feed production and the difference between the two diets would roughly represent the 'ethanol acreage demand.'

Acreage requirements for combined laying hens and broilers only contributed about 13% of the total land requirements in each system. This means that the acreage reducing benefits of the animals using the same pasture is not fully taken advantage of. If it were, either the total production of beef would need to decrease dramatically or the production of broilers and eggs increase dramatically. The pasture-based system for laying hens and broilers required 257,028 acres more than the confined laying hen and broiler system. There are anecdotal accounts from farmers that putting broilers and laying hens out on pasture can reduce their feed intake by between 15%[33] and 30% (Salatin, 1999). If this were the case then the difference between the pasture-based and the confined production could be reduced. The reduction in feed could be due to consumption of forages, insects and other protein sources that are available in the pasture. Though studies about pasture-based poultry have shown no benefit to feed consumption (e.g. Anderson, 2009, Chisholm *et al.*, 2003, and Fanatico *et al.*, 2008), it is difficult to judge definitively because these studies have not included rotation behind ruminants. Having

[33] Personal Communication, Mr. Patrick Henne 07/07/2010

ruminants on the pasture before the poultry are rotated onto the land could have any number of positive or negative effects. However, because I utilized the consumption numbers in the available poultry research to establish conservative estimates, the potential influence that ruminant pasture usage had on poultry feed consumption was not incorporated. It has been suggested that the reasons for the higher feed consumption in the pasture-based poultry system are based on the extra energy requirements associated with increased movement and exposure to variable weather conditions (Fanatico *et al.*, 2008). This increased consumption accounts for approximately 1.4 times more acreage required for growing the feed for the pasture-based broiler systems. While this difference did not contribute much to the overall acreage compared to the beef production system it is a significant increase in the required acreage needs when the systems are looked at individually.

Producing all the beef, chicken and eggs for Michigan would require drastic changes in Michigan agriculture. It is that this would occur. However if there was a goal such as 25% of Michigan's beef, chicken and eggs produced within the state using MSPR systems, the scenario seems more feasible. The acreage needed for this scale scenario can be seen in Table 4.1. While this scenario would still require a large change in the utilization in the agricultural land it seems more within reach.

**Table 4.1 Land and Animals Requirements at 25% of State Consumption**

| | Confinement | MSPR |
|---|---|---|
| Total Land Requirement | 1,232,562.49 acres | 1,764,823.65 acres |
| Total Beef Cattle | 292,594 | 355,380 |
| Total Broilers | 46,829,628 | 56,195,553 |
| Total Laying Hens | 2,122,574.7 | 2,794,723 |

## NUMBER OF FARMS

A goal of this study was to determine what type of change there would need to be in the number of farms in Michigan engaged in animal production, and specifically pasture-based animal production. This is a difficult question to answer accurately, because many of the statistics about animal production in the state are general. However it is important to know how much and what type of a change in farmer population there would need to be in order to gauge the implications of moving towards a food system dominated by MSPR production.

Using Polyface farm's yearly production as a template, I calculated the number of farms it would take to produce each product for Michigan (Table 3.4). Producing the needed number of broilers required just over double the number of beef farms and almost triple the number of farms required to produce eggs. Because beef production takes the most acreage, there would be room to put more chickens on each farm that is producing beef. Therefore it was calculated that if each farm producing beef would produce 63,251 broilers per year, then broiler production would fit onto the beef farms so it would require only 3,554 farms to produce all the beef cattle, broilers and laying hens for the state of Michigan. The farm requirements in this scenario can be seen in Table 4.1. In terms of acreage it would be possible to produce that many broilers per farm because they would only require 63.3 acres. It is uncertain whether this would be feasible for farms to produce and process this many chickens when other aspects of the system are considered. It may not be possible for a small to mid-sized farm to manage the needs of that number of chickens, both when they are being rotated on the pasture and the slaughter.

**Table 4.2 Number of Farms**

| Based on 1,000 acres of Pasture/Farm | Based on Polyface Production |
|---|---|
| 6,140 | 3,554 |

That being said, there is adequate acreage for the chickens, so there is potential to have all three production systems combined if there is enough processing and labor available. However only having 3,554 farms at the production levels used in this analysis would mean that on average the farms would be 1,727.6 acres of pasture. This is larger than the 1,000 acres of pasture[34] used on Polyface farm because it includes the cow-calf production. Polyface buys the majority of their cattle as weanlings, therefore does not require acreage for cow-calf production. If the number of farms were to be calculated based on the pasture acreage footprint of Polyface farm it would require 73% more farms to meet the consumption needs (Table 4.2)

In 2007 there were 56,014 farms with an overall average size of 179 acres and only 1,969 farms had 1,000 acres or more (USDA NASS, 2007e). There are 7,848 farms producing beef cattle in the state of Michigan, but 95% of those farms have an inventory of less than 50 beef cattle; only 21 farms have an inventory of 200 or more cattle (USDA NASS, 2007c). Of these beef producing farms 1,481 of them are cattle feedlots (USDA NASS, 2007h). While the overall number of farms producing beef in Michigan exceed either of the calculated farm number requirements in Table 4.1, it is reasonable that very few of these farms are the size that could be expected to expand production capacity to that of Polyface farm. With almost all of the farms owning less than 50 cattle on a given year, drastic on-farm changes would have to be made in order to have the Polyface farm production levels.

From these findings alone it is not easy to make conclusions as to whether there would be enough farms and farmers in Michigan because there are too many other factors that would influence the potential of a shift in production. Financial considerations, supporting infrastructure, willingness of farmers to adopt new production techniques and farmland access

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[34] Personal communication, Mr. Daniel Salatin, interview 01/30/2010

are just some of the other influences that would have to be considered to establish whether or not there are enough farms in Michigan to meet the demands of beef, chicken and eggs using MSPR systems. It is certain that at current consumption and known MSPR production levels, switching to this scale of production would monopolize most of the Michigan agricultural landscape.

The number of farms currently producing broilers in Michigan is well short of the 7,493 farms needed for pasture-based production and is still less than the 3,554 farms that would be required if the broilers raised per farm were increased. At 1,088 farms with broilers in 2007 (USDA NASS, 2007d) the number of farms raising broilers would have to increase by 6.9 times and 3.3 times respectively. In the census of agriculture data the size of farms with broiler inventory was not identified, however based on the broiler sales data over 95% of the broiler farms would have less than 2,000 broilers per farm (USDA NASS, 2007d).

In 2007 there were 5,247 farms raising laying hens (USDA NASS, 2007d); almost double the 2,720 farms required for producing enough eggs. However 83% of the farms listed in the Census of Agriculture were in the 1-49 hen category. A Polyface farm-type production would require just over 4,000 laying hens per farm. In comparison, there are only 14 farms with hen inventories over 3,200 (USDA NASS, 2007d).

A problem with these counts of the number of farms with beef cattle, broilers or laying hens is that some of the farms counted in the data might be counted twice. This would be the case with farms that produce more than just one of beef, chicken and eggs. Therefore when the totals of the number of farms for each production are added together it would count the farms producing more than one product twice resulting in an overall total that is artificially high.

While these comparisons give a general picture of the number of farms raising cattle, broilers and laying hens in the state, there is no indication in the Census of Agriculture what the average acreage is per farm. Therefore it is difficult to know what size the average farm producing beef chicken and eggs is currently. Even without the average size per farm the data suggest that if the MSPR production system was adopted as the predominant production system, Michigan's current farm sizes would not be large enough to accommodate a Polyface-scale of production. An option would be that the farms could lease or buy additional land to increase a farm's acreage in order to match Polyface farm production levels. The production size per farm used in this study was used solely to model the production at Polyface farm. It is not an indication that the farms have to match the production per year of Polyface farm in order to be a feasible and profitable enterprise. This study did not evaluate financial concerns of the production system, therefore it is unknown what production level is required to be a profitable business.

Data on the number of farms in Michigan that are producing pasture-based/grass finished animal products are very scarce. The best source is www.eatwild.com. This site lists 22 grass-finished beef producers, 16 broiler producers and 12 farms producing eggs. Some of the farms counted in this study produced two or all three of these products and thus are counted twice in these statistics. This is probably not an exhaustive list and does not profile the amount of production per farm, but it provides a sense of the scale of farms in the state attempting a similar production system. .

Another indication of the number of people using grass to produce animal products comes from the Census of Agriculture. The data show that in 2007 there were 7,151 farms that used rotational or MiG grazing (USDA NASS, 2007i). This figure is fairly vague because rotational grazing can cover such a wide range of management practices. This probably includes a number of dairy farms using rotational grazing for production. While this count of farms does not indicate any detailed information, it does show that there are a considerable number of farms that are familiar with at least some of the practice of rotational grazing.

## OTHER CONSIDERATIONS AND FUTURE RESEARCH

This study did not take into consideration what it would take to produce this amount of food in this manner. There are many infrastructure, legal and consumer issues that would need to be worked through.

A common warning to producers is that there is a difference in taste and texture of grass-finished beef and palatability will remain a consumer issue (Stiz *et al.*, 2005, Steinberg *et al.*, 2009). The palatability issue comes from grass-finished beef being traditionally tougher and having a different flavor profile than grain-finished beef (Gwin, 2009). However this is something that could be potentially solved by consistent diligence to pasture quality in the finishing stages and the treatment of the carcasses after slaughter. Currently after the cattle are slaughtered the carcasses are chilled soon after processing. Often when grass-finished carcasses are processed they are put into the same coolers as the grain-finished carcasses. Because there is less of a fat layer and marbling in the grass-finished beef the carcass cools down faster than its grain-finished counterparts. Cooling down this quickly can cause increased muscle shortening and reduced proteolysis both of which cause the meat to be less tender (Brewer and Calkins, 2003). If different handling guidelines for grass-finished carcasses were developed where they are cooled down slower, tenderness might not be as significant an issue. The flavor profile is an obstacle that has yet to be resolved, but it is a matter of personal preference and there are a growing number of consumers that desire the flavor profile of grass-based meat (Martin and Rogers, 2004). The physical and taste profiles of grass-finished beef have been studied for many years using the cooling procedures for grain-finished beef (Brewer and Calkins, 2003). To help understand the true traits of grass-finished beef it would be beneficial to determine what processing and handling techniques result in tender, possibly better tasting beef.

Other issues related to market characteristics and type of infrastructure should be considered. To fully examine what it would look like to have locally produced beef, chicken and eggs questions should be asked, such as: How many slaughterhouses would be needed and how would they be established? How would it be possible to provide a meat supply throughout the year? Would there be enough demand for less desirable cuts of meat? Would it be affordable for the average consumer? Should consumers consume less meat annually and reduce the scale needed?

This last question is particularly interesting because the current consumption levels exceed the federal guidelines for protein consumption (USDA My Pyramid, 2011). If the per capita consumption was reduced to the federal guidelines, this would reduce the consumption beef, chicken and eggs by about 25% and as a result the acreage requirements would also drop by approximately 25%. To more detailed analysis this subject should be studied further, but it is interesting to see the potential impact of changing dietary habits.

In order to better understand the implications of grazing management and production potential it would be good to expand the knowledge base about MiG grazing and multi-species systems. That way the academic community would not have to rely on anecdotal evidence of producers, which is often good but difficult to support. I see this area as an area with great potential for future research.

Because of the large difference in the acreage requirements in the poultry systems I feel it would be important to fully investigate the production system with regard to feed efficiency and feed requirements. However it is important to study the poultry production on pastures following the rotation of cattle to get a full understanding of what, if any the benefits are to broiler feed consumption.

## CHAPTER 5:
## CONCLUSION

As a result of this study I was able to identify the scope of change required if MSPR production systems were to supply the beef, chicken and egg demands for Michigan's population. It is apparent that making the switch to producing all of Michigan's beef, chicken and eggs using either system would drastically change the current agricultural landscape. Using MSPR systems would require large changes in production practices, especially on the cropland. This comparison illustrates the major causes for the MSPR system requiring more land than the current production system.

In both systems the largest single contributor towards acreage requirements is beef production . The cow-calf portion of the grain-finished system contributed more than half of the total acreage requirements for the confinement/grain-finished system. In the MSPR system the production of beef was by far the largest contributor to acreage needs. There are promising signs that if the grazing systems are intensively managed there could be an increase in per acre production from the conservative estimate used for beef cattle in this study. While not investigated to date, the anecdotal and preliminary data that have been found show the potential to reduce the overall land use for this scenario by 1-2 million acres.[35] If this reduction were accomplished the concerns about the required acreage would be greatly diminished.

The poultry systems are not as much of a concern, because overall they do not require nearly as much acreage requirements as the beef production system in this scenario. Their impact is also tempered by their ability to be rotated onto the land that is used for the grass-finishing of beef, which results in the pasture required for the broilers and laying hens not

[35] Personal communication, Dr. Jason Rowntree, Michigan State University Extension Beef Cattle & Forage Utilization, Faculty Coordinator Lake City Experiment Station.

contributing to the overall acreage totals. However the difference in the acreage requirements for poultry production is just as significant as the difference in the beef production acreage. All three systems within the MSPR system required roughly 1.4 times more acreage than its confinement/grain-based counterpart. While the impact of this difference is not as noticeable in the poultry production systems, and may not cause as much concern, it is still a significant increase in the acreage needs.

The profile of the current farms in Michigan is quite general and as a result it is difficult to conclude what the largest problem is due to the vague nature of the available statistics. However the results indicate that the template of Polyface farm would be too large a land footprint to work as an average size for beef, broiler and egg production in Michigan unless many of the small farms expanded greatly in scale (and possibly scope of products). The other option would be to have farms that required smaller land footprints, but it is unclear how small these farms can be while still maintaining profitability and producing adequate quantities of products for the region.

This study has presented a profile of what it would take to produce all of the beef, chicken and eggs for Michigan using MSPR systems that have been promoted in the popular press. In doing so I have laid out the boundary conditions, in land and farms that is required in order to have these MSPR products available to the population of Michigan on a daily basis. It fills a gap in the scientific knowledge where MSPR systems have not been fully examined scientifically to determine what this system would require in order for it to produce a larger portion of this country's beef chicken and eggs. Using the extreme case where this system produces all the beef, chicken and eggs for a state has exposed where the systems limitations are as well as identifying a large number of areas that would be very beneficial to research in the future.  It is our hope that this research will act as a springboard for future research in that it has identified the areas that could have the most significant impact on the understanding and efficiency of MSPR systems.

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