Environmental Challenges to the Local Food Movement in the Willamette Valley

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Abstract: Based on reviews of literature on the environmental sustainability of the local food movement, we determined key challenges to promoting the movement within Oregon's Willamette Valley. These challenges include defining local food, establishing the measures of sustainability in terms of food miles, the specific agribiogeography of the Willamette Valley growing region, and the potential effects climate change will have upon growing ability. We conclude that there is insufficient data available to determine the environmental sustainability of the local food system.

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I. Introduction

The local food movement is a relatively recent concept geared toward regaining ties with small farmers, purchasing locally farmed and seasonal produce, and finding a sustainable alternative to modern, mainstream agriculture. The definitions of "local" and the confusion inherent in each definition will be discussed in this paper along with the challenges to an environmentally sustainable, wide-spread, local food movement in the Willamette Valley. This paper will address three main challenges: food miles and their efficacy and shortcomings in demonstrating the negative environmental impact inherent in the production of a food item, agribiogeography and the types of foods that would need to be grown in the Willamette Valley to support the local population, and the impacts of climate change on the local food movement in the Willamette Valley. Our research on the three primary challenges to the local food movement will demonstrate that although the local food movement has the potential to be a viable and sustainable alternative to modern mainstream agriculture, it is not yet an environmentally sustainable practice.

II. Defining "Local"

Before any study of the local food movement can proceed, the term "local" must be defined. In the literature, many definitions of local arise. Some scholars see local singularly from a geographic perspective: from within a certain number of miles (Jones, 2002), to a county (Selfa & Qazi, 2005), to an entire country (Mariola, 2008), though most retailers in the Willamette Valley define local as anything produced within the state (Giombolini et al., 2010). The USDA defines "local food" as any food product transported less than 400 miles from where it was produced, or within the same state (Martinez et al., 2010). Those that take consumer opinion into account more than geographic boundaries when defining the local food movement include in the definition of "local" small farms, freshness, consumer support of local farmers, and reduced detrimental environmental impact through organic and sustainable production methods (Born & Purcell, 2006; Feagan, 2007; Martinez et al., 2010; Selfa et al., 2005). This definition reflects a concern for ecological sustainability and equity and also considers environmental agendas and emotional connections when setting the parameters for "local." The transparency to consumers of farming and transportation methods, workers' rights, and environmental impact of a local food system is of particular importance. Quantifying sustainability within the definition of the local food movement is, therefore, fraught with difficulties. Furthermore, a study conducted in Washington state indicated "local" was defined differently depending on the demographic of producers and consumers. Producers tended to define "local" as food coming from their own county or adjacent counties, while consumers considered food that originated from the state or the Pacific Northwest region as being local (Selfa & Qazi, 2005). The USDA has not yet defined the geographic scope of a local food system, but states that local can be defined "based on marketing arrangements, such as farmers selling directly to consumers at regional farmers' markets or to schools" (Martinez et al., 2010). The variety of definitions of "local" leads to confusion among both producers and consumers. For the purposes of this paper, food grown within the Willamette Valley bioregion, as established by Giombolini et al. (2010), will be considered "local."

III. Definition of the Willamette Valley

For this paper, we will be examining the challenges to the local food movement specifically in the Willamette Valley. The Willamette Valley is about 130 miles long and 25 to 30 miles wide (Highsmith, 1956), and lies between the Cascade mountain ranges to the East and the Pacific Coast ranges to the West. Within the Willamette Valley there is one main stream, the Willamette River, which enters from the south and flows northward in a braided, meandering channel (Highsmith, 1956). The actual valley floor is approximately 2,700 square miles, but the watershed encompasses approximately 11,500 square miles (Giombolini et al., 2010). The climate of the Willamette Valley is characterized by wet, mild winters, dry, moderately warm summer, and a frost-free season of an average of 200 days (Highsmith, 1956). It is said that the Willamette Valley is unique and that no other farming area in the country can duplicate the pattern of such wet winters associated with such dry summers (Highsmith, 1956). For these reasons, the Willamette Valley may not be an ideal study area for the local food movement if the concepts cannot be applied to other farming areas. The Willamette Valley is a fertile area, however, where a variety of crops are already being grown, so it can serve as a convenient case study of the main challenges to local food.

Willamette Valley land is primarily used for intensive agriculture due to its rich soils and temperate climate. Figure 1 shows the geographical distribution of all of the different agricultural crops grown in the Willamette Valley which includes more than 100 kinds of crops, from grass seed and row crops to berries and nuts (Giombolini et al., 2010; USFS, n.d.). Other uses of Willamette Valley land include dispersed grazing by sheep and cattle in pasture and cropland, and private forestry and intensive industrial forestry which occur on the footsteps of the valley perimeter as well as the Puget Trough (USFS, n.d.). An understanding of the physical landscape, soil types, and water distribution of the Willamette Valley is important in recognizing the richness of this region and its agricultural production potential (Giombolini et al., 2010). An analysis of dietary requirements in the Willamette Valley conducted in 2008 showed that the current agricultural production levels did not meet any of the six food groups: grains, vegetables, fruits, dairy, meat and beans, and oils (Giombolini et al., 2010). This shows that production of enough food in all six food groups to meet the dietary requirements for the people living within the Willamette Valley is a challenge. (Giombolini et al., 2010). While the Willamette Valley does not currently meet the dietary needs of its local inhabitants, it has the potential to produce a large portion of the produce needed to support the local population. In 1993, 54% of crops consumed within Oregon were grown in the Willamette Valley (Hinkle, 1997). However, population growth, in combination with a switch from edible to non-edible crops, led to a decrease in the percentage of locally grown food consumed within the Willamette Valley to only five percent (Armstrong, n.d.; Hinkle, 1997).

The current agricultural production in the Willamette Valley is dependent on the eleven different soil types that are present throughout. These different soil types consist of different sedimentary and organic materials and retain or lose water and moisture to varying degrees which impacts the types of crops that can be grown. In 2008, Willamette Valley agricultural production met 67% of the annual required grains, 10% of vegetable needs, 24% of fruit, 59% of dairy, 58% of meat and beans, and 0% of oil needs (Giombolini et al., 2010). The Willamette Valley is known for producing vegetables crops such as snap peas, carrots, sweet corn, cucumbers, and tomatoes (Giombolini et al., 2010). Vegetables are annual crops that require fewer infrastructures for planting than fruit and reach harvest in a matter of months rather than years (Giombolini et al., 2010). The primary fruit production crops consist of blueberries, apples, blackberries, and strawberries temperate climate and rich soils make the Willamette Valley ideal place to grow a variety of fruit crops (Giombolini et al., 2010). Dairy production in the Willamette Valley counts for 39% of the total value of production for Oregon's livestock as of 2007 (Giombolini et al., 2010). Dairy production in the Valley does not fluctuate in terms of yield and stays relatively high compared to other Willamette Valley commodities (Giombolini et al., 2010). Meat production has declined since 2006, but currently meets about 58% of the population's dietary needs by producing primarily hogs and pigs, eggs, and broilers (Giombolini et al., 2010). Hazelnuts and beans make up a large part of the bean production. Because hazelnuts are produced in only a few locations around the world large portions of what is grown in Oregon are exported, and even then Oregon still can't meet the demand for hazelnuts (Giombolini et al., 2010). Lastly, the oil production in the Willamette Valley reportedly meets 0% of the population's dietary needs due to the fact that most of the oils that are grown are being primarily used for the production of cosmetics and hair care applications and other smaller-yield oils such as canola oil are being used for biodiesel (Giombolini et al., 2010). It is clear from this analysis done in 2008 that the Willamette Valley has a vast amount of resources which facilitate the growth and production of food items from all six food groups. Production does not meet the full dietary requirements and therefore cannot support a successful local food movement because many crops are either inedible, processed for purposes other than human consumption, or are exported. Changing how and why we use the natural resources for growing crops will help immensely in the creation of a more environmentally sustainable and widespread food movement.

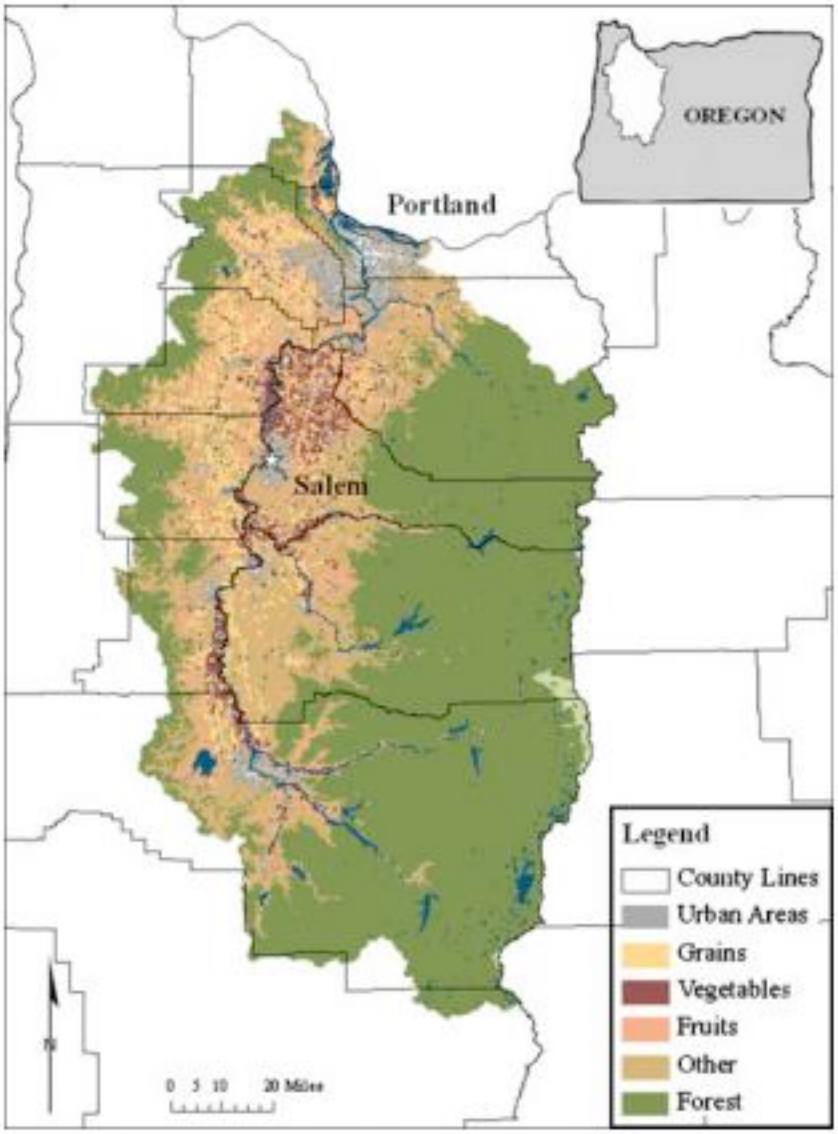

Fig. 1: Geographical extent of the Willamette Valley growing region (Giombolini et al., 2010).

IV. Food Miles

The concept of food miles is a divisive issue within the local food movement literature and is pertinent in the discussion of the legitimacy of advocating local foods as an environmentally sustainable movement within the Willamette Valley. Consumer knowledge of where and how food is produced are growing focuses, especially since the global food system has become increasingly interconnected and simultaneously obscured from the average consumer's common knowledge (Jones, 2002). In response to concerns about negative environmental impacts of the food industry, the idea of food miles was formed as a way to assess the amount of fuel consumed, and therefore the quantity of greenhouse gas (GHG) emissions released during the production and transportation of food (Edwards-Jones et al., 2008; Mariola, 2008; Paxton, 1994). Food miles are defined as the distance that food travels from where it is produced to where it is consumed (Ballingall & Winchester, 2008; Edwards-Jones et al., 2008). Food miles have since been promoted as a seemingly cut-and-dry method of quantifying the environmental impact a food item has in terms of GHG emissions. The implication of food miles is that if a food item has a low number of food miles, that item is more environmentally sustainable. This is not always the case, and being unaware of the environmental impacts of food products and their transportation can lead consumers into a false sense of justification for the environmental sustainability of the local food movement (Jones, 2002). Because the definition of "local" varies drastically, it is difficult to quantify whether it is an environmentally sustainable form of food production (Edwards-Jones et al., 2008). Is the distance a food product travels linked with and indicative of its sustainable production? Are there more factors to consider than distance travelled? Some proponents of the local food movement use the distance a food travels from producer to consumer as an indicator of sustainability (Feenstra, 1997; Halweil, 2002). Others look at a wider picture, using life cycle analysis (LCA) to examine the energy use throughout the entire life of a food product (Edwards-Jones et al., 2008; Van Hauwermeiren et al., 2007; Weber & Matthews, 2008). Others demand an even broader view, challenging the ways people measure environmental degradation through analysis of specific emissions and considerations of alternative methods of food distribution (Jones, 2002; Van Hauwermeiren et al., 2007). Those in opposition to the food miles method of measuring sustainability dismisses the idea as impractical due to the amount of data and specificity to location needed to correctly assess each situation (Edwards-Jones et al., 2008; Smith et al., 2005).

With the first publications of studies in 1994 examining the distance food travels, the focus of the local food movement has been on food miles measured from field to plate (Paxton, 1994). Concerns over the geographic distances food traveled from producer to consumer were emphasized. The thinking behind this is that food produced from far away takes more energy to reach the consumer than food produced locally. The average fresh food item travels 1300 to 2000 miles, from field to plate (Mariola, 2008; Nelson & Donahue, 2010; Wood et al., 2010). Also the energy needed, and subsequently carbon emitted, by different modes of transportation vary greatly in that transporting food by plane releases about five times as much carbon dioxide per kilometer as does transporting food by passenger car (Edwards-Jones et al., 2008). This data supports the argument that decreased food miles indicate greater environmental sustainability.

Research published in 2002 indicated New Zealand lamb purchased in the UK was more environmentally friendly than local lamb grown in the UK (Saunders et al., 2006). This article became one of the catalysts for the food miles debate over whether local was more sustainable. The authors of this article were part of the New Zealand: Agribusiness & Economics Research Unit, which presented a biased view in favor of their own agricultural production. This highlights one of the challenges to the local food movement and the difficulties in measuring environmental sustainability; as stated by Edwards-Jones et al. (2008), the estimation of carbon emissions is subjective to the conductor of the study in that estimates depend on the definition of "local" being utilized and the carbon accounting methodology being used. Other opposition to the pro-local stance includes the fact that transportation of the consumer to the food item within a country is not taken into consideration, the energy that goes into building the transportation infrastructure is not included, and the sources of energy between trading countries differ (Mariola, 2008). Many scientists are displeased with measuring the greenhouse gas emissions of food production solely through the lens of transportation, as 83% of an average family's carbon footprint in regards to food is a result of the production phase, not of transportation (Weber & Matthews, 2008). Taking into account the contribution of production to the total emissions, it is estimated that if one travels less than 4.6 miles for their food, it would be more sustainable than the large-scale transport system (Coley et al., 2009). However, as Mariola argues (2008), the local food movement is inherently unsustainable because it is dependent on fossil fuel use and therefore cannot fall under the broader category of sustainable agriculture. In this way, the local food movement is no more sustainable than other forms of agriculture and it should not be assumed that local food has a less negative environmental impact than globally sourced food items.

Instead of only measuring food miles, some authors look at a life cycle analysis (LCA) in order to trace the environmental impact of food production (Edwards-Jones et al., 2008; Martinez, 2010; Van Hauwermeiren et al., 2007; Weber & Matthews, 2008). In this case, all aspects of a food product including the transportation and manufacturing of farm supplies, cultivation, production, transportation to the consumer, and any waste transported to a landfill are factored into an assessment of food system sustainability. This method is seen as more indicative of the total environmental impact because it measures all energy flowing into and out of the system (Edwards-Jones et al., 2008). In addition, as found by Weber & Matthews (2008), 83% of GHG emissions come from the production phase, therefore a study reporting only the emissions from the transportation phase would be a misrepresentation of the actual impact. However, such studies often come to different conclusions based on the location of the study and the varying methodologies utilized, indicating that local food is not an absolute measure of sustainability (Edwards-Jones et al., 2008; Weber & Matthews, 2008). Instead of using the LCA method, some researchers use means/end analysis (MEA), in which the primary goal is to determine the most environmentally benign options for meeting a specific human need (Jones, 2002). This was developed in response to the LCA because the LCA resulted in different studies arriving at conclusions that were contradictory in their analysis (Edwards-Jones et al., 2008). An MEA is much more focused on alternatives to the transportation sector of food production, and can include a greater picture of the entire food-stream, including transportation of waste from the consumer (Jones, 2002).

The overarching challenge with determining food miles is that the authors have varying methods of measuring the environmental sustainability of food products. Some look at fossil fuel usage or energy consumed (Ballingall & Winchester, 2010; Jones, 2002; Mariola, 2008), while others calculate emissions of carbon dioxide (Jones, 2002) and other greenhouse gases (Edwards-Jones et al., 2008, Van Hauwermeiren et al., 2007). Different methods of transportation result in varying fossil fuel usage and efficiency and studies calculating food miles may or may not take varying transportaiton efficiencies into account (Edwards-Jones et al., 2008; Mariola, 2008). Additionally, as discussed by Mariola (2008), many evaluations attribute the entire release of carbon emissions from the transportation of a food item to that single food item.

Because large ships and planes transport mass quantities of product, it is more realistic to evaluate carbon emissions as shared between each item transported, thereby implying that non-local can be less harmful to the environment. Reports indicate road and air transport are the least sustainable transport options when compared with rail and ocean transport, depending on the amount of food transported (Jones, 2002; Pretty et al., 2005). Additionally, different emissions from agricultural production and transportation need to be considered. Carbon dioxide is not the only greenhouse gas that is produced from the local food movement, and other GHG can be converted to carbon dioxide equivalents for ease of comparison (Edwards-Jones et al., 2008; Van Hauwermeiren et al., 2007).

The discussion of food miles is of importance to the local food movement within the Willamette Valley because discrediting food miles as a legitimate measurement of sustainability undermines the arguments for the movement. As it pertains to the Willamette Valley, most food products are imported because the agricultural land is devoted to non-edible items such as Christmas trees and grass seed. In Eugene, only 5 percent of food consumed is produced locally (Nelson & Donahue, 2010). The food that is produced locally and sustainably may become less sustainable due to storage costs during winter months (Edwards-Jones et al., 2008) Since data is lacking for the Willamette Valley specifically, more research must be conducted to determine whether local or non-local is the most sustainable for the Willamette Valley, and for which food items.

In summary, food miles are an effective of how far food has traveled, but not an effective indicator of a food's environmental impact and sustainability (Ballingall & Winchester, 2010; McWilliams, 2009). To truly fall under the category of sustainable agriculture, food miles need to be analyzed from several different directions including emissions produced, energy needed for production, transportation to consumer, packaging, and waste management to be relevant to the local food movement. And, from a broader perspective, the development of the transportation infrastructure, and forms of alternative transportation that are more efficient and less reliant on fossil fuels should be considered. The issue of food miles remains troublesome in the local food movement because eating locally is much more complicated than consumers expect, and they are probably not willing to research every aspect of their diet on their own or understand the data if it is available (Edwards-Jones et al., 2008). In addition, because of the lack of information on cases specific to the Willamette Valley, residents of the valley would have difficulty in determining the most sustainable options.

V. Agribiogeography

"Agribiogeography", or food biogeography, is a major part of the environmental sustainability of local food systems. This can be defined as the ability of a region to support and produce agricultural products governed by the climate, geology, and site-specific conditions of that location. While not usually applied to the agricultural sector, biogeography encompasses the distribution of plants and animals on the earth over space and time. This can be related to the local food movement because certain areas or bioregions have limits on what can be grown and what time of year crops will grow in the most environmentally sustainable manner. In the Willamette Valley, local food movement challenges include; production of enough staple items like grains, costs of growing food in the off-season, and ability of the local region's soil and water availability to support a local food system.

The Willamette Valley encompasses one of the most diverse agricultural regions in the United States and produces more than 170 different crops (ODA, 2009). These include edible produce like apples, barley, blueberries, cabbage, corn, forage, apricots, nectarines, peaches, grapes, green peas, mint, oats, onions, pears, potatoes, can beans, sweet corn, and wheat (Risk Management Agency, 2011). Wheat is one of the most extensively grown crops in the valley, covering 170,000 acres (Hinkle, 1997). Non-food products which also dominate the region include Christmas trees, nursery plants, and grass seed; grass seed is grown on 290,000 acres, while Christmas trees are grown on 16,000 acres (Hinkle, 1997). Grass seed is the most widely produced agricultural product in the Willamette Valley which is known as the "grass seed capital of the world" (OSU, 2011). However, even though thousands of acres are dedicated to certain food crops, agricultural production in this area currently does not support enough staple items like grains to adequately feed the local population. In 2008, the Willamette Valley was able to support 67% of annual required grains, 10% of vegetable needs, 24% of fruits, 59% of dairy, 58% of meat and beans, and 0% of dietary oil requirements for the population (Giombolini et al., 2010). According to the USDA's food pyramid, consumers should obtain most of their staple nutrients from whole grains (USDA, 2010) which are not usually found in places where local food is sold such as farmers' markets and through CSA's (Giombolini et al., 2011). Based on the

USDA's dietary guidelines, the Willamette Valley does not currently support the grain needs of the population (Giombolini et al., 2011). In order to implement a local food system that could feed the entire population of the Willamette Valley, production of edible produce in the local sector would have to be increased. If grass seed farmers were to convert their land to wheat production, the grain needs could be met (Giombolini et al., 2011).

Because the Willamette Valley is unable to produce food products year-round, concerns for the environmental impacts of growing during off-seasons arise. Agricultural methods which would extend the season of crops, utilize greenhouses, and necessitate long-term storage of food products consume resources and compromise environmental sustainability. Depending on the season, it may be less detrimental for the environment, due to resource use, to import some produce rather than grow that crop locally (Ballingall & Winchester, 2010; Chappell and LaValle, 2011; McWilliams, 2009; Van Hauwermeiren et al., 2007). In areas that experience cold winters and lack a year-round growing season, such as the Willamette Valley, eating locally could be successful, but would not be considered environmentally sustainable. For example, tomatoes grown in the summer consume ten times less energy than tomatoes grown in a heated greenhouse during the winter (Van Hauwermeiren et al., 2007). In this case, it would be less environmentally detrimental to import tomatoes grown in season with solar energy instead of those grown with a nonrenewable energy source inside a heated greenhouse. However, sometimes locally-grown produce has a less negative environmental impact especially if the produce is in season, the transport and storage of the produce are minimized, the produce is grown under open air (e.g., not in a heated greenhouse), and the customer acquires the food via a sustainable transportation system. (Jones, 2002; Van Hauwermeiren et al., 2007). A local food system is most feasible during the summer months, but because year-round local food security is a necessity, crops that mature at different times could be used. For example, in the UK, regional varieties of apples could be planted so the country would have a year-round supply of apples (Jones, 2002). Preservation of seasonal foods could also be emphasized (Pothukuchi & Kaufman, 1999) but energy used for food storage and preservation also presents a challenge to environmental sustainability (Mariola, 2008). The infrastructure and energy costs of encouraging food preservation presents another challenge. In summary, if it is less environmentally sustainable to grow a food product locally in the off-season than it would be to import it from abroad (where input costs are less), eating locally, especially during the off-season, is not always the better option for an environmentally sustainable diet. In the Willamette Valley, relying completely on local food to feed the entire population would depend on heated greenhouse use during the non-growing season or increased infrastructure for food storage. The addition of costly food storage facilities adds to the resources required to support a local food system. The question can be condensed: can a local bioregion support a year-round supply of food while still being environmentally sustainable? This depends largely on the location of the region, resources in the area, and the manner in which these resources are extracted and used.

Two important aspects of agribiogeography are the soil type and water availability of a region. If the Willamette Valley were to sustain a local food system, information about the types of soils and water available for irrigation would have to be assessed to determine the regional environmental challenges to growing agricultural products. Some crops require certain types of soil in order to grow and reach full yield potential. If soils are unable to support local crop production, a local food system would be impossible. In the Willamette Valley there are four classes of soil, and each class has different characteristics in moisture retention, nutrient supply, and ability to support different crops. Challenges from urbanization also arise, due to changes in water and land usage throughout the region.

Data and research conducted in the Willamette Valley in 1956 demonstrated that Class 1 soils on recent alluvial deposits on present floodplains comprise 273,000 acres of the Willamette Valley (Highsmith, 1956). These soils are best for vegetables and other intensive crops, have good drainage, and abundant subsurface water for pump and sprinkler irrigation (Highsmith, 1956). Class 2 soils, comprising 527,800 acres of the Valley, are present in areas bordering the flood plains in the bottomland. These soils are well-drained, suited for important food crops including vegetables and grains, and can support intensive cropping and rotations (Highsmith, 1956; Taylor et al., 1992). More crops can be grown on Class 2 soils as long as the crops are irrigated. Class 1 and Class 2 soils are suited for food production, and will be an important asset in the implementation of a local food system, but there are two additional classes of soils which will make a suitable local system more difficult. These include Class 3 soils which make up 587,800 acres, and Class 4 soils, which make up 278,700 acres (Highsmith, 1956). Both of these soil types are poorly drained and found on the main valley floor. Although proper drainage and irrigation can improve the quality of these soils, they are better suited for grass seed rather than food crops (Highsmith, 1956; Taylor et al., 1992). This is problematic for the local food movement because, in order to feed the entire population of the Willamette Valley, food, rather than grass seed crops, would need to be grown. If these soils were to support the local population this could require a greater number of additions to make them suitable for crop production. Overall, an analysis of potential soil constraints to crop yield will have to be determined if the Willamette Valley region were to adopt a local food system.

Water is another region-specific resource. The Willamette Valley has wet winters with dry summers that are not found elsewhere in the United States (Highsmith, 1956). With high annual precipitation, it would appear that there would be enough water for irrigation in the dry summers, however since agriculture requires enormous quantities of water (78% of the total water used in the state) sufficient water is still a serious concern (SOWRD, 2009). This obstacle alone is pertinent to local food movements in any geographical location: if there is not enough water, yields will be low. Improvements on irrigation continue to develop, and will be discussed in the following paragraph.

Depending on the local resource situation, a switch to a local food system can lead to the alteration of water use in an area. Pressures from urbanization also present a challenge especially if the population of an area increases, resulting in less water available for agricultural production (Baker et al., 2004; Colasanti & Hamm, 2010; Pothukuchi & Kaufman, 1999; Pretty et al., 2005). A local food system that requires more water would have to consider the reallocation of water for agricultural purposes and the potential impacts on the population. Water treatments such as the irrigation of fields can result in increased sedimentation into rivers, silt removal, and damages to cropland (Moore & McCarl, 1987). However, one positive advancement that technology has brought to the agricultural system, more specifically to the Willamette Valley, is the advancement of irrigation. Irrigation in the Willamette Valley dates back to 1890 when farmers used wells with pumps to bring water up from the ground, especially during the dry summer months (Highsmith, 1956). Without sufficient water and an efficient irrigation system, a local food system in the Willamette Valley would be impractical.

Urbanization alters ecosystem services, takes up land space that could be turned into farmland for growing more crops, and alters water use patterns. Loss of agricultural land to urbanization usually goes unnoticed because consumers do not buy all their food locally (Pothukuchi & Kaufman, 1999). If an area is no longer able to support pollinators, water filtration, and biodiversity, its agricultural systems will fail (Chappell & LaValle, 2011).

Therefore, urbanization will make it more difficult or impossible to have access to all the services needed to successfully produce local food. A study performed in Detroit, Michigan observed current consumption levels by the population and tried to determine what level of food would need to be produced locally in order to sustain the population for a local food movement. The study discussed obstacles to determining acreage amounts, one of which was that some crops require more or less land and resources than others (Colasanti & Hamm 2010). This presents another challenge to the local food movement in the Willamette Valley because staple crops like wheat require large amounts of acreage to produce substantive yields. Crop-specific information would need to be collected to determine if growing these crops is environmentally sustainable in this region (i.e., without the use of unsustainable inputs).

Limitations set by the resources in an agribiogeographical area determine the ability of a region to support a local food system. Transitions to a local food system in this area would require increased cropping of staple foods such as wheat, analysis of the environmental impacts of year-round cultivation or food preservation, and inquiry into the ability of Willamette Valley soils and water resources to support this system. The transition to a local food system may not be entirely environmentally sustainable because of increased input requirements such as irrigation and greenhouse infrastructure and increased energy demand. Additionally, climate change represents a unique challenge to this area in that current agricultural ability may be different in the future. Local regions may become unable to grow what had previously been easily grown crops, and farmers may have to change to support different agricultural products altogether. Ultimately, the environmental sustainability of a local food system in the Willamette Valley will be site and region-specific, and may not be synonymous with sustainable agriculture.

VI. Climate Change

The next and final barrier to the local food movement in the Willamette Valley is climate change. According to the Intergovernmental Panel on Climate Change, agriculture itself is responsible for twenty percent of anthropogenic greenhouse gas emissions due to the extensive energy inputs required for food production and transportation (Horrigan et al., 2002). While agriculture contributes to climate change, warmer temperatures and shifting precipitation patterns can in turn affect crop production. As temperature and precipitation change, there will be shifts in which crops can be grown in the Willamette Valley and how well they grow. Thus, before implementing a local food system, it is necessary to consider how to prepare for changing agricultural conditions in order to ensure food security today as well as into the future. The fundamental problem surrounding climate change and the local food movement is that even if the Willamette Valley were to implement a wide-spread local food system today, the success of the movement will hinge on its ability to withstand changes in the climate that appear over the next few decades. What has been successful in agriculture today may not work in years to come. Furthermore, local food systems are more vulnerable to fluctuations in production that may arise as a result of climate change than a global system which is more plastic and thus better able to adapt. More specifically, climate change will affect growing season and pollination, water availability, and crop loss due to pests.

The influence of climate change on growing season is on both the phenology, or timing, of crop growth, and the number of days that crops can grow. This is turn influences plant-pollinator interactions. Over the last several decades, the Willamette Valley growing season has lengthened by ten to twenty days (Coakley et al., 2010). In addition to a longer season, crops are growing, flowering, and fruiting sooner (Jones, 2007). The lengthening of the growing season and the shift in timing is caused by a combination of higher minimum temperatures, a decline in the frequency of frost, earlier last frosts, and later first frosts (Jones, 2005). A longer season of growth could be helpful to the local food movement by providing more warm days during which crops can be grown. However, crops have very specific needs in terms of their mutualistic pollinator interactions. Shifts in the timing of plant growth will affect the availability of pollinators. A mismatch arises between when the crops bloom, and when the pollinators are out (Kjøhl M et al., 2011). Up to fifty percent of plant-pollinator interactions are negatively impacted by shifts in blooming time (Tylianakis et al., 2008). Thus, changes in growing season will affect which crops can be planted in order to ensure successful pollination and growth. For a local food system to be successful, farmers would need to choose crop varieties based on which ones will still have the necessary pollinators. These varieties may not be the same plants that are grown today.

An example of a crop with a shifting growing season in the Willamette Valley is the wine grape. The growing season for wine grapes has increased by 17 to 35 days (Coakley et al., 2010). In addition to being longer and more varied, the growing season is also warming. It is expected that over the next fifty years, the growing season for wine grapes will warm by 1.7°C (Jones, 2005). So far, these shifts have been beneficial to grapes worldwide (Jones, 2007). In the Willamette Valley, warming has changed the climate from marginal for wine grapes to a high quality wine climate (Coakley et al., 2010). However, Oregon's wine grapes require a very specific climate and are therefore especially prone to any variation in climate that arises as a result of climate change (Jones, 2007). As the temperature in the Valley continues to climb, the optimal climate for growing grapes will move further north, out of the Willamette Valley (Coakley et al., 2010). Furthermore, shifts in the phenological timing of grapevine growth in combination with a warmer and longer growing season will change the sugar content of the grapes, affecting their flavor, potentially making them less desirable (Jones, 2007; Doppelt et al., 2009). Grapes are just one example of crops with which the growing season will change in the decades to come. It is important in a local food system to be able to produce all the crops that are needed to feed the population. If climate change affects which crops can be grown in the Valley, it will be more difficult to grow the same crops that are grown today. Thus, to counteract changes in the growing season, different crop varieties will have to be found or produced that are able to survive in the new climate of the Willamette Valley.

A second problem that will have to be overcome to successfully produce food locally in the Willamette Valley is that the quantity of available water will be reduced as a result of climate change. Currently, the main source of water for the lower Willamette Valley comes from rainfall (Greenberg & Welch, 1998). Rain feeds the Willamette River, which is then used for agriculture (Greenberg & Welch, 1998). In the foothills, snow is more important: when it melts it provides water for irrigation (Greenberg & Welch, 1998). Due to warmer temperatures, more water will fall in the form of rain, rather than as snow (Coakley et al., 2010). As a result, snowpack in Oregon mountains is expected to drop to fifty percent of what it is today by the year 2050 (Chang & Jones, 2010). This is a problem for the local food movement because there will be less water available to irrigate the foothill farms during the summer months when the snow typically melts (Coakley et al., 2010; Doppelt et al., 2009; Chang & Jones, 2010). Most precipitation in the Willamette Valley falls between October and March, meaning that without water stored in mountain snowpack, there will more likely be shortages during the summer when there is less rainfall (Chang & Jones, 2010). In addition, climate change increases the rate of evaporation of water from the streams (Chang & Jones, 2010; Doppelt et al., 2009). Stream flow will consequently drop, and less water will be available for irrigation in the Willamette Valley.

Agricultural crops will also experience increased water stress in the soil due to greater evaporation from the soils (Doppelt et al., 2009). Water stress will make the local food movement difficult to implement. The farmers producing locally in the Valley will have to meet the agricultural demand of the population while there may not be enough water to irrigate their crops. As the population continues to increase, demand will rise and this will be even more challenging.

Climate change will not only make water less available, it will also increase the demand for remaining water sources. There is not a clear consensus on how much demand will increase. One estimate is that irrigation in the Willamette Valley will increase by ten percent for every one degree rise in temperature because crops will require more water as temperatures rise (Coakely et al., 2010; Chang & Jones, 2010). Another guess is that if agricultural water policies do not change, or if conservation is not encouraged, there will be a 65-120 percent increase in irrigation in the Willamette River Basin by 2050 (Baker et al., 2004). Urban demands will also increase, leading to conflict between agricultural and domestic use (Doppelt et al., 2009). Climate change and population growth will likely lead to fresh water being reallocated for domestic use (Gengenbach & Weikard, 2010). One solution is to use wastewater rather than fresh water to irrigate crops, but this can be hazardous for human health (Gengenbach & Weikard, 2010). It could also be possible to meet this demand by tapping more into groundwater found in the Willamette aquifer that lies below the southern Willamette Valley. Currently, water is discharged from the aquifer either by flow to the surface, and through wells (Woodward et al., 1999). Discharge is approximately equal to the recharge rate from precipitation (Woodward et al., 1999). Thus, if more water is withdrawn from the aquifer to meet increased demands associated with agricultural production, the aquifer may not be recharged at an equal rate, and it would quickly become depleted. Again, the problem is that sufficient water availability is a requirement to produce enough food to feed the local population. If this need is not met, the local food movement would be impossible.

A third problem associated with climate change is an increase in the number of pests that affect food crops. Climate change will result in more plant diseases, pathogens, and herbivorous insects (Coakley et al., 2010). The causes are complex, but involve higher temperatures, increased atmospheric carbon dioxide, and altered rain and drought patterns (Gregory et al., 2009). In the Willamette Valley, climate change will increase the prevalence of downy mildew on Oregon grape crops (Coakley et al., 2010). Warmer temperatures will also increase aphid populations by reducing mortality for overwintering aphids (Gregory et al., 2009). Mammal populations may also increase; in 2005, following a warm winter, vole populations in the Willamette Valley exploded, destroying grass fields and vineyards (Coakley et al., 2010). Although this may not have been caused by natural fluctuations in temperature rather than by climate change, climate change will likely show similar results. In addition to increasing the number of pests, climate change also makes it harder to get rid of the pests because as carbon dioxide levels increase, glyphosate, which is found in pesticides, becomes less effective (Coakley et al., 2010). As pests and pathogens become more common, it will become increasingly difficult to produce all the food needed to support the local population. Climate change in general will reduce crop yields; for example rice yields will decrease by five percent for every one degree Celsius rise in temperature (Gregory et al., 2009). Part of this reduction is due to an increase in damage by pests. Monoculture is especially susceptible to pests and pathogens, so farms involved in a localized food system would have to produce a diverse array of crops in order to produce sufficient yield (Doppelt et al., 2009). A globalized food system provides security against pest damage, because in years when pests are particularly bad, food can be imported from elsewhere. In a local system, however, if crops are destroyed by pests, there may not be enough crops remaining to feed the population. Therefore, when considering converting to a local system, alternative safety nets need to be put in place to deal with the consequences of climate change.

Climate change will thus create many new challenges that must be overcome for the local food movement to be successful in the Willamette Valley. In order to produce enough crops to feed the entire population of the Valley, those involved in agricultural production have to plan for the future impacts of climate change. An agricultural system that does not consider climate change will likely fail because what can be grown successfully today in the Willamette Valley may not have optimal growing conditions within a few decades. We have to determine what will happen in the Valley as a result of climate change, and how to deal with the effects to create a local food system that is able to last long into the future. It may be necessary to add extra inputs, such as pesticides to combat pest explosions, or to import water from elsewhere to combat drought. Another issue to consider is that a local food system is risky in a warmer world because there is less security against crop failures that may result due to higher temperatures, drought, or pest damage. A globalized, rather than a localized system, would provide a greater degree of security to ensure crop production at a lower risk.

VII. Conclusions and Future Research

While the local food movement is touted as a sustainable alternative to modern, mainstream agriculture, there is much inconsistency in the literature as to whether local food actually is environmentally sustainable. Despite having compared a variety of sources in an attempt to achieve a definitive conclusion regarding whether local food is environmentally sustainable or not, there simply is not enough data to support a conclusion one way or the other. One of the greatest challenges to the local food movement is that food miles do not provide a consistent or accurate way of quantifying the negative environmental impact of a food product. Another challenge is that agribiogeographical conclusions are not specific to the Willamette Valley, and climate change models are hypothetical and cannot be accurate. Overall, more research needs to be conducted in order to assess the environmental sustainability potential of the local food movement in the Willamette Valley; there simply is not enough region-specific data.

For the local food movement in the Willamette Valley to progress and become more environmentally sustainable, a more specific, quantifiable, definition of what is “local” needs to be established. Specific measurements of degrees of environmental sustainability need to be standardized and enforced. More research needs to be conducted on current methods of measuring local and sustainable agricultural endeavors in order to determine ways to improve pre-existing methods of production, transportation, etc. More research on the benefits and shortcomings of the local food movement in the Willamette Valley can provide insights into methods of improvement for local food movements in other regions. Case-specific data can be applied on a larger scale and improve local food movements’ environmental sustainability in other regions.

Further research conducted on the local food movement in the Willamette Valley will not only address the greatest challenges to the movement in this region, it would also potentially improve the environmental sustainability of local food movements everywhere.

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