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FOOD SUPPLY CHAINS AND FOOD-MILES: AN ANALYSIS FOR SELECTED
CONVENTIONAL, NON-LOCAL ORGANIC AND OTHER-ALTERNATIVE FOODS
SOLD IN MISSOULA, MONTANA

By

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Thesis

Presented in partial fulfillment of the requirements for degree of

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Food Supply Chains and Food-Miles: An Analysis for Selected Conventional, Non-local Organic and Other-Alternative Foods Sold in Missoula, Montana.

Committee Chairperson: Christiane von Reichert

Abstract:

The spatial patterns of the conventional food supply chain have played a significant role in increasing the amount of miles food travels before being consumed. As a result, this has increased the amount of energy that is required to transport food from the farm to the table. The food supply chain links production to consumption. However, as food-miles increase, this link becomes obscure. The food supply chain can be described as having two very distinct parts: the conventional food supply chain and the alternative food supply chain. Business consolidation, and large-scale production, processing, distribution and retail characterize the conventional food supply chain. As a result of such economies of scale, the conventional chain is also characterized by standardization of knowledge. The alternative chain, on the other hand, is characterized by direct sales, small-scale production, processing and distribution and by a more transparent market. Certified organic foods began as an alternative to conventional foods. However, certified organic foods have increasingly been criticized for adopting similar business practices as the conventional system and thus travel the same lengths, if not further, than conventional foods. This study is a place-based approach that compares the food-miles and subsequent energy use of the two food supply chains—conventional and alternative—that provide food to retail grocery stores in Missoula, Montana. Energy use is estimated in gallons of diesel and the subsequent byproduct, or emissions, of transportation is estimated in pounds of carbon dioxide. Four of the highest selling retail grocery products; apples, bread, ground beef and milk, are classified into three different categories: “conventional”, “non-local organic” and “other-alternative”. The food-miles, subsequent fuel usage and emissions are also estimated for each of the four products. The study shows a remarkable lack of transparency in the conventional food supply chain and relatively low food-miles, fuel use and carbon dioxide emissions for the other-alternative products.

Key Words: agro-food geography, alternative food networks, carbon dioxide emissions, certified organic, economies of scale, food-miles, food supply chain

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INTRODUCTION

The greatest danger is supposing food comes from the grocery.

Aldo Leopold

Choices about what food we eat are made on a daily basis. However, many times the impacts of our choices are hidden or masked. Americans spend only a small percentage of income on food—it is a much smaller percentage than paid by residents in any other country. But, there are costs not seen in the prices of food that are paid for elsewhere, by somebody else or by us all. Commonly referred to as the global chain, the conventional food supply chain has provided this seemingly cheap food. The strength of the conventional food supply chain resides in the ability to capitalize on the economies of scale, which play a dominant role in the low prices of food.

Economies of scale have allowed companies the ability to produce, process and transport large quantities of goods to the market at low costs. However, the costs are evaluated in strictly monetary terms with little regard to the social or environmental impacts. Such narrowly defined costs devalue the importance and implications of where or how food is grown, who grows it, or how far it travels from production to consumption. Many people are sheltered from these complexities. Indeed, one of the greatest dangers identified by Leopold is largely realized—food supposedly comes from grocers' shelves.

One trip through a grocery store, past the numerous selections of products, a shopper often has the impression that the conventional food system is secure and reliable. However, this deludes shoppers. The conventional food chain is heavily reliant on fossil fuels to transport food thousands of miles before even reaching the shelves. Additionally,

the large-scale processing required to capture the economies of scale have created some of the largest outbreaks of foodborne illnesses to date that affect consumers worldwide. The reliance on non-renewable fossil fuels coupled with large-scale processing jeopardizes the reliance and safety of the conventional food system.

Capital concentration and centralized large-scale farms, processors and retailers are characteristics of the global market—an ever-expanding market without borders. However, not all food available in America via the conventional food supply chain is dominantly part of the global chain. Products with a short shelf life such as milk and bread are typically processed within the United States in strategic locations that are close to main transportation routes.

Differing opinions on the best way to feed people is not new, nor is the criticism of the present conventional food chain. Social movements focused on agricultural sustainability have been organizing since the 1970s (Allen 2004), resulting in the formation of alternative food supply chains. Incidentally, this was during the same period as the first energy crises when oil prices skyrocketed. Since then, alternative agricultural movements have grown and continue to transform the spatial flow and demand for certain types of food—specifically local food and certified organic food. Much of the support behind local food points towards its ability to shorten the supply lines, thus using less fossil fuel and emitting less carbon dioxide. Yet, in the United States, only a handful of studies have been done to quantify how far food travels.

External costs, both calculable and implied, created by long transportation lines are crucial components of both the conventional and other-alternative food supply chains to address and evaluate, regardless whether the product is globally sourced or not.

Calculable external costs include the amount of diesel or gasoline consumed and pounds of carbon dioxide emitted during transportation. Implied costs include the anthropogenic factors that contribute to global warming and the reliance on fossil fuels. One measure used to evaluate the transportation component of the food supply chains is the “food-mile.” Food-miles refer simply to the amount of miles food travels from farm to the table.

Many factors have contributed to a renewed focus on the sourcing of food as well as the factors that influence food prices and the reliability of the market. A few of these factors include high gas prices and questions raised about the merit of United States Department of Agriculture (USDA) certified organic foods (Sligh 2002). The year 2006, for example, was seasoned with food issues and high gas prices. Certified organic foods, although already widely popular, truly hit mainstream when two of the top four largest grocery retail chains added organic foods to their shelves. Safeway successfully placed their own organic brand on the shelf and shortly after, Wal-mart, the largest retail grocery store in the world, announced their intentions to market their own organic brand. Given that less than 1% of farm and pasture land in America is certified organic (USDA Economic Research Service 2005), much of the organic food must be sourced globally to fill the grocers’ shelves. This adds to the already long distance the majority of our food travels to get to the grocery store.

The added distance that food travels has seemingly been unaffected by the rising gas prices. But, the global trekking of food has not gone unnoticed and the word “food-miles” has diffused into popular culture. Two news magazines, *Time* and *Business Week*, each dedicated almost an entire issue to food matters, from the “100 Mile Diet” to “The

Myth Behind Organic Foods.” To further emphasize the relevance of the distance our food travels, the *New York Times* listed “food-miles” as a 2006 buzzword.

The food supply chains, defined in the next section, are complex and dynamic systems influenced by multiple factors; from policies, to financial decisions of corporations, to people’s choices about what they purchase, and in a limited way, to the physical geography of our world. The distribution centers that serve a specific place, as well as the availability of local food makes each place unique. Because of this uniqueness, it is difficult to generalize food-miles for all of the United States.

Missoula, Montana was chosen as a study area in order to better understand how far food travels to reach a particular place. Missoula is an ideal place to study this topic because of its dynamic and changing involvements in all aspects of the food supply chains. In other words, the diversity in food choices of Missoula’s community reflects a demand for conventional, certified organic as well as other-alternative foods. Although certified organic foods are technically an “alternative” to the conventional system, they have been placed in their own category, non-local organic, because they share some traits with the conventional supply chain, which consequently affect how far these foods travel.

The purpose of this study is to first derive the food-miles of four frequently purchased food items, each of which are separated into three categories of food: conventional, non-local organic and other-alternative, and to map the spatial flow of these foods into Missoula for the different food chains. Second, to approximate the external costs of transportation related to energy consumption in the form of fuel use, and pollution levels in the form of carbon dioxide emissions that are associated with food-miles.

BACKGROUND

The food supply chain is a spatial kaleidoscope. Where food originates, how food moves, and the quantity of food that moves along the chain has changed significantly in just the last sixty years. The consolidated structure of modern agribusiness and advances in technologies have altered the pattern of food distribution from small localized or regionalized food production and processing to larger, centralized and often times globally sourced foods. The structure of the conventional food supply chain has created a façade of infinite, quick and convenient food for the market. However, problems with the conventional, global food regime have been identified, such as the food-miles products travel from production to consumption. These problems have contributed to the creation of different agro-food networks that focus on increasing the viability of farming, decreasing food-miles and creating a stronger link between production and consumption. Due to these alternative agro-food networks, two food supply chains now serve many places.

Each food supply chain can be differentiated by their characteristics in type of production, scale of production and means of distribution. The two food supply chains also provide different types of food to the market that can be separated into different food categories. However, to further complicate the understanding of the flow of food into a particular place, some of the food categories are not mutually exclusive to either the conventional or alternative food supply chain. “Certified organic” is one such category that embodies characteristics of both chains.

The geographic study of agriculture has primarily focused on either production or consumption (Winter 2003). More recent work by social scientists—sometimes referred

to as agro-food geographers—revolves around alternative agriculture and alternative food networks (Watts et al. 2005). However, a dualism between production and consumption is still typically embedded in the analysis—implying that there is no link between these seemingly mutually exclusive events.

Unfortunately, the distance food travels further reinforces this dichotomy. Very limited information is available on the amount of natural resources that are used to produce, process and transport goods. Without a link between consumption and production, feedback loops are ineffective. Feedback loops allow information and influence to flow through the channels in both directions, thus creating change when needed (Sundkvist et al. 2005). The longer the food supply chain is and the more opaque processes are along the chain, the less knowledge about the origins, processing technologies and methods of transportation are available. Without that knowledge it is difficult for people to make informed decisions. Instead, consumers rely on marketing to tell the story of the food item.

Our physical and cultural landscapes have been transformed by this constructed dichotomy that labels our food products as “commodities” and us as “consumers”. By analyzing the entire food chain instead of one side or the other with the focus on a particular place—specifically Missoula, Montana—the hope is to make connections and recognize that production and consumption are not mutually exclusive practices; instead, they are intrinsically tied together.

Food-miles are important because they offer one perspective on how to understand the food system and its energy use, how to quantify feedback loops and begin to bridge the gap between production and consumption. Food-miles can be used to

potentially move beyond the theoretical into more concrete communicable information for people inside and outside of academics. But first, an understanding of why a focus on energy use in the food system is needed.

The first section of the background describes the food supply chains and delineates some differences in the two chains: conventional and alternative. Energy use in the food supply chain is then addressed. Issues of energy use and their repercussions are elaborated on as well as how food-miles play a role in understanding energy use in the food supply chains.

The second section describes the spatial trends of the food supply chains; from factors that have contributed to an increased reliance on transportation, to the influence alternative agro-food networks have had on the spatial flow of food. In short, this section describes trends of the conventional food chain that have become contested traits by alternative agro-food networks: increased energy use, standardization and economies of scale. Additionally, theories of agro-food geographers, which previously have been used to label different emerging food networks, are used to differentiate the characteristics of the three categories of food: conventional, non-local organic and other-alternative.

The Food Supply Chain

A food supply chain is a spatial structure through which food moves from production to consumption. Food supply chains vary in levels of complexity; from who is involved in decision making, to how food is processed, to how and where food is distributed, to the form at which food arrives to the market. The number of links required to provide food for communities vary, and increase with the level of complexity. While a food supply chain connects production to consumption, different ways in which the food

supply chains are structured cause this relationship between production and consumption to be either opaque or transparent.

The two supply chains that will be addressed in this study include the conventional and alternative, which will be defined in the proceeding paragraphs. Although the two types of chains are being defined in this study, it is for the sole purpose of being able to differentiate between the two. Both chains are in a constant flux; however, each has unique traits that distinguish one from the other.

A complete food supply chain is the life cycle of food from the farm to the table to the landfill (Jones 2002). One big difference between the conventional and alternative chain is the number of intermediaries that the farm product encounters. In the conventional food supply chain, numerous intermediaries “add value” to the product by processing, packaging and labeling it before it reaches the store. The conventional supply chain is where the majority of food eaten by North Americans comes from; whether a person shops at a grocery store, eats at a restaurant, eats at a school or hospital cafeteria, or orders a quick meal at a drive-thru. The alternative chain, often characterized by direct markets, has fewer if any intermediaries and is represented primarily by farmers’ markets, community supported agriculture and other direct sales.

A more complete description of the conventional food supply chain described by other authors includes farm inputs such as finance, seeds, fertilizers and machinery (Coleman et al. 2004). Farm inputs are what commodity chain theorists classify as “appropriations” (Ilbery and Bowler 1998, Whatmore 2002). Appropriations, especially seeds and fertilizers, were once intricate units of the farm system that originated from the farm. Now seeds and fertilizers originate primarily from off-farm activities requiring

additional transport to get to the farm. To combine both ideas of Jones (2002) and Coleman et al. (2004) and truly include the complete life cycle of food, the conventional food supply chain includes: financing, production (including off farm inputs), first stage processing, second stage processing, wholesale and retail marketing, consumer purchasing and waste disposal of the packaging or spoiled and unused food.

First stage processing prepares raw farm products to sell to manufacturers; preparations include such things as wheat milling, oilseed crushing and animal slaughter. After the first stage is complete, the prepared products move to the second stage where “value” is added by further processing and packaging in order to create a consumer friendly product. For many products, the second stage processing is typically where substitutionism takes place—where agricultural products are reduced to industrial inputs and combined with synthetic or nonagricultural components (Friedland 1991, Whatmore 2002). An example of substitutionism is high fructose corn syrup (modified from corn), which has dominantly been used as a substitute for sugar. From the second stage, the prepared and packaged product moves to either a wholesaler or a retailer—this section of the conventional food supply chain is characteristically non-transparent and difficult to track due to the number of hands the product passes through when moving from warehouses to distributors to retailers. Once available in the market, it is purchased, taken home, eaten and the leftovers are thrown away.

An example of a conventional food supply chain for bread might include the financing a farmer obtains to purchase inputs such as seeds, fertilizers and equipment. Once planted, grown and harvested, the wheat is transported to multiple elevators. There is a good chance that the elevators are owned by one of the four giants that together

control more than 60% of the market: Cargill, Archer Daniels Midland (ADM), ConAgra and Cereal Food Processors (Hendrickson and Heffernan 2005). The raw wheat finally ends at a location where it is milled into flour, again with the likelihood of being milled by one of the four companies. After being milled, the flour is transported yet again to another processing center where other ingredients are added to make a final bread product. Such ingredients include high fructose corn syrup, yeast, oil, salt and other ingredients that it “may contain” such as sodium stearoyl lactylate, ethoxylated monoglycerides, diglycerides and monocalcium phosphate—strange components that the average consumer is not familiar with. Many of the extra ingredients included in bread are to preserve it and extend the shelf life. Once “value” is added to the wheat by baking it into bread and packaging it, the bread is shipped through a distributor or several distributors before it reaches the market. The bread is then purchased and taken home to eat. Leftovers such as the packaging and perhaps moldy pieces of bread are thrown away and finally transported to the landfill.

Food waste contributes to the bulk in landfills. In 1997, food waste was estimated to represent 10.3% of municipal solid waste—and that figure does not include packaging, such as cardboard and plastics, which were presented in their own category (Franklin Associates 1999). One truck delivery for a small, specialized grocery store accumulates enough cardboard to form approximately a three hundred pound bale. Although this cardboard is usually recycled, the numerous trash bags full of plastic used to wrap the pallet of food as well individual cases are not recyclable. Large retail grocery chains receive larger and more frequent deliveries, which means more packaging and waste.

Alternative chains have fewer stops before reaching the household or landfill and less elaborate packaging due to the fact that many alternative foods are delivered directly from the farmer to the market. Other products that require processing are done at smaller plants. For example, an alternative food supply chain for bread might still include financing for the farmer to purchase seeds and other inputs. But, once the wheat is harvested it is stored on the farm or delivered directly to the processing plant where it is milled into flour and baked with less fillers. The bread is then delivered directly to the retailer.

There are many characteristics of the conventional and alternative chains that differentiate the two from each other. The conventional chain, as mentioned in the introduction, functions on economies of scale. In short, this means food products are produced, processed and/or purchased in large volumes in order to force the cost per unit down, which then allows a company to gain a larger share of the market because smaller companies become unable to compete with the low costs per units. However, one must keep in mind this system is heavily reliant on cheap fuel for transportation. Additionally, to store raw farm products or process them into convenient and time saving food—large quantities from multitudes of farms are mixed in a centralized location. In other words, they become undifferentiated goods referred to as raw commodities.

The alternative chain, on the other hand, operates at a smaller scale. The items can typically be differentiated between farms. Additionally, because the chain is more direct it creates a transparent market, which in turn increases the level of trust. The trust the conventional system attempts to create is typically in the form of regulations, such as USDA inspected beef packing plants. However, as has been apparent in the news,

regulations have been unable to stop large numbers of people and animals from getting sick. Large-scale processing has become a problem with outbreaks of E'coli that was seen in the spinach recall in the late summer of 2006 (Allday 2006). The spinach from multitudes of farms was cleaned and prepared in one plant in California, yet spinach with E'coli showed up in the majority of the Pacific Northwest states as well as the Eastern United States and into Canada. Other examples include the salmonella tainted Peter Pan and Great Value peanut butter that was processed in a Georgia plant and made its way to China (U.S. Department of Health and Human Services 2007a). Melamine tainted pet food made in China killed many pets in America (U.S. Department of Health and Human Services 2007b). Another recent recall on a food product due to detecting E'coli is Moran's meat whose customers include Albertson's and SuperValue. Moran's claim to be "the largest processor of ground beef in the United States under one roof" (Moran's All Natural Beef n.d.).

Transparency as well as trust is lacking in the conventional chain with its many intermediaries—typically these are vertically integrated intermediaries owned and operated by one company. The lack of trust is obvious. Countries such as Japan and South Korea have banned American beef due to concerns about mad-cow disease. Other differences that will be elaborated on throughout the remainder of this report include the levels of consolidation, where, who and what knowledge is being used to produce or process a food item, and the scale of production and processing that results from this system.

Transportation between each segment of the food chain is required (except perhaps the financing) for both the conventional and alternative food networks. However,

advocates of alternative networks refer to the potential of the alternative chains to reduce the length of transportation involved and thereby reduce the reliance on non-renewable fossil fuels. While fossil fuels are also used extensively in the production of farm products, the focus of this study is on the transportation required to get a product to the market; specifically, the transportation that links the various stages of the food supply chains. The reason for this focus is multifaceted. As oil costs continue to rise who will pay for it—the farmer, retailer, consumer or entire communities? Additionally, this heavy dependence on fossil fuel combustion contributes substantially to emissions of carbon dioxide and other greenhouse gases that lead to global warming.

Energy Use in the Food Supply Chain

How does a civilization survive? It survives by harnessing enough energy and providing enough food without imperiling the provision of irreplaceable environmental services. Everything else is secondary...

V. Smil

Energy and food are intrinsically tied together. On the most elemental level, food requires energy to grow and we require the energy from food to function in our daily lives. The amount of energy used to grow and distribute food has greatly changed through the years as societies have learned how to appropriate energies to reduce the amount of human labor needed, and to extract and convert raw materials for “the provision of physical comforts” (Smil 1987:1). The appropriated energies are primarily provided by natural resources. Natural resources that are used in the food supply chain include fossil fuels, solar, soil, water and wind.

The natural resources required to grow, process and transport food to where it is consumed have significantly increased. This increase is a result of mechanized farming,

increased use of synthetic fertilizers and pesticides, increased use of electricity needed to process food products, and the increase in the transportation required to move raw commodities and processed products to the market. Indeed, as the world's population continues to grow and becomes more concentrated in urban areas, more energy is required to feed more people. The "global agro-food complex based on global sourcing" (Heffernan and Constance 1994:41)¹ is seen as a necessity to solve food insecurity issues. However, food trade has increased at twice the rate as the world's population (Jones 2002). Unfortunately, there is an inequality or unequal distribution to this trade. The global trade pattern consists of "networks of agro-food chains that deliver fresh fruits and vegetables [and other foods] from all over the world to economically privileged strata in North America, Western Europe and Japan" (Friedland 1994:211).

While energy input has increased, the amount of output has remained relatively the same. The amount of energy, measured as kilocalorie (Kcal), that now goes into food production and distribution has been calculated to be significantly higher than the energy output of a food product (Pimentel and Pimentel 1979). In other words, the food system's energy bank account is overdrawn. Indeed, the irreplaceable environmental and natural resources are being imperiled. How long can a system run on a deficit?

Although all natural resources play important roles in our food supply chain, this study addresses the use of fossil fuels. Energy use in terms of fossil fuel consumption in the United State's food system accounts for 17% of the total energy consumed by the country (Pimentel and Pimentel 1996). Although this percentage may seem low, it is still

¹ Heffernan and Constance are referring to the global "food regime" that Friedmann and McMichael have analyzed (1989). The global food regime "...refers to different international divisions of labor linked to different periods of capitalist accumulation creating an international food production and consumption system".

several times more energy than used by lesser-developed countries. Per capita, the United States uses three times more oil on producing, processing and transporting food than other developed countries (Pimentel and Pimentel 1996). Fossil fuels are used in all aspects of the food supply chain from production to consumption. However, the focus here is on the fossil fuels required for transportation—or simply put, the distribution of market-ready food—through the food supply chain.

Fossil fuel combustion required for transportation increases the concentration of carbon dioxide in the atmosphere. Carbon dioxide emissions are one of the most “important environmental consequences of fossil fuel energy use” (Smil 1996:218). The consequence with the largest focus presently is the connection between these emissions and global warming. The burning of fossil fuels increases the concentration of carbon dioxide in the atmosphere, which in turn blocks in the heat that is re-radiated by the earth’s surface. This process causes a general warming trend in the troposphere. Events that have been attributed to this process include: the melting of the polar ice sheets and the increase in extreme weather conditions such as droughts, floods and hurricanes—all of which could greatly change the ability to grow food.

The use of fuel (gasoline and diesel) is a significant factor related to the food supply chain that transitions us to some calculable monetary concerns. “Demands for transportation fuel in the food and fiber system are likely to continue to increase in the foreseeable future” (Barton 1980:i). Indeed, statistics show this to be the case. In just five years, between 1987-1992, the number of trucks used for agriculture increased by 0.5%, for wholesale trade by 17.2% and for retail trade by 26.9% (U.S. Department of Commerce 1995). Additionally, mixed freight (a large portion of which includes supplies

for food restaurants, fast food chains, grocery and convenience stores) has increased by almost 400% between 1997-2000 in terms of value (U.S. Department of Transportation 2006). However, farmers' incomes do not reflect this increase.

Although numerous studies on fuel usage were conducted during the 1970s—in part due to a reaction of the energy crises of the time—little has been done since then. Fuel usage will have monetary repercussions all along both food supply chains. The peak in oil production, which is projected to occur around 2010 (Kerr 1998, 2005), will subsequently result in a decline in the amount of available fossil fuels. That decline, coupled with an increase in demand, will only drive fuel prices higher. Increases in the costs of fuels have already become apparent with an average of over three dollars per gallon in the United States.

A simple chart shows the costs of crude oil per barrel for over thirty years (see Figure 1). The first large peak in the cost per barrel occurred in the late 1970s to early 1980s. Again, this was the time of an oil crisis when much research was focused on energy use—specifically fuel use in the food system.

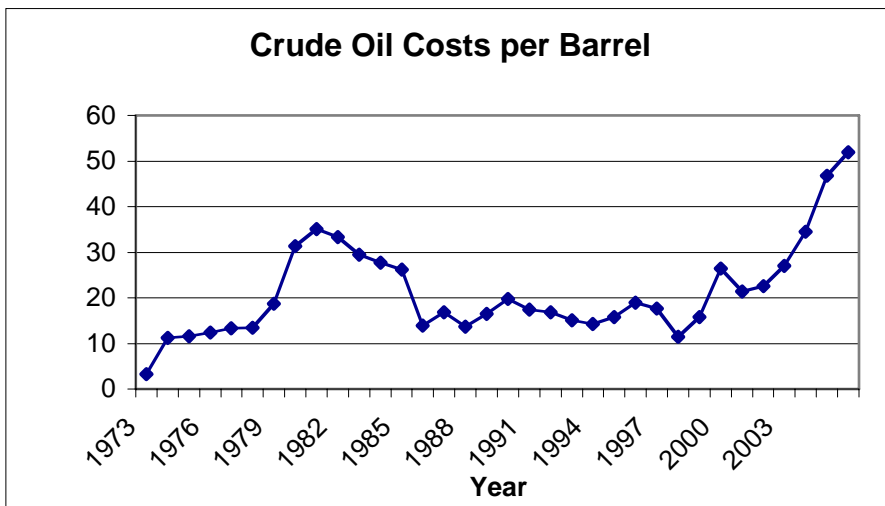


Figure 1: Crude Oil Costs per Barrel
Data derived from U.S. Department of Commerce. Bureau of the Census 2006

Even though it is obvious by the chart that the costs per barrel have continued to increase over the last decade, with a slight drop in 2001, research has yet to reach the level of the 1970s.

To further complicate the situation, oil imports into the United States have continued to rise since the 1980s (see Figure 2). Consequently, we are not only consuming more energy, but also increasingly becoming reliant on foreign sources for that energy. Cuba and North Korea are striking examples of what can happen when a country is reliant on imported oil. When political alliances failed, the countries were faced with serious repercussions related to food production (McKibben 2007, Yu 2007). The reliance on non-renewable energy adds to the environmental burdens caused by society and creates a food system that is vulnerable to the supply and price increases of fossil fuels (Heller and Keoleian 2003).

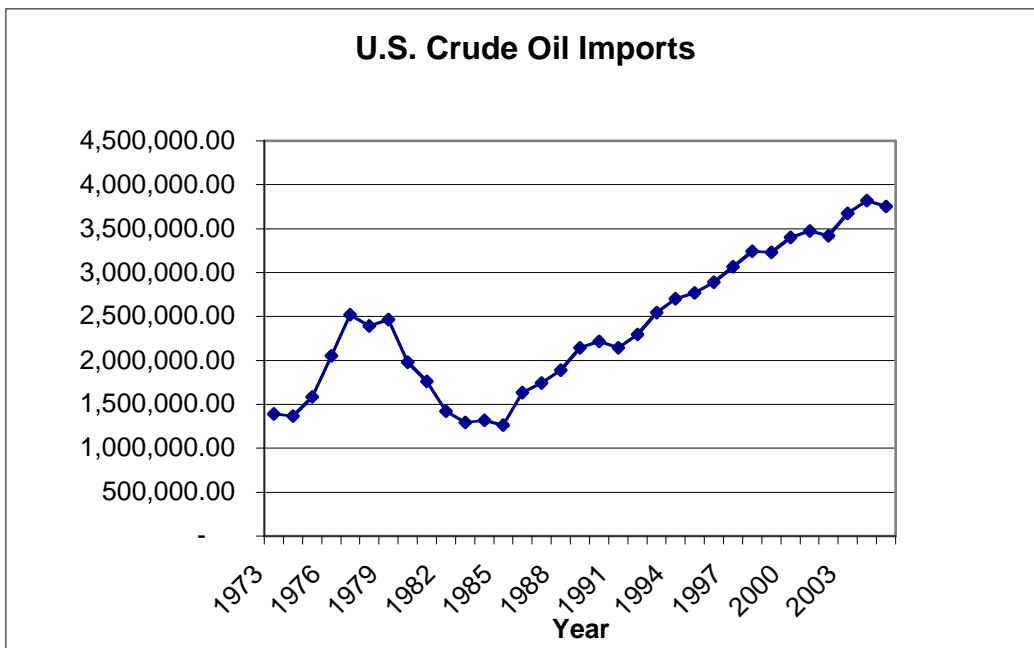


Figure 2: U.S. Crude Oil Imports
Data derived from U.S. Department of Commerce. Bureau of the Census 2006

As the cost per barrel of oil increase, the cost of fuels tends to follow, and this affects the cost of food. Food retailers have already seen a rise in transportation costs. These costs have risen 23% between 2002 and 2005 alone (Cooke 2005). Information on average food prices from the U.S. Department of Labor (2007) also shows a similar trend. When charted together with the average consumer price of gasoline, both bread and ground beef show a similar trend of continued cost increase (see Figure 3). There are multiple factors that would contribute to this trend, but the correlation between increased gas prices and increased food prices should not be overlooked.

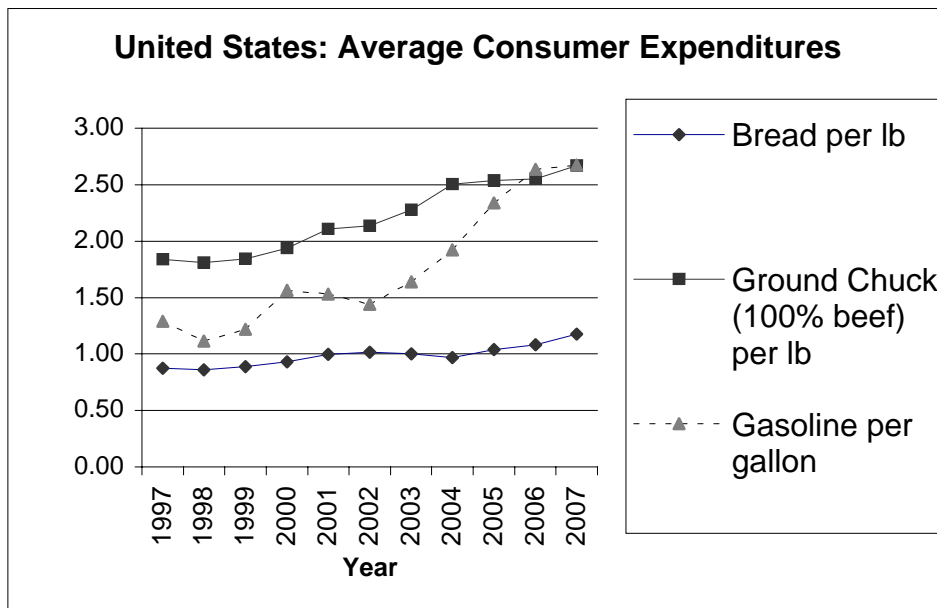


Figure 3: Average Consumer Expenditures

Another factor that is influencing higher priced food is ethanol production. Ethanol development is seen as a way to reduce the United States reliance on oil. Recently, within the last year, due to increased demand for corn for ethanol production, the price of corn has risen. Corn is used as feed for both dairy and beef cows. Thus, the costs of corn will and has affected the costs of meat and milk. These issues related to ethanol production further reinforces how important it is to look at how far food travels

and ways in which transportation links can be shortened, regardless of what type of fuel is used.

Food-miles Studies have been done to calculate the energy costs of our food system due to the relationship between food, energy and the consumption of natural resources. Different measures of energy use and output in the food system include the kilocalorie (Kcal) (Pimentel and Pimentel 1996), gallons of fuel used (Barton 1980), megajoule (MJ) (Jones 2002), and food-miles (Hird et al. 1999, Pirog et al. 2001, Smith et al. 2005). While there are strengths and weakness to all types of calculations, this study quantifies energy use in the food system using food-miles. Food-miles are then the base to quantify the amount of fossil fuels consumed to transport products and the subsequent CO₂ emissions.

Researchers have calculated food-miles to analyze or compare two different food systems: the “global-conventional” and “local-alternative”. In 1998, Pirog et al. (2001) estimated food-miles for food consumed in Iowa and found that conventionally sourced meat and produce traveled almost 1,500 miles further than locally sourced products. Similarly, Jones (2002) analyzed the sourcing of apples in Britain and concluded that “[t]here is a clear decrease in transport energy consumption as the product is sourced closer to the point of consumption” (568). Other groups such as Department for Environment, Food and Rural Affairs (DEFRA), based in the United Kingdom, have conducted studies to analyze the change of food-miles over the years, the impact of food-miles and if food-miles can be used as an indicator for sustainable food chains (Hird et al. 1999).

The story of food-miles told here is about energy use—specifically in the form of fossil fuel consumption and carbon dioxide emission that are a direct result of the transportation of food. But food-miles are also about knowledge, feedback loops and in part food security. It is important to note that food-miles do not account for the fuel usage on the production side, nor fuel used to transport the required crude oil or materials for packaging. Food-miles are the amount of miles a product travels through the food supply chain from the farm to the consumer’s plate. For this study, due to lack of available information in the conventional food supply chain, the food-miles are derived for the distance that products travel from processing to retail sale.

The evaluation of external costs helps open a dialog about how many resources are being consumed by the structure of the food supply chains, thus creating feedback loops to which people can respond. One main objective in evaluating external costs is to determine the “...most environmentally benign options for meeting a specific human need” (Jones 2002:564). While the most benign option is not always apparent, nor can food-miles be the ultimate decider, they can be used to help understand the distance between the production and consumption of food and how much fossil fuel energy goes into the transportation of food into a particular place.

As the scale of production, processing and retail increase, food products increasingly travel longer distances in the conventional food chain. This indeed has created food products that are experienced travelers, which is problematic because of the resources, both hidden and obvious ones, that are being consumed.

Spatial Trends of the Food Supply Chains

The spatial flow of food in the present conventional food supply increasingly uses more and more energy as origins of food have changed from small regional and local production to much larger regions that incorporate many states and even countries. In order to understand how access to food has changed throughout the years and the factors that have influenced that change, this brief description of the historical spatial dynamics of food is focused on consolidation from production to retail and the simultaneous changes in transportation that have also occurred.

Since World War II, the food supply chain has undergone a transformation in large part due to the modernization of agriculture, improvements to transportation infrastructure (such as the creation of interstates), and increase in international trade. These factors were exuberated by low transportation costs (Cook 2006, Heffernan and Constance 1994, Jones 2002). As these trends accelerated, the market also changed and concentration in the production, processing, distribution and marketing of food intensified. Post World War II “spawned modern agribusiness” (Cook 2006:101). The spatial transformation that resulted from modern agribusiness has made small farms, local processors and corner grocery stores unable to compete with the low market prices of the consolidated system. Consequently, as more companies consolidated and global trade increased, the amount of miles food traveled to the market also greatly increased, creating a food chain that is highly reliant on fossil fuels.

Concentration is seen in all links of the conventional food chain from farming to processing to retail: the later two more so than the farming sector. The number of farms in the United States has decreased by 50% since World War II (Robbins 1974)—reducing

the farming population to less than 2% of the United States population. Although this is a very large decline, even more startling is the consolidation in the processing and retail sector, which in turn limits many options for the farmers. Many food processing companies are both vertically and horizontally integrated. As a result, farmers contract with large processors, as is seen in the broiler, or chicken production industry. By 1960 more than 93% of broiler production was contracted and concentrated in the South (Heffernan and Constance 1994).

Improvements to technology, which are costly, have played the largest role in the consolidation of the food processing industry (Ollinger et al. 2005). The number of plants in eight categories of food industry decreased by one-third and the number of workers declined by 20% (Ollinger et al. 2005). The eight categories include: meatpacking, meat processing, cheese products, fluid milk, flour milling, corn milling, feed and soybean processing. Similar to the farming sector, advancements in technology have allowed food processing industries to increase output with less and cheaper labor. For example, production of fluid milk increased by approximately 250% between 1977 and 1992—increasing output from 27.9 million pounds to 70.6 million pounds. During the same time, the number of plants that process fluid milk decreased by more than half (Ollinger et al. 2005).

The concentration ratio for the top five (CR5) grocery retailers is 46% (Hendrickson and Heffernan 2005)—which means that those top five companies control 46% of the market. When the concentration ratio for the top four or five companies is 40% or more, economists view that as an indication of the market losing its competitive character. It is important to note that grocery retailing is not the only sector of the food

chain that has a high CR4 or CR5 ratio. In the beef packing industry, the top four companies have captured 83.5% of the market (Hendrickson and Heffernan 2005).

Market concentration is strengthened further by vertical integration, which connects retailers to the processing sector. Store brands have become the norm as well as self-manufacturing (Davies and Konisky 2000). For example, Rancher's Reserve (a trademark of Safeway) steaks and roasts are sourced exclusively from the: "richest cattle growing regions of the Great Plains". Beef sold under the Rancher's Reserve trademark is processed by an exclusive supplier under the "strict Safeway guidelines to promote tenderness, juiciness and flavor" (Ranchers Reserve n.d.). For Missoula, the highest selling food products that are researched in the study are a mixture between store brands that are either self manufactured or are contracted with a regional processor. A large portion of the top fifty food retailers in terms of sales "...are fully integrated into grocery wholesaling, and the leading companies have considerable investments in warehouse, trucks and trailers (Davies and Konisky 2000). Self-distribution retailers accounted for half of the food sales in 1998 (Kaufman 2000). This creates a challenge for grocery suppliers as the needed volumes increase.

The decisions on what food is safe, what practices are acceptable and who gets subsidized are made by only a few people that many times benefit from these decisions; regardless of the cultural and environmental impacts the decisions may have on particular communities. Economic power demonstrated by market control does transfer to political power. "The agrifood system we have today is the product of the power relations that have shaped the organization and practice of agriculture and reinscribed these power relations in political institutions" (Allen 2004:188). Concentration in all realms of the

food chain is evidence that economic democracy does not exist in the conventional food system.

Although the cost of transportation presently does not impede on the size of companies that utilize economies of scale, analysts argue that it potentially could. The cost of transportation has increased; however, it has been gradual enough that the influences to the costs of food have gone unnoticed until recently. It is not an issue of ‘if’, but an issue of ‘when’ transportation costs will have a noticeable impact on food prices and where food comes from. Transportation costs do have an affect on business margins and prices of food. When the transportation costs outweigh economies of scale, it becomes more costly to produce and transport at such large scales (Berry et al. 1987). USDA analysts even supports this by documenting that the increase in transportation costs could result in more successful, smaller processors (Ollinger et al. 2005).

The configuration of our contemporary food supply chain has been greatly changed by the processes of consolidation, which have resulted in fewer and larger farms, processors and retailers. The economies of scale have been made possible by technological advances that have increased yields, improved storage as well as decreased the amount of time required to get a product to the market via transportation. However these technologies are predicated on standardized processes and knowledge and are broadly applied across the board instead of being area specific. Because of this, farmers and communities “...increasingly depend on external inputs and expert systems...” (Sundkvist et al. 2005:229).

Products, practices and knowledge have become standardized with only a few players controlling the “know-how” (Morgan and Murdoch 2000). Monsanto’s control

over genetically modified seeds, such as Roundup Ready[®] corn, is an example of this. Monsanto's patented seeds are designed for use in conjunction with their patented herbicide, Roundup. A farmer not only buys both products from the same company (Monsanto), but is also required to purchase new seeds every year. This obviously increases the input costs for farmers. Historically farmers stored their own seeds for next years crop. Even before genetically modified seeds, with the introduction of hybrid seeds, this practice has changed. Hybrid seeds either do not reproduce or decompensate significantly in one year, thus, must be purchased yearly or every other year.

Farm contracts with vertically integrated companies are another example of knowledge concentration with the know-how's disseminating to the farmer via the company. Tyson, the world's largest protein company (Hendrickson and Heffernan 2002), issued a 2005 Sustainability Report that documents this clearly:

Our contractual relationships with producers enable families to remain on farms instead of potentially being forced off by economic pressures. We provide farmers with state-of-the-art veterinary support, scientifically formulated feed, and technical assistance, with Tyson technical advisors visiting farms typically on a weekly basis. We work with producers to educate them on litter management, optimal lighting and ventilation for chicken, and disease control. We also strongly promote animal well-being at all stages of the birds' lives (Tyson 2005: 39).

Essentially, Tyson has documented that farmers cannot afford to continue farming, nor understand the processes in the competitive world of highly technical and specialized farm applications. Indeed, with the scale of production being so large, outside expert knowledge is required.

This loss of knowledge is apparent through the entire food supply chain. The knowledge of how to preserve and even prepare food has been standardized or substituted by companies that control the "know-how". Food can be bought already canned and

meat already separated from the bone, cut in strips with grill marks added for aesthetics. All these stages of knowledge loss create even more distancing between production and consumption.

Standardization has had obvious spatial implications on the cultural and physical landscape by increasing the scale at which farm products are produced, processed, transported and sold. This specialized standardization has created agricultural pockets of production throughout the United States and arguably other countries of the world. For example, cheese production is primarily located in Wisconsin, almonds in California, apples in Washington, corn in the Midwest, beef cattle in the Great Plains, broiler production in the South and some specialty fruits such as cranberries in the New England States (Wheeler et al. 1998). This is by far not a complete picture, but scholars argue that it does coincide with J. H. von Thunen's geographic location theory of food production.

Thunen's location theory is primarily affected by land costs. The cost of land decreases the further it is located from a population center. Although Thunen's theory was specifically a place-based location theory (Barnes 2003), it has been applied to the entire United States and even beyond. This theory is applicable at national and global scales, in part, due to the phenomena of consolidation. However, it is important to note that with increasingly concentrated populations, food-miles also greatly increase as land near population centers is expensive and many times uneconomical to farm.

Standardization of knowledge and simultaneously technology has created a seemingly efficient system, but at a cost. Technologies have enabled farmers to increase yields and decrease the amount of labor needed on the farm. They have also enabled processors to increase volume and speed up "capital turnover" (Harvey 1990). Similarly,

improvements in storage and transportation have allowed companies to “reduce seasonal fluctuations” (Marsden et al. 1996:368). The technological progression, or “treadmill”, continues with larger more expensive equipment, genetically modified crop seeds, and even potential approval by the Food and Drug Administration of using cloned animals for meat and milk (U. S. Department of Health and Human Services 2006). “Every technological intervention increases distance” (Kneen 1993:39). Increasingly, each new technology requires more capital to purchase the inputs such as machinery, chemicals or genes for cloning. In turn, this reinforces the trend of consolidation as only the top players with the most money can invest in these new technologies. The system is predicated on the idea that economies of scale via consolidation provide affordable food, which benefits everyone; and that we can continue to transport our food thousands of miles without worries or repercussions.

Agro-Food Geography The conventional food chain has created “spatial shifts of capital” (Escobar 2001:145) and food products that are experienced travelers. The change in scale and uneven spatial shifts in capital as well as a system that is reliant on oil has initiated a focus on alternative chains, which are more direct and democratic. Agro-food geographers have picked up interest in evaluating these alternative agro-food movements that have formed out of resistance or opposition to the conventional food supply chain managed by agribusiness. Different approaches to food procurement and marketing by alternative networks have been analyzed: from quality labeling (Murdoch et al. 2000), to shortening the supply chain (Marsden et al. 1996). Primarily, these different approaches have once again created new spatial patterns or essentially a new food supply chain focused on decentralization and relocalization.

Different approaches to agricultural practices and business are not new. Rather, they have been gaining momentum for many years; from opposition to the overuse of pesticides, to ecological modeling, to locally focused markets. Many refer to Rachel Carson's book, the *Silent Spring* (1962), which brought to the forefront problems with pesticides and synthetic fertilizers. An ecological modeling example is the Land Institute in Salina, Kansas founded by Wes Jackson more than twenty years ago. The goal of the Land Institute is to model natural prairie plants to create a viable polyculture crop system—if successful this system would greatly reduce fossil fuel use on the production side.

Farmers' markets are an example of a different approach to marketing food, and the receptiveness of communities to participate in a localized community-based market. Farmers' markets began to gain popularity in the mid 1990s as forms of community development and demand for access to local food increased. From 1996-1998, farmers' markets increased by 20% (O'Hara and Stagl 2001). This trend still continues with an increase in over 600 markets from 2002-2004—making an 18% increase (USDA Agricultural Marketing Service n.d.).

Farmers' markets, The Land Institute and focus on reduction or elimination of synthetic pesticides are just a few examples of the momentum and ideas behind alternative agro-food movements that have begun to redraw the shape and concentration of our food system. The structure and function of the food networks themselves have also begun to change.

Alternative food networks by label alone are comprised of a “collaboration” of people involved to address food related issues at “relevant physical scales.” The milieu

of alternative agro-food networks includes farmers, ranchers, nonprofit organizations, and academia, just to name a few. Alternative networks have begun to utilize the political process to promote networks of change. However, there has been a limited amount of discussion on how alternative agro-food organizers have begun to use politics and policies.

Conventional modern agribusinesses historically have been aided and influenced by policies for their benefits in the pursuit of “abstract quantities” (Berry 2001:68). These abstract quantities, which are the bases of what scholars label the “industrial culture,” are arguably the root of consolidation, distancing, and disregard for unique geographies and appropriate scale. The economic and political power demonstrated by these companies has disempowered people—making it more comfortable and agreeable for people to be ignorant of our food system rather than knowing what is really going on. This ignorance, ironically, is relied upon by the industrial/conventional system (Berry 2005).

Due to this disempowerment, alternative agro-food movements have too begun to use policies to obtain funding for, and to promote networks of change. USDA funded programs such as Sustainable Agriculture Research and Education (n.d.) have funded projects for “research and educational grants, professional development grants and producer grants,” all of which are focused on “sustainable agriculture”.

A specific example in Missoula includes the non-profit Garden City Harvest, which received a USDA Community Food Project grant in the late 1990’s to begin “planting the seeds for a diverse and fruitful community effort” (Garden City Harvest n.d.). This same program now educates students about sustainable agricultural methods

through hands on work, manages a number of community gardens around the city and donates thousands of pounds of organically grown produce a year to the Missoula Food Bank.

Another coalition of non-profits geared towards supporting sustainable Montana agriculture and improving access to healthy foods for the entire state of Montana is Grow Montana. This non-profit coalition has in turn created multiple networks with links to particular places in Montana, such as Missoula. One example of these links includes the FoodCorps. The FoodCorp operates in four different cities through Montana to begin building bridges and links between Montana farms and Montana schools in order to increase farm viability and at the same time provide healthy food to school cafeterias. Grow Montana has also played an active role in initiating and following up on food related legislation.

The USDA funding that supports some of these programs, as mentioned earlier, is focused on “sustainable agriculture.” However, there is no agreed upon definition of what is local or sustainable. There are, however, commonalities in the definitions. For the purpose of this study, the similarities in the definitions of the two will represent the alternative approach to food provision. These commonalities are in direct opposition to what scholars argue to be some of the most vulnerable traits of the conventional food supply chain that can potentially jeopardize communities’ access to food: the increasing food-miles, the reliance on fossil fuels and the dependence on external resources. Thus, in order to create a less vulnerable food supply chain, the alternative approach is aimed at: decreasing the miles products travel, decreasing the use of fossil fuels and decreasing

dependence on external resources (Heller and Keoleian 2003, Hendrickson and Heffernan 2002, Kloppenburg et al. 1996).

There are many contrasting characteristics of the conventional and alternative food supply chains that were addressed through the background (see Table 1). These characteristics have directly impacted the spatial flow of foods to and from particular places. This list is not comprehensive; instead it highlights some of the dominant themes previously addressed.

Table 1: Characteristics of the Conventional and Alternative Food Supply Chains

Conventional	Alternative
Consolidated	Decentralized—locally and regionally based
Standardized knowledge and technology	Diversified production and locally/regionally based knowledge
Large- scale	Small-scale
Decisions made by few people	Democratic
Lack of trust	Trust
Non-transparent market	Transparent market

Farmers’ Markets, the Land Institute, Garden City Harvest and Grow Montana are just a few examples of movements towards alternative and localized food systems. These are the alternative approaches to food procurement because they operate on many different principles than the conventional agribusiness dominated food chain. Alternative agro-food networks do not function outside of the system—rather they function within the open spaces or weakness, vulnerabilities and concerns of the current system (Hendrickson and Heffernan 2002). Instead of relying on the “everywhere, no-where”, these open spaces become a concrete foundation on which to work towards the vision to re-embed food production and consumption “...primarily within human needs rather than

within the economist's narrow 'effective demand' (demand backed by ability to pay)" (Kloppenburg et al. 1996:36).

Quality and Labeling The conventional food system is also going through a qualitative shift, in part due to demand for higher quality food (Murdoch et al. 2000). Quality refers not only to the look of the item being purchased, but also quality in the production and processing practices—essentially how much nature is perceived to be in the product. Health and environmentally conscious consumers have objected to practices using synthetic inputs and question the healthy quality of food produced by such means. In other words, substitutionsim is being largely objected to. The standardized products, made available by the conventional system, are contested factors that question the merit or authenticity of these food products that are provided from the large-scale conventional system (Allen and Kovach 2000, DeLind 2000, Sligh 2002). The qualitative shift seen in the conventional food chain is most obvious in the marketing and distribution of certified organic foods.

Consumer countertendencies to the conventional food chain have arisen in part due to practices using synthetic inputs, as well as the numerous food scares previously mentioned. Allen and Kovach (2000) address the concept of "green consumerism" as a way for people to essentially vote with their purchase dollars. However, they argue that green choices cannot be made without good information, which is many times difficult to obtain.

"Environmentally concerned consumers are faced with difficulties in making the right choice of food product, since there is little information available on which production methods have been used and how they might effect the environment"

(Sundkvist et al. 2005:230). For companies, there is not “an incentive to discuss everything about their production methods, but only to discuss those aspects of their production methods that distinguish them favorably from conventional producers” (Allen and Kovach 2000:226). This holds true for transportation as well: how the food is transported and how far it is transported. As Pollan observantly points out, health food and organic products tell the story green consumers want to hear: this “...storied food is showing up in supermarkets everywhere...” (Pollan 2006:135).

The organics movement has done a good job of educating the public on the negative health effects of conventional practices—none more apparent than organic milk that does not include the bovine growth hormone. However, as many have noted, certified organic foods have largely taken on similar traits of the conventional food chain. Many certified organic products are processed in large scales with a few companies in control of a large portion of the market (DeLind 2000). Inequality has grown in this sector as large agribusiness farms increase their market premiums with certified organic foods, more so than is possible for small-scale producers (Khosla 2006). Little discussion has occurred about how organic foods get to the shelf and the long supply chains that are involved.

Transparency in the marketing of organic foods is also hindered by the complicated supply lines; thus making people who chose to purchase certified organic foods reliant on the standards and certification processes, which potentially can be and have been weakened. In 2006, the Organic Trade Association which represents Kraft, Dole, and Dean Foods, just to name a few, successfully attached a rider to weaken the organic food standards on the 2006 Agricultural Appropriations Bill. The rider allows

“certain synthetic food substances in the preparation, processing and packaging of organic foods” (Gogoi 2006: 2).

Some actors that have once been involved in the organics movement have now chosen to opt out. One example is the creation of the Homegrown label in Missoula, Montana (Slotnick 2006). Several factors have influenced farmers’ decisions to opt out: one being dissatisfaction with the fact that the story of their farm was being used to sell highly processed organic products—the very stories portrayed in grocery chains around the nation that Pollan (2006) addressed. There was no differentiation between their locally and organically raised foods from the organic foods seen in stores that potentially travel thousands of miles to get to the shelf—all were simply under the title “organic.” The Homegrown label shortens the distance their food travels as well as creates a transparent market with invitations and encouragements for people to visit their farms.

New terminology that has surfaced, in regards to farmers working together to create their own labels based on region specific qualities and knowledge, includes the “Participatory Guarantee system.” According to the Food and Agriculture Organization of the United Nations, “the reason for these ‘alternative’ methods of certification vary, but are often a result of high certification costs” (Lernoud 2005). Main components of Participatory Guarantee systems as lined out by the United Nation’s Conference on Trade and Development (n.d.) include: a shared vision among farmers and consumers, participatory involvement, transparency in the entire process, trust or an “integrity-based approach,” a continual learning process and a share of power or responsibility.

It seems inappropriate to place certified organic foods entirely in the “conventional” or the “alternative” category. Certified organic foods are alternative to

the conventional in production practices. Studies have shown that organic production is less energy intensive. However, the miles traveled by a product could off set these energy savings (Hird et al. 1999). On the other hand, the marketing of certified organic foods has similar characteristics to the conventional chain. In fact, conventional companies have purchased many organic companies. One example is Horizon, a company that produces organic dairy products. Horizon was purchased in 2003 by Dean Foods—“the largest processor and distributor of milk and other dairy products” (Dean Foods n.d.). Due to the contentious debate over organics and the overlapping characteristics, this study differentiates food into three categories: conventional, non-local organic and other-alternative. Table 2 shows the characteristics of three different food categories that are analyzed in this study.

Table 2: Characteristics of Three Food Categories

	Conventional	Non-local organic	Other-alternative
Production	Non-organic	Certified organic	Certified organic or Participatory Guarantee
Processing Scale	Large-scale	Large to medium scale	Small-scale
Distribution	Uses a distributor	Uses a distributor	Direct delivery

Shortening the Supply Chain Long transportation lines creates a physical distance; the distance of which are influenced by consolidation. These characteristics of the conventional food supply chain, consolidation and distancing, are by far not the only characteristics and are perhaps a little oversimplified because of the food system’s complexity. But, they are arguably signs of an unstable system—a system that is resource intensive and alienates people from the entire process. This alienation has led to a food or commodity “fetishism” because the system conceals the social and geographical information about how and under what conditions food is produced, as well as the links in-between required for the food product to reach the grocers shelf (Harvey 1990). For

example, people do not see the conditions under which fruit is picked, or the conditions under which meat is processed—both of which are based on cheap labor. Instead, the distance food travels and the numbers of pit stops mask these labor-intensive and many times repetitive processes.

The global and centralized conventional chain does link us to “...a variety of places, people and resources” (McMichael 2004:xxviii). However, because of the extremely long feedback loops these links are not recognized, nor do we react to the problems that might occur somewhere along the chain—a new application of the NIMBY anachronism. The production and consumption of a food item can be linked by feedback loops; however, in the consolidated system that characteristically distances people from the source, these feedback loops are “masked” (Sundkvist et al. 2005). The consumption point relies upon resources not found in the area. Similarly, the farms that food items originate from rely on external resources, two of which are seeds and fossil fuels. All these factors; masked feedback loops, prostituted localities for corporate gain, and reliance on fossil fuels become contested spots and support a strong argument to once again reconfigure the food system with shorter supply chains.

Food prices are already on the rise. One major criticism of local food initiatives is affordability. The conventional food supply chain is the dominant chain for food presently because of its ability to provide seemingly cheap and convenient food to the market. Researchers that have studied food-miles indicate that the costs of transport have not reached the point to make local foods competitive against conventional foods (Pirog et al. 2002). However, the costs of a geographically distant food chain could outweigh

the benefits of the conventional chain “as we reach the limits of our petroleum sources” (Hendrickson and Heffernan 2002:364).

Alternative food theories that stress quality and embeddedness (Murdoch et al. 2000) and shorter supply chains (Marsden et al. 1996) have formed to describe some vulnerable traits of the conventional food chain. These vulnerabilities are the “open spaces” (Hendrickson and Heffernan 2002) that advocates of alternative agro-food networks have attempted to work within to promote their ideal food chain.

Watts et al. (2005) have evaluated the different theoretical approaches addressed in this section such as product differentiation by quality assurance via labeling, and shortening supply chains. They argue that labeling, or focus on food quality such as certified organic foods, is a weak alternative to conventional foods because the focus is on the foods and “...not the networks through which [the food] circulate[s]” (30). Instead, the “...stronger alternative to increasingly globalized food supply chains...” (32) resides in alternative networks that are focused on shortening the supply chain.

Shortening the supply chain intrinsically means reducing food-miles. For this study, food-miles are used as a measure to identify how far food travels that is sold in Missoula retail grocery stores and quantify the energy consumption of the food supply chains. What does the spatial flow of food look like and how does this translate into energy consumption in terms of fuel use and carbon dioxide emissions? These three measures—food-miles, fuel use and carbon dioxide emissions—are compared for the three categories of food: conventional, non-local organic and other-alternative. Can a conclusion on which food category is less energy intensive and thus more environmentally benign be drawn using those three measures?

METHODS

The aim of this study is to identify and analyze the food supply chains that frequently purchased foods travel through to reach Missoula, Montana. These foods are categorized as either conventional, non-local organic or other-alternative. Food-miles—how far foods travel—are used to analyze the spatial patterns of food transportation. Food-miles are further used to estimate the amount of fuel required for transport and the subsequent carbon dioxide emissions. This study also compares attributes of the food supply chains for the three categories of food: conventional, non-local organic and other-alternative.

This study focuses on food items that are frequently purchased and can be locally sourced with Missoula, Montana as a study area. As no ready-to-use data set showing food-miles exists, information about available food and its origins were gathered by taking inventories in retail food stores and by interviewing store managers, store employees and food distributors.

This chapter, which outlines the methods used, consists of descriptions of the study area, the approach for determining the food items, methods of gathering data through store inventories and interviews, procedures for determining food-miles for the three food categories and methods of calculating carbon dioxide emissions.

Study Area Description

The city of Missoula, located in the county of the same name, is the largest urban center in western Montana. The city is nestled in a valley carved out by historic Glacial Lake Missoula. Mountains to the east, north and south create visual boundaries but do not limit the flow of food products to and from the city. Situated approximately at the

midpoint of Mullan road, which historically connected the Missouri and Columbia water routes, Missoula has always played a significant role in trading and distributing goods. However, the quantity and distance of that trade has greatly changed through the years.

Since the inception of the town, agriculture has played an important and dominant role. Gold mining camps, like two near Butte, provided a significant market for farmers. Products that were available in Missoula Valley's regional market in the late 1800's included eggs, peas, potatoes, meats, hay, grain, flour and many vegetables (Coon 1930, Herrin and Gussow 1989). The radius of the market for Missoula was not very wide and the majority of trade originated from the east. Both these factors were due to "...transportation facilities [that] were not sufficient to get these products to a wider market" (Coon 1930:588).

Trends described in the background of increased production aided by technological innovations in farming have impacted the role of agriculture in Missoula as well as made Missoula's regionally based foodshed unable to compete with the larger, more concentrated market. Policies, technology and cheap transportation all have influenced land uses and distribution of food into, out of and around Missoula County. These agricultural policies have left some obvious signs on the landscape; from irrigation ditches; to narrow but long lots designed for orchards. Other signs, which are not as evident without past knowledge to inform the built landscape include: the old beet factory turned to architect firm, and corner grocery stores either converted to houses or empty on the Northside of Missoula.

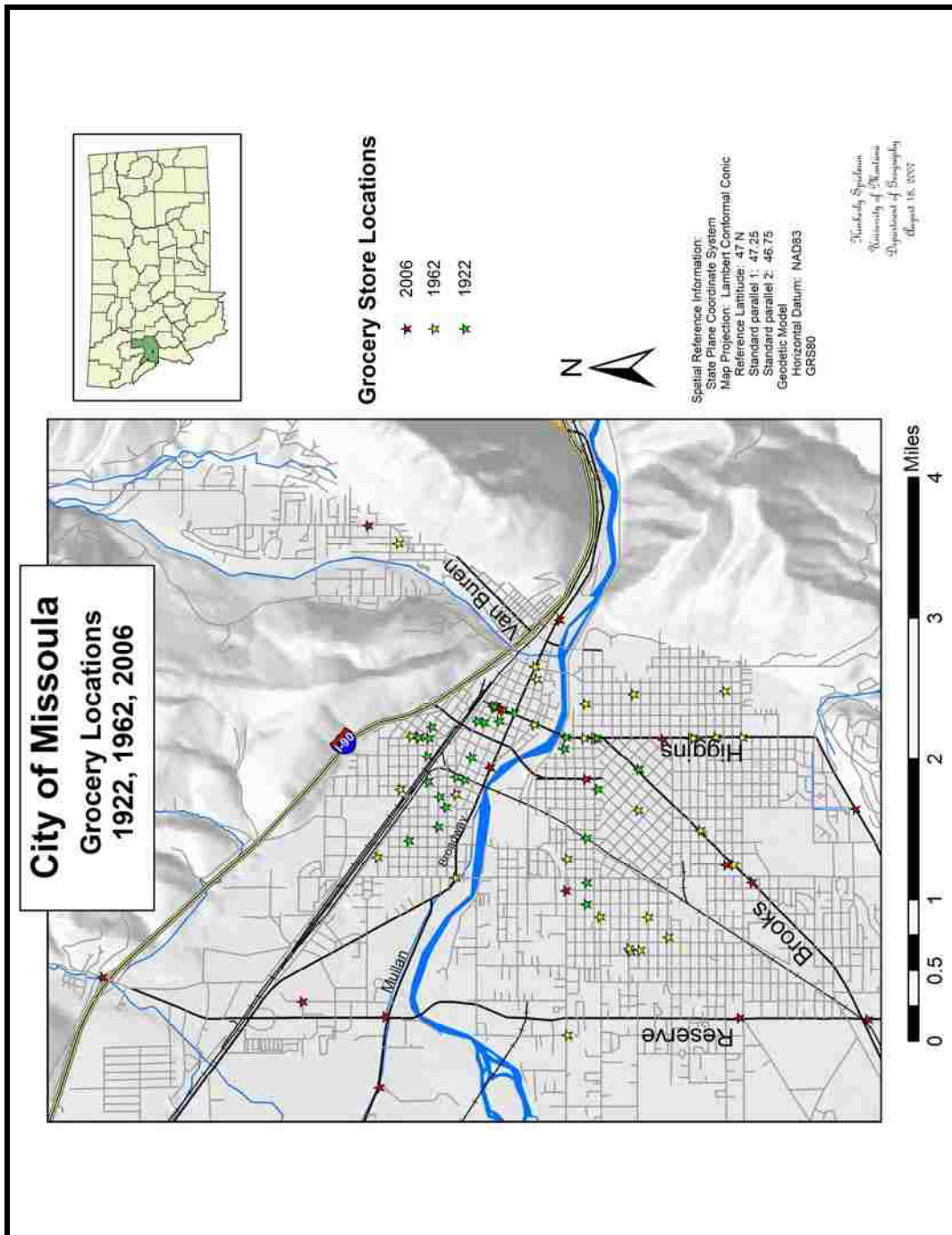
The city of Missoula once boasted the name 'Garden City' because numerous produce and orchard farms provided food for people in the valley. Other major crops in

the county were wheat, sugar beets, apples, potatoes and alfalfa. From the late 1930s to early 1940s the county had up to seventeen dairies. Now there are none, even though the county's population has increased threefold. Chief industries listed for Missoula County in the Missoula County Polk Files from the 1920s to the 1960s included lumber, agriculture, wholesale and distribution. By the 1970s, agriculture was no longer listed as a main industry; however, Missoula still plays a vital role in wholesale and distribution.

A peak in agricultural production in the county was followed in the mid 1960s by a decline. According to Missoula's Planning office agricultural protection study (1983), the demise of the local producers was caused by local producers not being able to compete with the low priced and non-seasonal supermarket foods—a problem that is further compounded by high land prices. Thus, food imports became the primary sustenance as large retail grocery chains entered the city. A map with the location of grocery stores in Missoula from 1922, 1962 and 2006 depicts the trend of reduction in the number of stores as well as a shift towards more centralized locations (see Map 1).

The peak in number of grocery retail locations for the three years occurred in 1962, with 47 listed retail grocery stores in the city. The Missoula County Polk Files listed 37 grocery vendors in 1922—many of which were simply named after the owner. The 1962 listing is a combination between stores named after individuals and chain stores such as Safeway and Albertsons. The number of grocery retailers listed for 2006 was 16, six of which are supermarket chains. Evident from the map is the change in locations between the three years. The majority of stores in 1922 were primarily located on the Northside. During 1962, a large number still appears on the Northside, but an almost

equal amount appears on the south side of the Clark Fork River. By 2006, with fewer stores, the majority or the stores are located along highly traveled roads.



Map 1: Missoula Grocery Store Locations: 1922, 1962, 2006

**1922, 1962 Addresses obtained from Missoula County Polk Files; 2006 locations obtained from Dell Phone directory.

Due to competition by large-scale retailers and producers outside of the region, the availability of food for Missoula, like most places across the United States, has changed greatly from growing and producing the majority of products, to importing the majority of food products. In other words, the supply chains have become longer and feedback loops masked as Missoula urbanized and became more reliant on external sources for food.

Even with these trends, Missoula offers a unique availability of alternative foods. The county and surrounding areas still serve as sources for Missoula's foodshed, although not enough to meet the consumption requirements of the city. Programs that use food within the Missoula foodshed include the Farm to College program, which began at the University of Montana in 2003 and has been recognized by *Time Magazine* (Roosevelt 2005). In 2006, the program reached a sales mark of one million dollars. Other places to purchase local food in the city of Missoula include: The Good Food Store, Orange Street Food Farm, Pattee Creek Market, two community supported agriculture programs, two farmers' markets, as well as numerous restaurants which purchase local foods when possible. In addition, Garden City Harvest Community Gardens give residents opportunities to rent garden plots to grow their own food. The combination of the conventionally sourced food and the availability of local food makes Missoula an interesting area for identifying and comparing food-miles and associated carbon dioxide emissions of conventional, non-local organic and other-alternative food items.

Data

Data was collected on food items that are commonly purchased at retail grocery stores. The food items themselves were chosen based on two criteria. The first criterion includes products that fall into Montana's highest ranked agricultural products by the amount of sales (USDA National Agricultural Statistics Service 2002b). The second criterion includes products that are frequently purchased food items and therefore represent a common staple in people's diets in Missoula.

The purpose for choosing the first criterion relates to the availability of a particular food to be grown and/or raised in Montana (see Table 3). Comparing the food-miles of conventional, non-local organic and other-alternative would be inapplicable if an item was picked that could not be raised or produced in Montana. The second criterion represents the demand for the product. Again, if there were no demand for a product, even if it can be raised/grown in Montana, comparing food-miles would again be inapplicable. Thus, these two criteria actually link production to consumption.

Table 3: Market Value of Top Agricultural Products Sold in Montana 2002

Item	Number of Farms	Sales (\$1,000)
Cattle and calves	11,793	1,015,169
Grains, oilseeds, dry beans and peas	6,517	507,090
Other crops and hay	6,234	157,980
Milk and other dairy products	235	41,842
Nursery, greenhouse, floriculture and sod	318	33,832
Vegetables, melons, potatoes and sweet potatoes	242	28,027
Hogs and Pigs	542	26,531
Other animal products	444	21,740
Sheep and goats	1,860	21,210
Horses, ponies, mules, burros and donkeys	2,527	12,870

*Data originated from USDA.NASS 2002b

To obtain a list of food items for the second criterion, three grocery store managers were asked for a list of the top ten highest selling food items (which food items went off the shelf the fastest and in the greatest volume). These lists were the general classification of the food item such as bread, milk, soda, et cetera, instead of brand names (see Table 4).

Three stores that were asked submitted a list: a specialty health food store, a locally owned grocery store and one large supermarket chain. However, the list from the supermarket chain was obtained from the public relations department instead of the manager because the manager was not able to give out the information that was potentially confidential. The public relations department gave a list of eight items that “should be” the highest selling (or fastest turnover) for **all** retail grocery stores. A list of the top ten specific for that particular store was deemed “confidential”.

Table 4: Top Ten Highest Selling Food Items for Missoula Retail Grocery Stores

Specialty Health Food Store	Supermarket Chain*	Locally Owned Grocery
Milk	Milk	Milk
Bananas	Bananas	Bananas
Bread	Bread	Breads (includes bakery items ex. cookies)
Eggs	Eggs	Hamburger (ground beef)
Coffee (in bulk)	Hamburger	Snack foods (includes potato chips, nuts, ect.)
Bottled Water	Apples	Beer
Energy Bars	Potatoes	Canned fruits/veggies (house brand)
Chips	Carrots	Soda
Soymilk		Soup
Cereals		Apples

*The Supermarket chain is the list of “should-be’s.”

Based on the selection criteria, the food items of interest include milk, bread, ground beef and apples. All these items met the specified criterion except for apples and ground beef. Apples are not listed on the 2002 Census of Agriculture. However, they are still included because they are on two of the three stores lists and apples do grow in this region (unlike bananas, which in 2005 came primarily from Central America with Guatemala showing the highest percentage of imports into the U.S. (Food and Agriculture Organization of the United Nations 2005)). Meat was not listed on the top ten from the specialty store. Nevertheless, it is included because it is on the other two lists. An assumption was made that due to difference in clientele between the stores, there is a higher percentage of vegetarians that shop at the specialty store than the other stores. Although eggs are present on two of the lists, they were omitted from the study due to time restraints.

Product and Origin Information

An inventory of the products available in each category was taken at five stores: a specialty health food store, a locally owned grocery store and three large retail supermarket chains. The inventory included brand names and if available on the packaging, the location of either the headquarters of the company or the processing location. The inventory, however, was not one hundred percent of the available products at the stores; instead, it was based on criteria specific for each product.

The milk products identified were all available gallon and half-gallon containers of fluid milk: whole, 2%, 1% and skim. The bread products that took up the most shelf space were the ones identified. The assumption made here was that the items with the most shelf space sold the quickest and in the highest volume. This was actually the

majority of the bread available. There were relatively few brands of ground hamburger—the large retail grocery chains carried only one brand.

Due to the seasonality of apples, a one-time inventory taken in the middle of winter would not accurately represent where apples originate. Instead, the origins of apples were identified at only one store, due to the availability of in-depth specific information from that store. A list of all the apples sold through the months of September to November was obtained. This allowed seasonal availability to be taken into account. The information obtained includes the types of apples, weights delivered, the source of the deliveries, number of deliveries, and a general idea of the origins of the apples.

Five informal interviews were conducted: two grocery retail store managers, one produce manager, an administrator to the executive staff at a major dairy company, and a logistics manager with the same company. The purpose of these interviews was to obtain origin information, delivery and distribution information as well as general feedback on transportation issues that affect the distribution of food products.

The United States Department of Agriculture requires milk containers to be branded with a four-digit identification code unique to each processing plant. This code, typically located as a printed number on the top of a milk jug, or occasionally on the label, was recorded along with the brand name of the milk in order to identify where milk was processed. Calls to companies that sold the brands available in stores were made to find the location of the specific plant based on the four-digit code. In addition, informal interviews with logistics managers and administration staff were conducted to determine how the milk products get to Missoula.

Origin information for bread and ground beef were the most difficult to acquire. After multiple attempts with one grocery supermarket chain, the processing place for their store brand of bread was obtained, but no other information would be given, again due to confidentiality issues. The remainder of the bread origination information was obtained by informal interviews with store employees. During an inventory of bread at one of the stores, there was a chance encounter with a bread deliverer. Already it was apparent that there was much overlap between the brands of breads, or company trademarks, that were available at all the inventoried grocery chains. Thus, much valuable information was obtained from this 20-year veteran. Another grocery manager validated the origination information.

Origin information for meat was also obtained by informal interviews with employees in the meat departments. However, some available information was just about the company that processes the beef, not the specific processing location. Thus, an assumption was made that the beef was processed at the closest facility to the distribution center that delivered food products to the given store. A map of the number of feedlots by county does validate the assumption and will be discussed in more depth in the findings section.

Comparing Food-Miles

In order to compare food-miles, products are differentiated into separate categories. The categories include: conventional, non-local organic and other-alternative. As a reminder, each category differs in characteristics from how the food arrives at the market, to the scale of and type of production (see table 2 in background section).

Initially the intent was to use the weighted average source distance (WASD) to calculate the food-miles of the products (Carlsson-Kanyama 1997). The WASD essentially is a formula used to calculate the movement of different weights and distances of a product or products to a single place—ending with a weighted average distance that the product(s) traveled.

$$\text{WASD} = \frac{\sum d_p(w_p)}{\sum w_p}$$

Where:

p = The product

d = The distance traveled

w = Weight of the product

However, to calculate that, the total weight delivered for a specified time, or the monetary value of the total purchased during a specified time needed to be obtained. All stores, except for one, were not willing to reveal this information. This again is due to confidentiality. During an interview with one grocery manager, the reason why this information could not be released was explained. The inability to obtain information on total weight was based on an assumption that a person could calculate a store's market share with that number. Thus, the WASD was not used for any of the products except for apples, in which case one store was willing to compile the needed information.

For the remaining food items, the food-miles represented by the products in this study are the literal miles that the products travel for one trip from the point of processing to the Missoula store. The distance between locations was calculated using MapquestTM. Thus, the mileage represents the amount of miles traveled on major highways from the processor to retailer. To determine how many food-miles a specific food item represents in each of the three categories, the distances each brand traveled is averaged together in order to present the average food-miles for one trip for each food item and category. It is

important to note that the products represent only a small portion of the volume that is being transported on the trucks. However, that mileage is still traveled in order to bring food into Missoula.

It should be emphasized that the food-miles derived for this study are not calculated for the complete length of the food supply chain covering the entire life cycle from farm to landfill. Instead, they cover a segment of the food chain from the processing plants to Missoula retailers. For conventional and non-local organic foods, the origin of food could not be traced back to farms. Due to the unavailability of farm locations for conventional and non-local organic products, there are many hidden miles not accounted for. This means that the average food-miles for conventional and non-local organic foods are low. For other-alternative foods, on the other hand, information about farm origins is available. However, in order to make information for the three food categories comparable, the segment from the farms to processors is omitted for other-alternative foods. Those distances would have added very few food-miles.

Calculating Carbon Dioxide Emissions

To determine the external costs related to travel, carbon dioxide emissions are estimated in order to compare the levels of pollution between the categories. The average food-miles traveled for one trip are used to estimate the CO₂ emissions for each food item and market category. The type of vehicle used for transport plays a large role in the amount of emissions that are produced. This stems from differences in vehicles efficiency related to miles per gallon. A 53-foot semi-tractor trailer is the traditional type and length of truck used by large distributors—as was verified during several of the informal interviews. A light goods truck, or a box truck, is typically used for smaller

loads that generally do not travel as far. The average gas mileage for these vehicles were obtained from informal interviews and supported by data from the U.S. Department of Energy (2004)² (See Table 5).

Table 5: Types of Vehicles Used by Product

Products	Type of Vehicle Used					
	Ship	Semi tractor trailer (MPG:6)	Semi tractor trailer (MPG:6)	Light goods truck (MPG:10)	Light goods truck (MPG:10)	
Conventional milk		Processor→	→→	Local distributor	→→	Retail
Conventional bread		Processor→	→→	Local distributor	→→	Retail
Conventional ground beef and non-local organic milk		Processor→	Wholesaler/distributor	→→	→→	Retail
Non-local organic apples	Port→	Wholesaler→	Distributor→	→→	→→	Retail
Other-alternative apples					Producer→	Retail
Other-alternative milk, bread and ground beef					Processor→	Retail

The number of gallons of diesel used is calculated based on the food-miles and the gas mileage per vehicle. In turn, this is used to calculate the pounds of CO₂ emissions using the following equation:

$$\text{CO}_2 \text{ emissions (Pirog et al. 2001)} = 7.12 \text{ lb/gal (density of diesel)} * .874 \text{ (percentage of carbon in diesel)} * 44/12 \text{ (converting C to CO}_2\text{)} * \text{number of gallons of diesel used.}$$

It is important to note that there are many variables that will change the efficiency of a vehicle and the amount of emissions, such as speed, weight, and if the vehicle is

² The U.S. Department of Energy. Energy Information Administration since the completion of this research has submitted an updated report for 2006. The average mileage per gallon for vehicles have increased. For trucks, this increase was 1 mile per gallon. The calculations for this study used the 2002 data.

refrigerated. These calculations should not be viewed as exact amounts, but as approximations. They are conservative, low estimations used to approximately compare the carbon dioxide emissions between the three categories.

Strengths and Limitations

The methods used in this study allow for knowledge to be obtained about how far a product travels from point of processing to Missoula. While this is good information, arguably it is only a starting point in analyzing energy use in the food supply chains that serve Missoula, due to the fact that the miles are calculated from point of processing instead of the farm.

Farm production also utilizes a lot of transportation related energy. Organic farming methods have been calculated to use less energy in relation to conventional farming. However, due to the fact that little information is known about energy use in the farming practices for the non-local organic products, it is not possible to determine the miles that off set the benefits of organic production.

Based on the inventory criteria, several food items do not have a brand in all three of the categories: conventional, non-local organic and other-alternative. Organic bread was available at only one store and did not require much shelf space, thus was not recorded. All organic ground beef available fit into the other-alternative category. Due to the fact that all three categories are not represented for all of the food products, a comparison between the categories of conventional, non-local organic and other-alternative as a whole needs to be interpreted with caution. Instead, the analysis between each individual food item and their respective categories is a better indicator of the differences in food-miles and energy use.

There are also limitations to this study when comparing the fuel use and CO₂ emissions of the different foods and categories of food. Calculating the fuel usage or CO₂ emissions generated by a specific item is beyond the scope of this study (for example, the fuel use and CO₂ emissions that are attributed to just one gallon of milk). In fact, because the other-alternative food products are delivered directly and are not typically a multi-mix of different food products, as is the case for the conventional and non-local organic products, the CO₂ emissions attributed to each specific food item could be higher. However, due to the lack of transparency in the conventional and non-local organic food categories, it is difficult to calculate CO₂ for each individual food item without making numerous assumptions. In short, there are many hidden food-miles that are not apparent in conventional and non-local organic food categories. Most notably, the location and miles from the farm to the processing center are not available. Table 6 lists some of the hidden food-miles and the food categories in which they are present.

Table 6: Hidden Food-miles of the Food Supply Chains

Hidden Food-miles	Conventional foods	Non-local organic foods	Other-alternative foods
Transport of fossil fuel to refinery	X	X	X
Transport of diesel/gasoline to the market	X	X	X
Transport of pesticides and fertilizers to farm	X		
Transport required on farm for production	X	X	X
Transport of raw farm products to processor	X	X	
Unknown intermediaries from storage to processor, to wholesaler to retail	X	X	
Transport of additional ingredients to make a multi-ingredient product	X	X	X

Arguably, calculating the share of food-miles or carbon dioxide that one gallon of milk generates is over complicating the situation. This can be best described by a brief discussion of a family vacation. If a family of eight travels in one vehicle to a favorite vacation spot 1,600 miles away, one person from that family would not say they traveled only 200 miles to reach their vacation spot because they represent only 1/8th of the passengers. However, a person might claim they lowered their emissions by carpooling with the family verses driving alone. But, if one person decides to vacation alone to a spot only 100 miles away, that person may represent a higher level of CO₂ emissions compared to what each of the remaining 7 represent—even though the **total** overall emissions for that one vehicle trip of 100 miles is much lower. Imagine the reduction in CO₂ emissions if the entire family chose to carpool to that vacation spot 100 miles away.

It must be emphasized that the average values for food-miles derived here are based on a limited number of products that represent only part of their food chain. Although limited by data constraints, the strength of this study lies in looking at a specific place and in identifying and analyzing for that place important dimensions of food travel. While incomplete in capturing all miles that food travels along all segments of the food chain, the information obtained is new and available nowhere else. The findings, presented in the chapter below, further show important differences between conventional, non-local organic and other-alternative products.

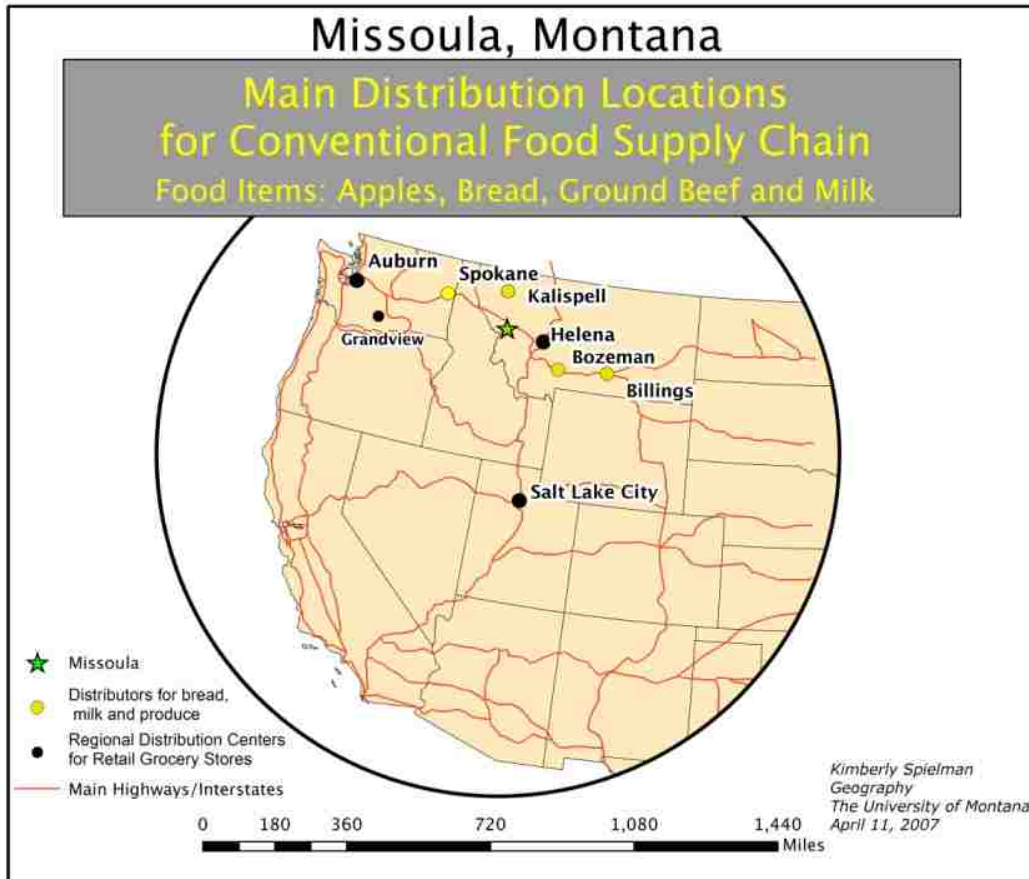
FINDINGS

Missoula's Food Supply Chains

Missoula's food supply chains for bread, ground beef, milk and apples are intricate chains that link the city to places on both sides of the Rocky Mountains and even across the Pacific Ocean. The food supply chains represented by these products are only a fraction of foods movement to, from, and within the city. However, this analysis does shed light on the complexities of food supply chains and creates awareness of where foods are processed, how far foods travel, how much fuel is used for distribution and the subsequent emissions created by the combustion of fossil fuels. This analysis further affirms—as discussed in the background section—a remarkable lack of transparency in the conventional food supply chain; a sector which is highly consolidated and produces, processes and distributes foods at large scales.

The first step in sketching out Missoula's food supply chain is to locate the main, conventional distribution centers that serve the retail grocery stores and transport the selected food items. Four main regional distribution centers deliver the majority of the conventional products to Missoula. It is important to note that all of the food products in the non-local organic category are transported from one of these regional distribution centers except for one, which is distributed through a milk processing company to only two stores. Not all of the products are transported from the distributor or wholesaler to the retailer directly. Bread and some milk products are distributed from a total of four processing locations into Missoula—many of which are delivered to an intermediary distributor within the city. This is due to Missoula's role as a distribution hub for most communities in western Montana.

A total of ten distribution locations serve the stores inventoried, five of them are located in the State of Washington, four are in Montana and one is in Utah (See Map 2).



Map 2: Distribution Locations for Conventional FSC and Non-local Organic Foods

The majority of the centers have a mountain pass along the route into Missoula: Look Out Pass and Fourth of July Pass west of Missoula, McDonald Pass to the east, and Monida Pass to the south—a clear sign that geographic restraints are a mere challenge, not a barrier. A combined total of 3036 miles for one, one-way trip into Missoula is traveled to source all four food products to the five retail grocery stores (see Table 7). Based on the average miles per gallon for 53’ semi-tractor trailer and using the carbon dioxide equation, an estimated 506 gallons of diesel is consumed and 11,546 lbs of CO₂

is emitted for one trip. This is a combined total for one trip from each of the distribution locations. To further emphasize the extent of energy use for food transport; each store receives 3-7 deliveries a week.

Table 7: Main Distribution Locations for Conventional Supply Chain and Non-local Organic Foods

Distribution Company	Location	Miles to Missoula	Product	Total Miles
Safeway	Auburn, Wash.	477	Ground beef, bread, non-local organic milk	3036
United National Foods Inc.	Auburn, Wash.	477	Non-local organic milk	
Interstate Brands	Billings, Mont.	346	Bread	
Darigold	Bozeman, Mont.	203	Milk	
Associated Foods*	Helena, Mont.	113	Ground beef	
Meadow Gold	Kalispell, Mont.	122	Milk	
Wal-mart	Grandview, Wash.	375	Ground beef, non-local organic milk	
Albertsons	Salt Lake City, Utah	525	Ground beef, non-local organic milk	
Charlie's Produce**	Spokane, Wash.	199	Apples	
Franz Bread	Spokane, Wash.	199	Bread	

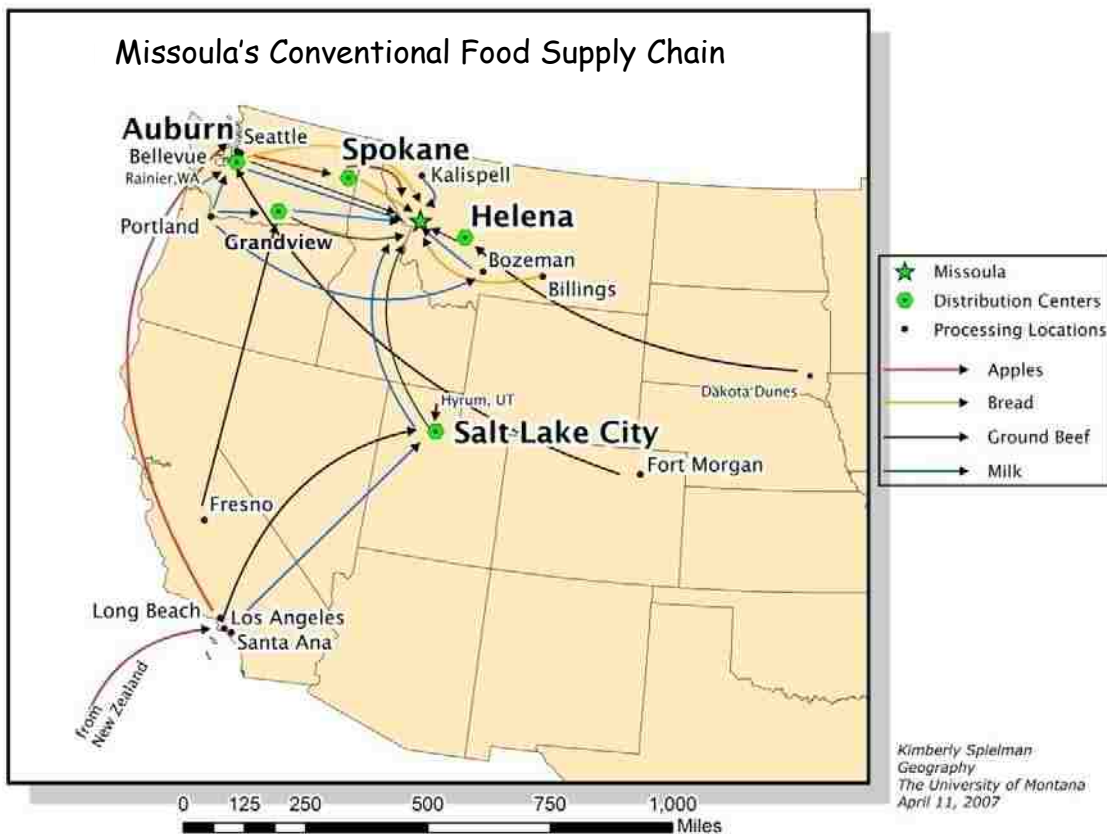
*Associated Foods' parent warehouse is located in Salt Lake City, Utah.

**Charlie's Produce's parent warehouse is located in Seattle, Washington.

The 3036 miles, however, is not an accurate picture of how far food travels. Rather, it is the link in the food supply chain that connects the last distributors to the retail grocery stores. Several distribution centers are smaller warehouses that receive deliveries from their parent warehouse before shipping the product to Missoula. It is also

important to keep in mind that the five stores are only a small percentage of stores where food can be purchased. Thus, the 506 gallons of diesel and 11,546 lbs of CO₂ is only a small portion of energy consumption and pollution created by the conventional food supply chain that serves Missoula.

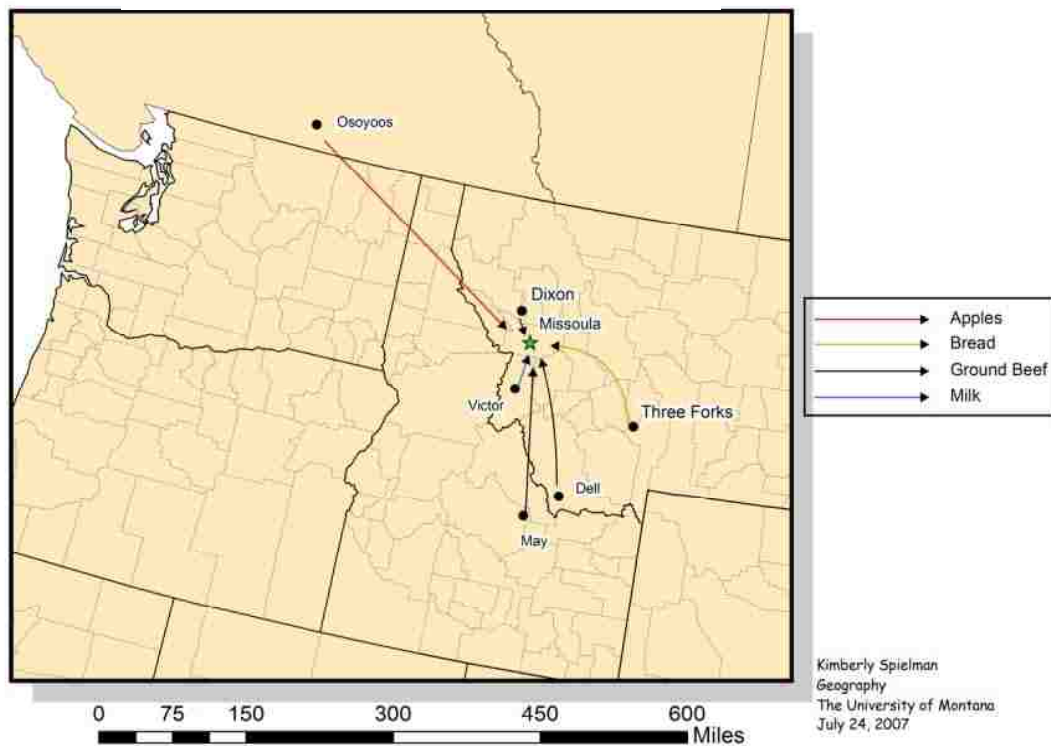
When the food supply chain from processing to distribution to Missoula for the products analyzed in this study are mapped, the picture is much more complicated. On Map 3, it is visually evident that several products actually bypass Missoula on route to a distributor before arriving to Missoula. For example, ground beef processed in Fort Morgan, Colorado travels to Auburn, Washington then to Missoula. This seems illogical if analyzed on a basis of miles traveled; however, it is the economies of scale that heavily influence this pattern.



Map 3: Missoula's Conventional Food Supply Chain

The food supply chain for the other-alternative foods looks much different (see Map 4). Only one map is needed to visualize the flow of these foods into Missoula, due to direct deliveries from either the farm or the processing locations to Missoula. Of the seven locations where the other-alternative food products originate, all but two are located in Montana. A total of 1059 miles is traveled for one, one-way trip to Missoula (see Table 8). Thus, the other-alternative products travel one-third the distance. Due to the fact that the smaller trucks used for delivery get slightly better gas mileage than the semi tractor trailers, the other-alternative products use an estimated one-fifth less fuel and emit less than one-fifth the pounds carbon dioxide when compared to the conventional food supply chain from the distribution points.

Missoula's Other -alternative Food Supply Chain



Map 4: Missoula's Other-alternative Food Supply Chain

Table 8: Distribution Locations for Other-alternative Supply Chain

Distributor	Location	Miles to Missoula	Product	Total Miles
Farmer	Osoyoos, British Columbia	386	Apples	1059
Big Sky	Dell, Mont.	212	Ground beef	
Alderspring	May, Idaho	192	Ground beef	
Garden City	Missoula, Mont.	10	Ground beef	
Montana Natural Beef	Dixon, Mont.	45	Ground beef	
Wheat Montana	Three Forks, Mont.	174	Bread	
Lifeline	Victor, Mont.	40	Milk, ground beef	

The other-alternative food item with multiple brands, ground beef, corresponds with the agriculture product with the highest sales in the state—cattle. There is a large difference in availability of these other-alternative food items. Bread is the only other-alternative item that is available at all five retail stores. Milk is available at only two of the stores: the locally owned store and the specialty health food store. Three of the beef products are available only at the specialty health food store and two are available at the locally owned store (but not always on a regular basis).

Food-miles are a useful concept to analyze how many miles of transport are required to provide food for Missoula from the distribution centers and to compare the two supply chains: conventional (which includes the non-local certified organic products) and other-alternative. However, a further analysis was done to compare the food-miles from processing to Missoula between the different food items. Due to the complexity of the food supply chains, where the items are processed, the number of brands available and how they get to Missoula, each food item is first analyzed individually. A large

portion of information is embedded in each individual product beyond the food-miles, which further enhances our understanding of Missoula’s food supply chains. Each item will be analyzed individually before comparing all four together.

Bread There is a large difference between the two represented categories for bread: other-alternative and conventional. There are organic lines of bread available. However, as mentioned in the methods section, the bread inventoried was not one hundred percent of all bread available. Instead, it targeted the items that were assumed to be quick movers due to the amount of shelf space allocated to them. The organic brands, similar to other slow moving conventional breads, did not fit into the criteria.

The conventionally sourced bread traveled almost twice as many food-miles as the other-alternative bread. The trucks that transport the conventional bread used three times more fuel and emitted three times the amount of carbon dioxide than the trucks that transported the other-alternative bread (see Table 9). If an assumption is made that these trucks are delivering comparable quantities and weights, the transportation of the other-alternative bread requires less energy.

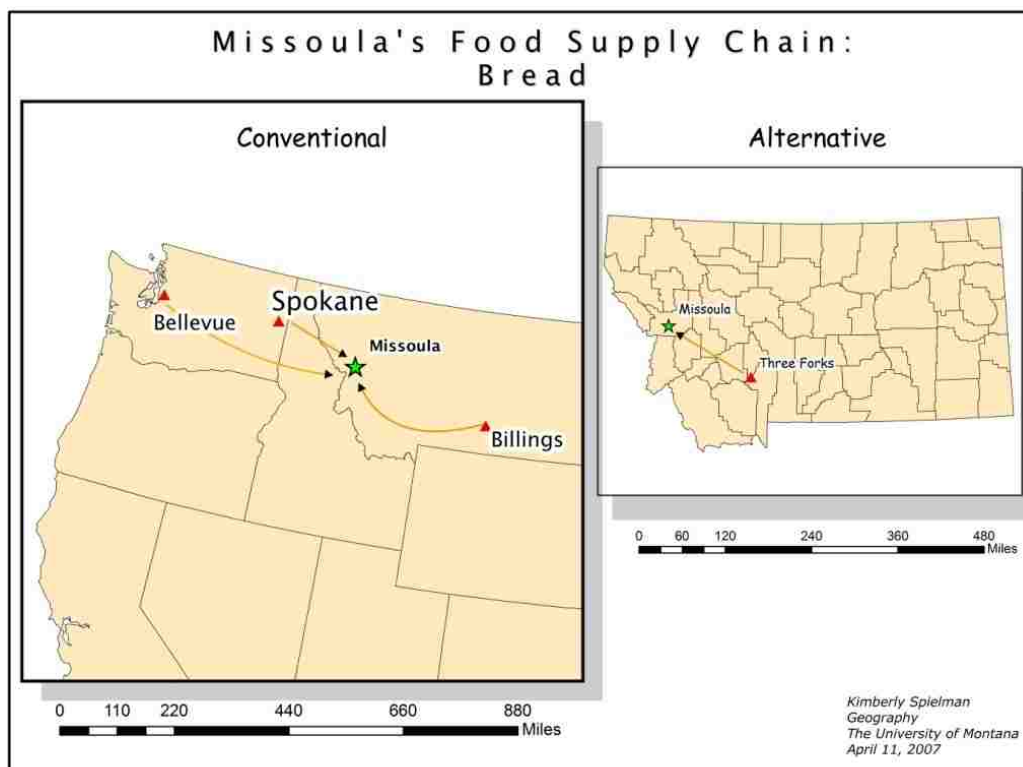
Table 9: Bread: Average Food-miles Traveled for One Trip

	Truck Type	Food-miles	Fuel Used (gallons)	CO ₂ (lbs)
Conventional	53’ Semi	344	57	1301
Other-alternative	Box truck	174	17	388

This does not, however, represent the total travel cycle of the main ingredient used to make bread (flour) or the raw commodity used to make the flour (wheat). Flour is not milled at these processing plants; instead it is shipped in along with the numerous

ingredients listed on the labels. The other-alternative bread, Wheat Montana, does mill some of the flour at the same plant where the bread is baked. Additionally, many of the farms that provide the wheat are located in close proximity to the plant, so there are fewer hidden food-miles. It is safe to assume that this is not the case for the conventional bread. Consequently, the estimated food-miles and subsequent energy calculations for conventional bread are low estimates because of the hidden miles.

Due to bread having a relatively short shelf life, even with preservatives added, the processing plants for conventional bread are located strategically in or on the outskirts of large urban areas. The processed conventional bread purchased in Missoula originates from Billings, Montana, and Bellevue or Spokane, Washington (see Map 5).



Map 5: Missoula's Food Supply Chain: Bread

Unlike the other products, data from the United States Department of Agriculture (USDA) does not supplement our knowledge of where the wheat is grown to mill the flour. Since Montana harvested the 3rd highest amount of acres of wheat in the United States at 5,235 thousand acres in 2005 and 5,215 thousand acres in 2006 (USDA National Agricultural Statistics Service 2007), an assumption could be made that the wheat used to mill the flour originated from Montana. However, Montana also ranks 4th in the amount of wheat exported (USDA Economic Research Service 2004). Consistently from the 1990s to present the United States imports close to the same amount of wheat by weight as is exported (Food and Agriculture Organization of the United Nations 2005)—consequently some of the wheat could actually originate overseas.

Also not represented by the food-miles is the fact that flour milling is a heavily concentrated business with the top four companies—Cargill, ADM, ConAgra and Cereal Food Processors—controlling 61% of the market in 1990 (Hendrickson and Heffernan 2005). Due to the pattern of continued acquisitions and mergers within the food industry (Harris 2002), this number would most likely be higher if information was available to calculate the concentration ratio today.

The processing of bread also appears to be fairly concentrated with eleven of the brands inventoried originating from only four suppliers (see Table 10). The other-alternative bread is the only one sourced directly from the processing plant to the stores. Two conventional store brands are produced on contract with a large processor (Great Value presently contracts with Franz, and Albertsons contracts with Interstate Brand).

Table 10: Brands of Bread Available

Company Name	Brands	Processing Plant Location
Franz	Franz, Snyder, Great Value,	Spokane, Wash.
Interstate Brand	Standish Farms, Wonder, Western Family, Albertsons, Country Farms, Sweatheart	Billings, Mont.
Safeway	Safeway	Bellevue, Wash.
Wheat Montana	Wheat Montana	Three Forks, Mont.

Bread is also a high volume item. The bread delivered from Spokane, for instance, comes to Missoula twice a day on a standard 53' semi tractor-trailer and is distributed to multiple stores. This is primarily due to the fact that Missoula is the main transportation hub for most of western Montana for this particular brand of bread: Franz. To further emphasize the inventory of bread required to keep the shelf stocked, much of the bread is delivered to the stores daily or every other day.

Ground Beef Unlike bread, the calculated food-miles for ground beef do give an indication of concentration levels within the beef packing industry. Meat processing and packaging is the most concentrated part of the food processing industry. Conventional ground beef travels almost 1,300 food-miles. For all conventionally sourced products inventoried in this study, ground beef ranks highest in food-miles. In addition, the four conventional brands of ground beef inventoried originate from the top six beef packers in 2006 and are owned by only three companies (see Table 11).

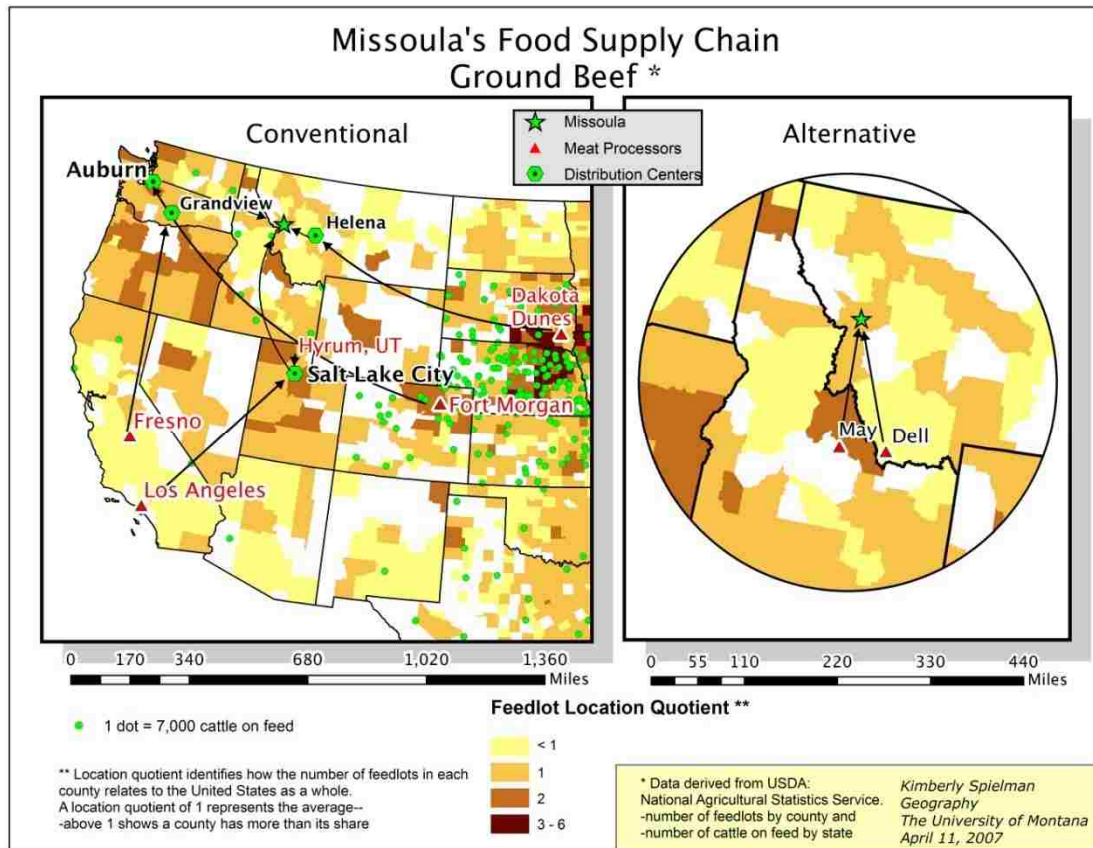
Table 11: Available Conventional Ground Beef by Top U.S. Beef Packers

Rank*	Company Name	Brand Name
2	Cargill Meat Solutions	Rancher's Reserve
2	Cargill Meat Solutions	Beef Packers
3	Swift & Company	Miller's Blue Ribbon
6	United Food Group LLC	Moran's all Natural Beef

*Rankings based on sales. Obtained from Cattle Buyers Weekly, October 2006.

The ground beef was the most difficult item of the four products to trace. Many assumptions had to be made on the source of the meat, as was explained in the methods section. The main assumption made was that the closest beef packing plant to the distribution center was where the beef was processed. For example, from the information available, Hyrum, Utah is the closest Swift & Company beef packing plant that provides the brand Miller's Blue Ribbon, which is a product of Albertsons and distributed from Salt Lake City, Utah.

USDA data supplements the understanding of where the conventional ground beef available in Missoula (and the majority of the U.S) originates. It is evident from that map that a higher concentration of feedlots and number of cattle are located within close proximity to the processing locations, except for Los Angeles (see Map 6).



Map 6: Missoula's Food Supply Chain: Ground Beef

Los Angeles is the location that was placed at the company’s headquarters, United Food Group LLC, due to unavailability of any processing location. This is also the company that produces Moran’s meat and claims to process the highest amount of burgers under one roof in the United States—thousands of pounds of this brand was recently recalled due to E’coli tainted meat. Table 12 lists the details of available ground beef for each food supply chain.

Table 12: Ground Beef Food-miles by Brand

Brand Name	Processing Plant	Distribution Point	Miles to Distribution	Miles to Missoula, Mont.	Total Miles
Rancher’s Reserve	Fort Morgan, Colo.	Auburn, Wash.	1353	477	1830
Beef Packers	Fresno, Calif.	Grandview, Wash.	832	375	1207
Moran’s*	Los Angeles, Calif.	Salt Lake City, Utah	593	694	1287
Miller’s Blue Ribbon	Hyrum, Utah	Salt Lake City, Utah	248	694	942
Miller’s Blue Ribbon	Dakota Dunes, S.Dak.	Helena, Mont.	1034	113	1147
Conventional	Products = 5			Average Miles	1283
Montana Natural Beef	Dixon, Mont.			45	45
Lifeline	Victor, Mont.			40	40
Big Sky	Dell, Mont.			212	212
Garden City	Missoula, Mont.			20	20
Alderspring Ranch	May, Idaho			192	192
Other-alternative	Products = 5			Average Miles	102

* Information on the location of the processing plants for this brand was not available; thus, the Los Angeles location was used due to it being the company’s headquarters.

While inquiring about the source of the ground beef, employees in the butcher departments even struggled with the origin question and had to search their storage rooms to find a box or label which had the company name or location on it. This was the case for the conventional ground beef at all the stores. Although the employees work with these products on a daily basis, the source of the conventional ground beef was practically irrelevant. This could indicate that employees do not take much interest in the origin of food, possibly due to customers not asking where the meat is from. The two stores that carried a local or other-alternative brand of meat knew immediately where that ground beef came from.

Overall, the conventional ground beef traveled almost 13 times more food-miles than the other-alternative beef. The trucks that delivered the conventional ground beef used an estimated 21 more gallons of diesel and emitted 21 times more pounds of CO₂ into the air than the trucks that delivered the other-alternative ground beef (see Table 13). Again, assuming that comparable quantities and weight are delivered, the transportation of the other-alternative beef requires less energy.

Table 13: Ground Beef: Average Food-miles Traveled for One Trip

	Truck Type	Food-miles	Fuel Used (gallons)	CO ₂ (lbs)
Conventional	53' Semi	1283	214	4882
Other-alternative	Box Truck	102	10	228

Milk All of the store brand fluid milk products that fall into the conventional category are pasteurized under contracts at milk processing locations inside Montana. Consequently, the average food-miles for one trip of the conventionally sourced fluid

milk are relatively low at less than 200 miles (see Table 14). However, this is not a complete picture. The miles traveled to get the milk from the farms to the processing centers for conventional milk, as well as non-local organic milk, are hidden. Thus, the average miles for conventional and non-local organic milk are, again, a low estimate. The other-alternative milk, on the other hand, is pasteurized at a creamery near the farm.

Table 14: Milk: Average Food-miles Traveled for One Trip

	Truck Type	Food-miles	Fuel Used (gallons)	CO ₂ (lbs)
Conventional	53' Semi	154	26	593
Non-local organic	53' Semi	772	129	2941
Other-alternative	Box Truck	41	4	93

The non-local organic milk traveled the furthest, used the most fuel per truck and consequently had the highest CO₂ emissions. However, it is important to keep in mind that the non-local organic milk represents a very small percentage of the total products that would be delivered on the truck. For a small specialty store, the organic milks represented approximately 3-4% of the total weight of the load for the store.

The large amount of food-miles required to transport non-local organic milk products does create a gap between production and consumption since information on the production side is very limited. However, some information is available through the USDA and through the media. The largest organic milk cooperative is Organic Valley—a brand that was available at two of the inventoried stores. The Organic Valley website includes short biographies of a few of their family farms. Although the herd size is not apparent, the number of farms that produce this brand of organic milk for Montana is forty. The farms are located in Washington and Oregon (Organic Valley Family Farms n.d.).

Another brand that was available at two stores during the time inventories were conducted is now available at only one. This brand was pulled from the shelf due to consumer complaints about the debatable issue of “access to pastures,” (rather or not the cows actually had access to pastures, which is required under organic standards) as well as the size of the farms. Ironically, this is the one inventoried organic brand owned by a large food company: Dean Foods (also owner of Meadow Gold—one of the conventional milks in this study). Twenty percent of the company’s milk supply originates from two company-owned dairy farms (Wallace 2006). The rest are family owned farms. However, three of those farms have herd sizes greater than 1,000.

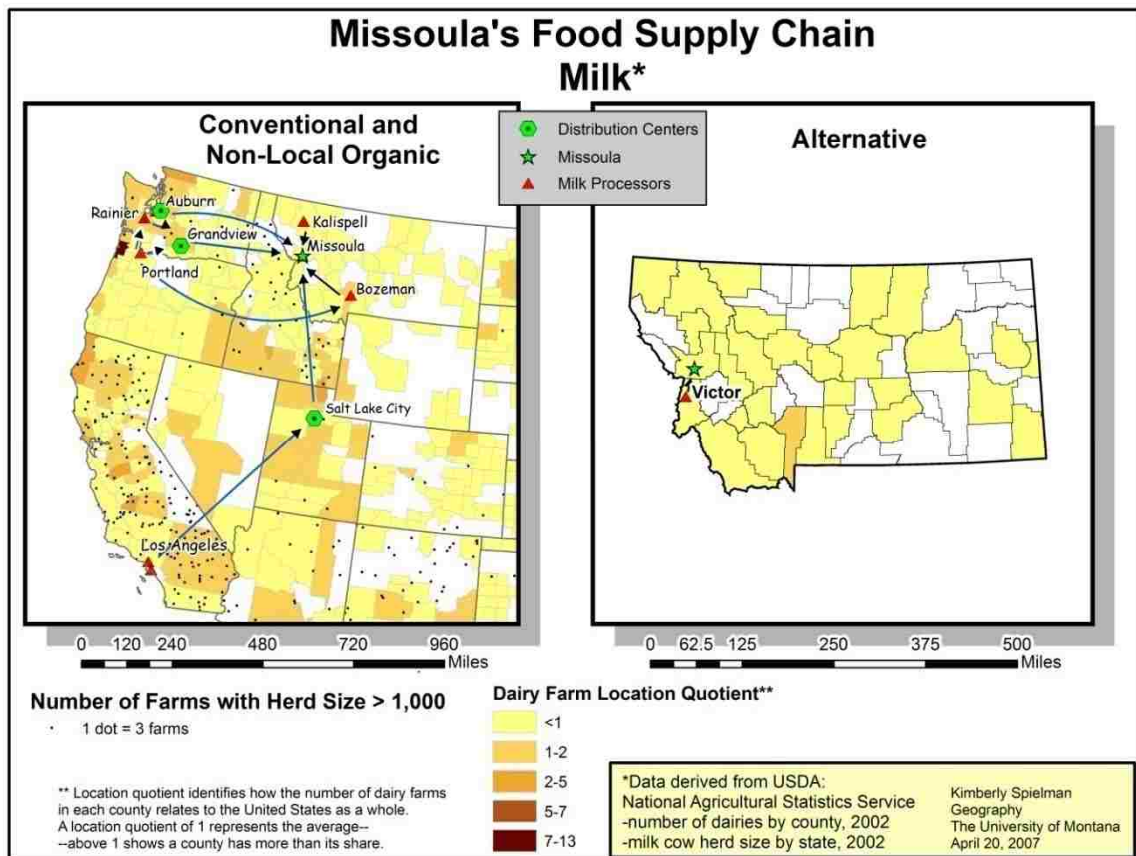
All of the conventional milk available is delivered from processors in Montana. According to the USDA, there are 624 dairy farms in Montana totaling 118,913 cattle—none of which have herd sizes over 1,000 (USDA National Agricultural Statistics Service 2002e). The two Montana processors produce six of the ten available fluid milk brands that were inventoried: two of which are store brands produced on contract (see Table 15).

Table 15: Processing Locations for Milks and Plant Identification Numbers

Brand Name and Processing Location	USDA Code	Brands Available
Country Classic Bozeman, Mont.	30-18	Dairy Gold (Gallon) Lucerne*
Meadow Gold Kalispell, Mont.	30-40	Viva Great Value Meadow Gold Western Family*
Westfarm Foods Portland, Oregon	41-34	Dairy Gold (half-gallons) Horizon
Rainer Dairy Rainer, Wash.	53-21	Organic Valley
Stremicks Santa Ana, Calif.	No identifiable code	Stremicks Heritage

*Store brands produced on contract

The price of store brands versus the brands of the processing plant can vary by more than one dollar, with the store brands such as Lucerne™ or Western Family™ being the least expensive. Both milk products, however, come from the same undifferentiated milk. One brand is actually processed in two states: the gallons are processed in Montana and the half-gallons, which are labeled rBGH free, are processed in Oregon. In the case of two stores, these half-gallons of milk actually travel from Portland, Oregon to Bozeman, Montana then back to Missoula (see Map 7).



Map 7: Missoula's Food Supply Chain: Milk

When dairy distributors were asked about backhauling (if anything was brought back after delivery to Montana) the common response was “no”. Trucks that make

deliveries to Montana typically return empty, because Montana is primarily a “consumption” state. Clearly the two conventional processing centers in Montana that serve Missoula play a very significant role and their importance should not be overlooked.

The large difference between the conventional and non-local organic milk arguably could simply be a sign of an “organic” market that has not fully reached its potential. Milk is the fastest growing part of the organic sector where demand has outpaced the supply (Dimitri and Venezia 2007). In other words, there are not enough milk processing centers which have the ability to pasteurize organic milk. There are also relatively few certified organic dairy producers.

Organic milk is primarily ultra-pasteurized, which extends the shelf life. This suggests there are two changes that could happen in the milk supply chain: increase the number of farmers and processors that raise and produce organic dairy, and possibly reduce the food-miles to match the conventionally sourced milk. The other change could potentially increase the food-miles, because continued use and increased use of the ultra-pasteurization technology could increase the distance milk travels, due to the ability to extend the shelf life by several days.

Milk is typically pasteurized by HTST (high-temp-short time) process. Ultra-pasteurization (UHT), which is typically used for cream or specialty dairy products, is becoming more popular for all milk. The difference between HTST and UHT is the heat and amount of time milk is pasteurized. Ultra-pasteurization significantly extends the shelf life, which would allow companies more leeway in the amount of time needed to

get milk to the market. In other words, the market for one processing center greatly increases as the ability to ship milk further also increases.

The role of new technologies in the market size of the “milkshed” has historically played a significant role. With the introduction to new technologies such as electric refrigeration, in addition to cheap transportation costs, three large dairies during the 1930s were able to capture the economies of scale and expand their market. “During this period (1920s-1930s) improved transportation and the invention of the electrical refrigeration meant that the “milkshed” for a dairy plant could expand” (Baker 1992:1087). These three dairies included Beatrice (now Dean Foods), Borden and National Dairy (now Kraft). The question is will this pattern of new technologies continue to benefit only a few players?

Apples The data on apples used in this study came from only one store. However, it is the most detailed data that was obtained due to information on weights being made available. Accordingly, the food-miles calculation for apples is based off the WASD equation. The calculation is a more accurate computation of fuel usage and pollution created by the transport due to the weighted average equation. However, all of the apples inventoried and available from the store are certified organic. The data shows that apples travel further than all the products due to seasonality, which creates a necessity to source from overseas in order to provide year round access.

The category of non-local organic apples logged the highest food-miles because certain varieties, the majority of which are fuji apples, are grown in New Zealand and then shipped into the port in Long Beach, California. At that point, they are transported by truck to a produce wholesaler in Washington, who in turn delivers to Missoula. Aside

from the New Zealand apples, the majority of the certified organic apples were grown in the Wenatchee Valley of Washington—according to the produce distributor. For this distributor, these apples are shipped to their parent company in Seattle, Washington before moving to Spokane, Washington and finally to Missoula.

The other-alternative apples did not include any locally grown apples. These apples were actually grown in British Columbia, Canada. However, the farmer transported them directly from his biodynamic farm to the Missoula retail store.³ The reason locally grown apples were not included is related to the summer weather in 2006. During the beginning of the summer in 2006 when insects typically pollinate the fruit trees, the temperatures became unseasonably warm. Due to this, the pollination of many of the trees did not happen and there were fewer apples available in the local area. In fact, predicting the amount of local apples that will be available in any given year is very difficult. Apple availability is a “feast or famine” situation. All growers in the area either have a lot of apples, or all growers have very little. However, had they been available, the majority would have originated from the Bitterroot Valley and traveled approximately fifty miles or less.

The data for apples show seasonal variability. Due to apples not being ready in Canada in September, there were no other-alternative apples delivered this month. November appears to be the peak month for other-alternative apples. During November, the other-alternative apples counted for 48% of the total apples delivered that month, but only 5.6% of the food-miles (see Figure 4).

³ The apple farmer is also the brother of the farmer who raises dairy cattle and processes the local-organic milk.

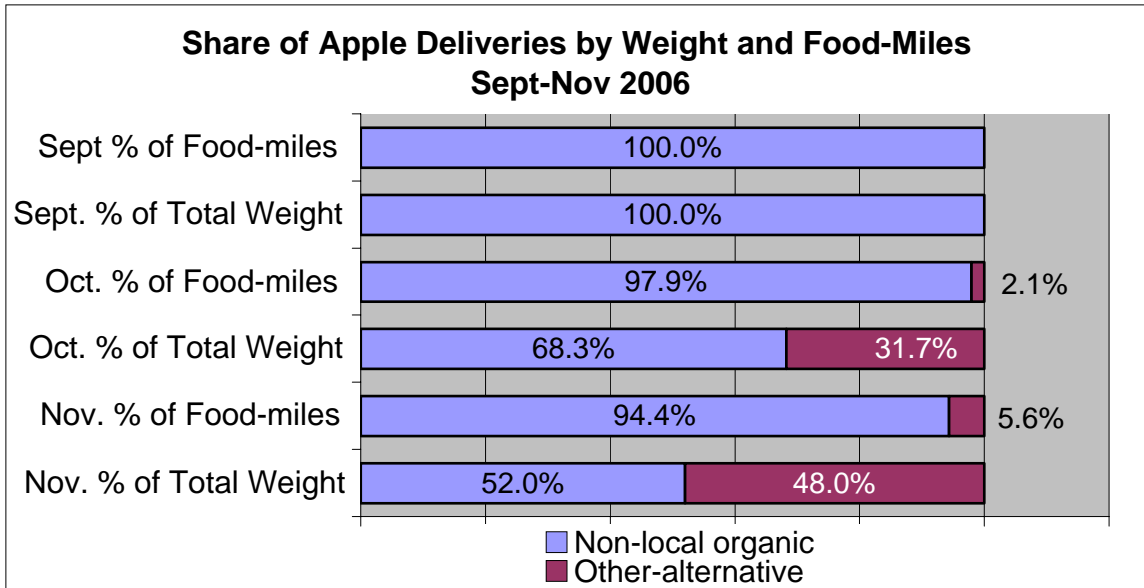


Figure 4: Share of Apple Deliveries by Weight and Food-miles

Although the other-alternative apples accounted for 30% of the total weight delivered during the months of September through November, they represented only 3% of the total food-miles (see Figure 5 and 6). The difference in the percentage of weight delivered and food-miles is due to the fact that the other-alternative apples were delivered less frequently than the non-local organic apples.

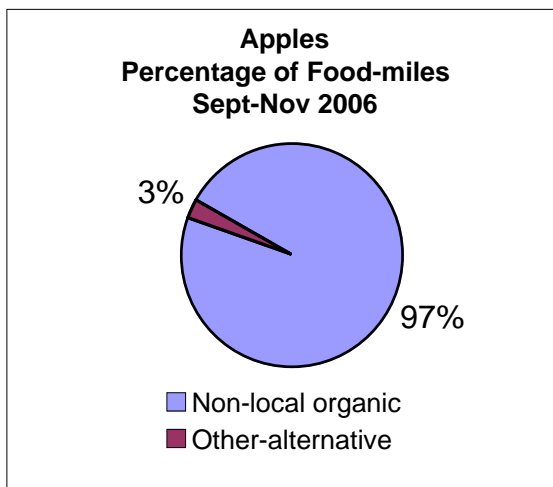


Figure 6: Apples: Share of total Food-miles

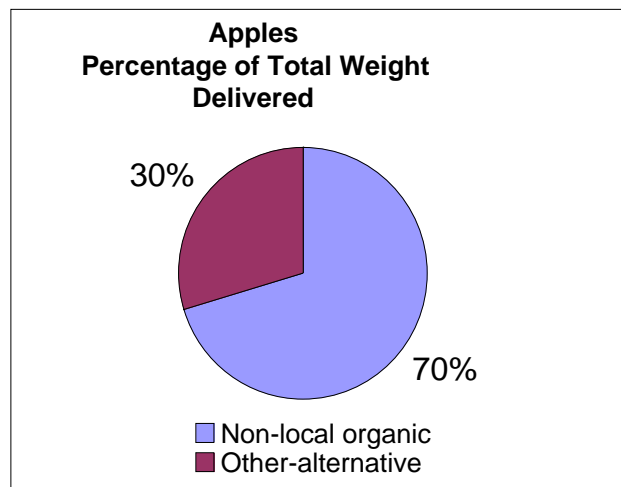


Figure 5: Apples: Share of Total Weight

Using the weighted average source distance, the other-alternative apples traveled a total of 2,316 food-miles during those months, while the non-local organic apples traveled 79,672 food-miles. The trucks delivering non-local organic used an astounding fifty-eight times more gallons of diesel and emitted fifty-eight times more pounds of carbon dioxide. Admittedly, the trucks that deliver the non-local organic apples from produce suppliers in Washington are carrying many other types of produce items. However, one can safely conclude that the hauling of other-alternative apples consumes considerably less fuel and produces much lower emissions than shipment of non-local organic apples.

Food Items Compared

The beginning of this findings section compared food-miles traveled from the distribution points to Missoula for conventionally sourced (which included non-local organic) and other-alternatively source foods. A more comprehensive analysis was done to compare food-miles from the processing locations to Missoula, as was seen for each individual food product. However, the question still remains: which category: conventional, non-local organic or other-alternative travels the furthest?

The conventional chain is an elaborated food distribution system, which involves food products changing hands many times. There is a large difference in the food-miles from processing to Missoula versus the food-miles from just distribution to Missoula for the conventional category, as well as non-local organic. However, this is not the case for the food-miles of the other-alternative products. Table 16 shows the calculated food-miles broken down by food item and category. As expected, the product that represented

the highest average food-miles traveled for one trip was the one product on the list that is sourced globally on regular basis: apples (See Table 16).

Table 16: Food-miles for Selected Products

	Apple	Bread	Ground Beef	Milk
Conventional	—	344	1283	198
Non-local organic	2845*	—	—	901
Other - alternative	386*	174	138	40

* In order to compare all products, average food-miles traveled are used. This is different from the weighted average source distance (WASD) miles, which could only be derived for apples as discussed in the section above.

Apples show the greatest amount of food-miles for the two categories: non-local organic and other-alternative. Although, there were no conventional apples in this research, undoubtedly this category would have also had the highest food-miles, due to the necessity to obtain apples on the global market while they are not in season in the United States. Other countries exporting conventional apples to this market are: Argentina, Canada, Chile, China, Mexico and Japan (Food and Agriculture Organization of the United Nations 2005).

Given the high food-miles for apples, transporting them uses the most fuel and emits the most CO₂ (see Table 17). This is not only because some of the apples' origins are in another country, but also due to the fact that thousands of miles of travel, via semi-tractor trailer, are required to transport the global apples from the port in California to the wholesaler in Washington. This indicates that one of the best ways to reduce food-miles is to eat produce that is in season and local.

Table 17: Energy Use of Food Items Compared

		Conventional	Non-local organic	Other- alternative
Apples	Fuel	—	474	39
	CO ₂	—	10,807	889
Bread	Fuel	57	—	17
	CO ₂	1,301	—	388
Ground Beef	Fuel	214	—	10
	CO ₂	4,482	—	228
Milk	Fuel	39	193	4
	CO ₂	889	4,400	91
Total	Fuel	310	667	70
	CO ₂	6,672	15,207	1,596

While this study shows that the non-local organic products logged the highest food-miles, it is not a suitable comparison of the energy use in the form of fuel use and carbon dioxide emissions. Typically, the method of farming organically uses less energy and creates less pollution than a conventional farm that relies on many external and synthetic inputs. This study was not designed to account for that (primarily due to lack of information) nor can one deduce from this study at what point the amount of food-miles out weighs the benefits of organic farming. Companies that market certified organic products have used the conventional distribution system that is already in place in order to get the certified organic products to the market.

Overall, the other-alternative food items proved to travel the least amount of food-miles, use the least amount of fuel and emit the least amount of carbon dioxide. However, the volume of food that is transported via the conventional distribution system and the other-alternative chain is important. The ground beef and non-local organic milk are transported on trucks that carry a lot of other products (but again, the origin and the

distance these other products travel is unknown). Similarly, the regional produce delivery company transports many different types of produce as well as the apples. Although the companies distributing these goods attempt to transport at full capacity, the volumes of food that retail grocery stores order is beyond their control, thus many times the trucks are not loaded fully and many return empty. Transporting food in trucks that are not completely loaded as well as returning empty is a reality for all three of the food categories; however because the other-alternative foods travel the least amount of mileage, the overall impact is decreased. From the perspective of this study, the other-alternative products are more environmentally benign.

Many challenges arise with marketing other-alternative or locally produced food items. Grocery stores have utilized the convenience of ordering from only a handful of companies to get their goods several times a week: the regional company that supplies primarily the highly processed foods such as macaroni and cheese, microwavable meals and coffee; a dairy company supplying milk, a bread company supplying the bread, and a produce company supplying all the needed produce. These companies have the ability to distribute all the necessary food items, due to the large-scale processing and warehousing of products. Many more phone calls, paper work to track orders and labor, is required to get local food items into the stores in the volumes that are required and expected by customers. Hats off to the stores that have already taken those steps.

CONCLUSION

*Let us swear an oath, and keep it with an equal mind,
In the hollow Lotus land and live and lie reclined
On the Hills like Gods together, careless of mankind.*
Alfred, Lord Tennyson
The Lotus-Eaters

Our fast paced society has the tendency to disconnect citizens from the land and the understanding of how food is grown or raised and even where it comes from (Kneen 1993, Harvey 1990). It is simple to drive to the grocery store and buy already prepared meals that just need to be reheated or to purchase already butchered and packaged tenderloins that came from unknown locations. This convenience has mesmerized us in a similar way that the lotus hypnotized Odysseus' men. Once Odysseus' men ate the lotus, they soon forgot their mission to get home, succumbed to happy indolence and never left the island.

The convenience and low prices of food in the conventional food supply chain has masked the amount of energy required to get food to the table. By deriving food-miles for selected products, some of the external costs become more apparent. Additionally, through the research in obtaining information to calculate food-miles, stark realities of the conventional food supply chain become apparent: lack of transparency, lack of knowledge and a general pattern of concentration.

The complicated conventional food supply chain makes information difficult to obtain. Information such as the origination of food and the quantity of food being delivered is either unknown or not available. The lack of transparency hides many of the energy costs and continues to create a separation between production and consumption. This disconnection between production and consumption was further reinforced when a

startling lack of knowledge about conventional products and even the location of distribution centers became very apparent while conducting informal interviews. On the other hand, knowledge and information about other-alternative foods was much more accessible.

The accessibility to information on the conventional food supply chain is in part due to the levels of concentration and business consolidation. The levels of concentration seen in the conventional food supply chain industry limits many people from being involved in producing, processing, marketing and in general making decisions about the safety of our food. The continued shift towards increasingly expensive technologies geared towards large-scale, centralized production and processing also limits market entry and access for many who would wish to be involved, but may not have the means to obtain the finances that are required.

Food-miles are a good indication of the concentration level in the industry, as was evident by the ground beef—which traveled the most food-miles of all the conventional products of this study. If food-miles could be calculated from the wheat field—or even the storage elevator to the flourmill to the bakery, food-miles most likely for bread would also indicate a pattern of concentration. The conventional product that traveled the least amount of food-miles was milk. However, all the conventional milk sold in Missoula originate from only two processing facilities in Montana.

Non-local organic products proved to travel the furthest for the food items that had a non-local organic option available. However, it is unclear if that distance offsets the benefits or energy savings of farming organically. Non-local organic foods have utilized the conventional system's already established distribution networks. This has

aided in increasing the availability of these certified-organic foods in the market, but has also increased the amount of miles the products travel. Additionally, the amount of available information on the certified, non-local organic products is limited and again the link between production and consumption is masked.

Other-alternative foods, primarily locally based and purchased via direct sales, traveled the least amount of food-miles, even when compared with the conventional system and its numerous hidden miles that are not accounted for. Other-alternative foods also used less fuel and emitted the least amount of carbon dioxide. Information on these foods is more readily available with opportunities for direct contact with farmers, if one chooses. This creates a much stronger link between production and consumption. However, at this time, the supply of these products would not meet the consumption demand of the Missoula area. Indeed, there is a necessity for both types of food supply chains at this point. However, an increase in local alternative foods could decrease some of the reliance on external sources, and thus create a less vulnerable food chain.

Transparency in the conventional food system is lacking, which makes a study of food-miles very difficult to conduct. Consequently, food-miles do not link production to consumption in the conventional categories or even for the non-local organic products. Instead, the study further emphasizes how non-transparent and complicated the food supply chain is in terms of the origination of food, the destination of food and the quantity of food being delivered.

The conventional market has been able, in a sense, to speed up time. Food products from overseas make it to the grocers' shelves in a matter of hours if flown in or days if shipped across the seas. Similarly, less time is spent preparing and consuming

foods, due to the convenient highly processed foods that are available. However, an enormous amount of time is spent on things not related to feeding ourselves. Ironically, this time spent is time used to make money to purchase the convenient foods we chose—the stories of which we know little about beyond the wording on the package.

The story of Missoula's food supply chains told by the food-miles for the four selected products is incomplete. Part of the untold story of the conventional meat includes feedlots in the Great Plains (primarily Kansas, Colorado and Texas) that are packed with 10,000 or more cattle and the beef packing plants that have required an enormous amount of outside, underpaid labor. The social dynamics of these areas have changed greatly due to immigrants moving in to work in the beef industry. There are also environmental implications associated with the amount of waste created by that many cattle concentrated in one area. This is only part of the untold story of the available conventional beef.

Wheat that is used for flour and subsequently bread also has missing components not told by food-miles. The story not told here is the farmer who planted 1,400 acres of wheat. Due to a late frost, the wheat ended up being devastated and yielded only five to six bushels per acre, one tenth of what it should. The cost of fuel to cut the wheat would exceed, by a large amount, the market value of the wheat. Thus, the farmer is now faced with serious financial choices of how to cover those losses: two of the choices being to sell land or to acquire more loans.

A farm crisis continues in the dairy sector as the number of Washington dairy farmers decrease due to the rising input costs of feed that are forcing them to sell out. The high costs of feed are attributed to the rise in corn costs due to increased demand for

corn to make ethanol. Essentially, the cost to produce milk, again, has exceeded the market price for milk (Wihelm 2007). Virtually nothing is known about the apple orchards where Missoula's conventional apples originate from, but much debate has surfaced over immigrant labor and the conditions where workers are "harvesting poison" (Clarren 2003).

An even larger, untold story concerns the fossil fuels required to continue moving food products around the United States as well as the world and how long the oil supplies will last. As fuel costs continue to rise, so will the costs of food. Places that are reliant on external sources of food and have little to no foundation set up for access to local foods, become increasingly vulnerable. Meeting consumption requirements and providing affordable access to food for all will become increasingly difficult.

As farmers' markets and direct sales of agricultural products to restaurants, schools, cafeterias and grocery stores continue to grow, the link between production and consumption continues to be abridged. Each food item is accompanied by a story not told on the packaging, but communicated through a network of people. This agriculture network is set up to provide healthy foods that are beneficial for people as well as the environment. The link between production and consumption can be apparent as more people become involved and inquisitive about where their food is coming from and make choices about food beyond reading the labels.

"We can hardly choose **not** to eat, but we have to chose **how**, and our choices can have astounding consequences" (Kingsolver 2002). The consequences span the social and environmental spectrum. Social costs include the rising cost of food, disconnection from the knowledge of food production, preservation and preparation, as well as the

struggles faced in rural agricultural based economies. Environmental costs associated with long supply lines include carbon dioxide emissions. In all reality, carbon dioxide is most likely being emitted in far larger quantities from our food system than we want to admit or even calculate.

Food-miles are a good concept to start with in order to gain an understanding of a particular place's food supply chain(s). However food-miles are just the cliff notes to understanding and calculating energy use required to move food from field to the plate. To advance beyond the cliff notes to a complete story of energy use; food-miles should begin with the fuel use and inputs required to raise or produce a product on the farm. This approach would allow a more comprehensive comparison between non-local organic, other-alternative foods and conventional foods. Furthermore, an understanding of where the "open-spaces" are for reducing our energy consumption can become even more apparent.

The general quest of learning about agricultural food chains allows for an additional conclusion: the two distinct chains are both necessary at this point to provide food and meet the consumption requirements of a community. While each chain has weaknesses, one cannot rise above the other because each is a safety net of the other. As long as other-alternative chains fall short of reaching the consumption needs of the community, the conventional food supply chain remains the safety net. On the other hand, if and when there becomes a fuel and food economic crisis, the other-alternative food chain will become the safety net for the communities that have committed to producing and consuming other-alternative, local foods.

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