MEASURING AND UNDERSTANDING LOCAL FOODS: THE CASE OF VERMONT

A Thesis Presented

by

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to

The Faculty of the Graduate College

of

The University of Vermont

In Partial Fulfillment of the Requirements
for the Degree of Master of Science
Specializing in Community Development and Applied Economics

May, 2006

Accepted by the Faculty of the Graduate College, The University of Vermont, in partial fulfillment of the requirements for the degree of Master of Science, specializing in Community Development and Applied Economics.

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Abstract

Across the United States there is increasing interest in local foods, as seen in the renaissance of farmers' markets and other forms of direct sales from farmers to consumers. Nationally, direct sales increased from $517 million annually in 1992 to $812 million in 2002 (in constant 2002 dollars), an increase of more than 50%. Also, hundreds of initiatives and projects have been implemented around the country to promote local food. In the northeast, every state department of agriculture has implemented some kind of buy-local initiative. Such efforts would benefit from more and better data about local food, since evaluating and assessing the efficacy of local food programs depends on such data. Yet local food data are not readily available, and there is no systematic way of tracking local food use at regional, state or community levels.

The major objective of this thesis research is to develop tools to quantify local food use in the United States. The thesis first presents an overall introduction of local food issues and a general review of previous studies on local food, then presents two articles, one on measuring local food, and a second on understanding direct food sales. The thesis concludes with a summary and recommendations for future research.

Vermont has been a leading state in promoting local foods. This thesis reviews Vermont's local food efforts, identifying major factors associated with the local food movement. It also reviews previous Vermont local food studies for clues about the state's production potential, and looks to agricultural location theory and consumer research on local food for explanations about why food might be local in Vermont (or anywhere).

The first article reviews previous methods used in measuring food self-sufficiency and local food and presents a method for estimating local food consumption, comparing results from Vermont with those from the other 49 states. An upper bound on Vermont local food consumption is 38%, based on in-state production, and a lower bound is 1.2%, based on per-capita direct sales from farmers to consumers. While the range is broad, both bounds provide useful indicators for monitoring changes in local food use.

In the second article, regression models are developed to help understand how direct sales vary at the state and county levels around the country. Four variables that significantly correlate to direct sales are identified: average farm size, population density, geographical region of the country, and available farmland. On a per capita basis, Vermont has the highest direct sales in the United States, at more than five times the national average. But regression results can be used to assess potential for further growth, and suggest that Vermont direct sales could still be increased substantially.

If promoting local food is a policy goal, efforts to quantify the extent and impact of local food are needed, as is greater understanding about local food potential in different geographic areas. This thesis research begins to fill such gaps in knowledge about local food, which has been increasingly promoted, though little understood.

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1. Introduction

Food is life. We are, literally, what we eat. It is thus understandable if many of us take more than a passing interest in our food: where it comes from, what is in it, and the prospects for its continued provision. This study focuses on local food in Vermont, a place that like many, once supplied most of its own food, but now does not. And like most Americans, Vermonters do not know how much of their food is produced in the state, because this information is not readily available. That is the main subject of this inquiry. As Hinrichs (2003) noted in Iowa, people have a "sense of disjuncture living in a major agricultural state that imports most of the food it consumes."

A local foods movement is growing in Vermont and around the US, driven by at least four groups of factors:

1) Preference for fresher and more nutritious foods: industrially grown food varieties may be selected more for convenience of picking, packing, and shipping than for taste, as is easily ascertained by comparing an industrial tomato to one grown at home. Foods are usually highest in nutrients at the time of harvest, and nutritional quality deteriorates over time. Foods grown closer to points of consumption are potentially fresher and more nutritious.

2) Support for local economies and local farmers: Shuman (1998) encourages communities to reclaim control of their economic destinies with local investments, including supporting local food growers. Hoffer's (2000) report on Vermont's import dependence calculates that substituting Vermont food for 10% of food imported into the state would create $376 million in output and 3,616 jobs in the state.

3) Desire for better food security: in the wake of 9/11, this can mean concern with vulnerability of the food supply to disruption or contamination. Food security can also be a measure of the extent to which all members of society have access to food. Note that both of these definitions of food security are used by different authors, and that they have rather different policy implications.

4) Concern about environmental effects of food transportation: most US food travels many miles between producers and consumers. For example, Pirog (2001) calculated the weighted average source distance for typical U.S. produce to be 1,494 miles. Food transportation in the U.S. food system consumes 63% of the energy of food growing (Heller and Keoleian, 2000), and is likely the single easiest food-system target for reducing energy consumption and CO_2 emissions.

While environmental impacts of food transportation may not be consumers' main reason to choose local foods (as discussed below), transportation reduction is the least disputable rationale for relocalization of the food system, since sourcing food closer to consumption points would unambiguously result in less transportation. While all of the other reasons given above for local food have adherents, all have detractors as well (some economists, for example, would dispute the support-the-local-economy rationale, arguing that economic specialization is more beneficial than investing resources in enterprises like food production that may be better suited to other regions). A focus on transportation effects also allows priorities to be set around local production: spices, for example, are easy to transport, and historically were one of the first food items to be shipped long distances. On the opposite extreme, milk is energy intensive to transport, since it is both heavy and needs refrigeration. Milk would be a higher priority than spices for local or regional production, based on transportation energy required.

Though motivations vary, many signs point to a growing local food movement. Koc and Dahlberg (1999) describe farmers' markets, community-supported agriculture (CSA), local food policy councils and coalitions, community gardening, and a new emphasis on food security as signs of the change.

Local food is usually associated with small-scale distribution, countering general food-supply trends. Guptill and Wilkins (2002) observe both increased direct marketing of local food as noted above, and at the same time concentration in traditional retail food outlets, characterized by fewer, larger food retailers. These may carry a few local foods, but in general have "extended supply chains to unprecedented geographic lengths," tying consumers into a world food economy.

Vermont holds a number of examples of a nascent local food movement. As elsewhere in the US, local food in Vermont is usually associated with small-scale distribution of produce and specialty foods. Historically this took place mainly through farmstands, with farmers assuming a retailer role, selling directly to consumers. This allowed farmers to retain a larger portion of the consumers' food dollar than in the mainstream food system, and consumers to gain the benefits of local food. Thus the unfettered free market has provided some local food. But a number of other interventions are also underway, as described below.

1.1 Current Vermont Local Food Efforts

Examples of initiatives to promote local food exist at both community and statewide levels. Though most of these efforts are not new, many have experienced recent surges in growth. Together they constitute a relatively comprehensive movement towards increasing local food use.

1.11 Community and School Gardens

At the most basic level, local food means growing your own. Supporting such individual initiative is one form of the local food movement. In urban areas, this means connecting people with arable land. Burlington Area Community Gardens, run by the City's Parks and Recreation Department, provides 400 garden plots each year, at eight different sites throughout the city. Annual fees range from $16 for a 10'x 12' youth plot to $50 for a full-size 25' x 30' plot, including water (http://www.burlingtongardens.org). Plots sell out early, and there is normally a waiting list for garden space.

The National Gardening Association (also in Burlington) provides materials and small grants to encourage such community gardening efforts. As they point out, community gardening is not just about growing food, but also helping to "rebuild neighborhoods, instill community pride, build self-esteem, and rehumanize urban environments. Community gardens provide a source of food, add aesthetic value, encourage physical activity, help preserve cultural identity and, most importantly, cultivate neighborhood relationships" (http://www.garden.org).

National Gardening also actively promotes school gardening programs, providing curricula to both teach children science through gardening and instill gardening habits early in life. Many schools around Vermont and the country have such in-school gardens.

1.12 Farm-to-School Programs

A logical connection to school garden programs is getting other locally produced food on school cafeteria menus. In 2003 Burlington started a school food project (Growing Farms, Growing Minds) with three major goals: increasing schoolchildren's awareness of local and healthy foods through an education program, increasing school access to and use of healthy locally produced foods, and building capacity to meet food needs of low-income Burlington students (Croom, et al., 2004). The project included a plethora of designed activities and later spin offs. One such spin off was the Carrot Muffin project, designed to produce a tyke-palatable food made with local ingredients. The U.S. Department of Agriculture (USDA) funded Growing Farms, Growing Minds, which was a collaboration of a number of food and education-related organizations around the city and the state.

Similar programs are underway at about ten schools around the state, and at some colleges. Middlebury College's green dining project, for example, has gained national attention for its efforts to source local foods for its institutional food program. Institutional purchases from other large buyers like prisons, hospitals, and nursing homes can also be encouraged, especially when public expenditures are involved.

1.13 Farm-to-Restaurant Programs

The Vermont Fresh Network is a non-profit organization dedicated to helping local farmers, chefs, and restaurant patrons to find each other and build partnerships, since the "quality and beauty of Vermont's landscape depends upon working farms and working farmers." The Network now includes 70 member farmers and 139 member chefs (http://www.vermontfresh.net), with its distinctive logo an increasingly-common sight at Vermont restaurants, especially higher-end eateries.

The idea of a chef-farmer network is closely related to the aims of the international Slow Food Movement, which aims to put time and enjoyment back into eating through slow-dining convivia (http://www.slowfoodusa.org). Slow Food USA encourages its convivia to "invite a local farmer to come and give a talk, or arrange a visit to a farm or orchard. Ask someone's grandmother to show how she makes hominy grits, orange marmalade, or tamales." The organization ties food enjoyment directly to experiencing the authentic, distinctive tastes of one's locale.

1.14 Farmers' Markets and Community Supported Agriculture

Direct sales of food from farms to consumers are increasing in Vermont—from $6.8 million in 1997 to $9.6 million in 2002, a 26% real (after inflation) increase (US Department of Agriculture, 2004). Roadside stands are the traditional direct-sale method, but community supported agriculture (CSA) and farmers' markets are increasingly common.

CSA is a form of food-subscription service, where members pay an annual, up-front fee to join, in exchange for weekly pickups or deliveries of fresh foods throughout the growing season, and sometimes after the season from stored crops. The CSA model provides a way to capitalize farm operations, spread some of the inherent risk of farmers to members, and tie members more directly to the land where their food is produced. The farm tie is especially strong when consumers go to the farm to pick up food. A 1996 study found that CSA consumers perceived taking the time to pick up food on the farm as an added benefit (not a cost) of belonging to a CSA (Pelch, 1996).

The Northeast Organic Farming Association of Vermont (NOFA) lists 40 Vermont CSAs and 52 Vermont farmers' markets on their website (http://www.nofavt.org). Beyond representing new outlets for local food, farmers' markets and CSA also represent ways in which local communities organize themselves to distribute local food, and make social connections that go beyond food sales. The social and community-building dimensions of farmers' markets and CSA thus go further than farmstand sales. Indeed many farmers' markets seem to be as much about building social capital as anything else.

1.15 Urban Food

While the plains of Kansas may come to mind when discussing food production, much of the local food movement is actually about production in or near urban areas. Havana, Cuba is now a well-known international example of a city organizing to grow much of its own food within city limits, in Havana's case out of necessity after the Soviet collapse (Moskow, 1999). Lapping (1999) notes that in the United States, Metropolitan Statistical Areas (MSAs) contain 1/3 of all farms, and that metropolitan farms in the northeast produce more than 2/3 of all fruits and vegetables grown there.

In Burlington, the Intervale project redeveloped old farmland near the city center, with a combination of small growers, CSA farmers, community garden plots, and other farm-related commercial ventures. The Intervale Foundation estimates that 6.5% of Burlington's produce now comes from the Intervale (Ketchell, 2005). Urban agriculture is based on the notion that proximity to consumers is just as important to farmers as proximity to fields. The urban food movement is about further developing this food production capability, in part by preserving remaining tracts of agricultural land near urban areas.

1.16 Buy-Local Campaigns

A mainstay of the local food movement is marketing campaigns to persuade consumers of the value of locally grown foods. This buy-local emphasis is seen at number of levels. Nationally, the USDA maintains a direct marketing web page, with a guide to farmers' markets, and other resources to help local farmers and consumers find each other (http://www.ams.usda.gov/directmarketing).

The Vermont Agency of Agriculture challenges consumers to shift 10% of food spending to local providers, with its "Buy Local, It's Just That Simple" campaign, and a local product directory (http://www.vermontagriculture.com/buyvermont2.htm). Smaller, local non-profits also engage in buy-local campaigns. The Foodroutes Network develops and provides materials for such campaigns (http://www.foodroutes.org).

1.2 Defining Local Food

A first question in studying local food systems is to define what is meant by local food, for which there is no commonly accepted definition. In the Midwest, Pirog (2003) found that 37% of consumers surveyed considered local to mean a distance of 25 miles or less, 22% thought 100 miles or less, and 27% thought local meant produced within the state[1]. Guptill and Wilkins (2002) found that among buyers for grocery stores, most defined local as coming from the buyer's county or an adjacent county, or from a radius of 30 miles.

Vermont law requires that items claimed to be "local" originate within 30 miles of the point of sale, while the term "native" can be used to describe products originating anywhere within the state[2]. Other states have definitions that vary from Vermont's.

The question of production location becomes more complicated for prepared foods, which may come only in part from a particular area. The European Union handles this with a three-tiered system (http://www.defra.gov.uk/foodrin/foodname/infopack.pdf):

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[1] Data used are from the control group for a larger study that also gauged consumer response to different eco-labeling schemes (data used are from consumers who did not view any eco-labels).

[2] 9 V.S.A. § 245

- Protected Designation of Origin (PDO): product must be produced and processed and prepared in the designated geographical area (example: Cornish Clotted Cream). This is the strictest “local” definition.
- Protected Geographical Indication (PGI): product must be produced or processed or prepared in designated geographical area (example: Gloucestershire Cider).
- Traditional Specialty Guaranteed (TSG); name must be specific in itself or express the specific character of the foodstuff (example: traditional farm fresh turkeys).

While defining local as a radius from point of purchase is achievable in supermarkets, and may meet consumer expectations, radius definitions create problems for gathering data about local foods: in order to measure local food consumption, one would have to calculate distances from every point of production to every point of sale in the food system. Such data are not available today. For research purposes, some political boundary must define the unit of analysis. This approach does create inconsistencies around borders: in a state-level study, for example, border regions may be closer to adjacent states than to further reaches of their own states. Such problems are unfortunately unavoidable.

This study focuses primarily on Vermont food systems, and as noted above, accepts reduction of food transportation as the strongest rationale for local food. Thus this study defines Vermont local food as:

- Being grown within the state of Vermont (since having imported ingredients processed in the state is not likely to reduce transportation impacts), and
- if processed, being processed in Vermont (since exporting food for processing and then reimporting also fails to reduce transportation).

Processed foods with multiple ingredients can also be described as being a percentage local (e.g. 75% Vermont local), that percentage being calculated as:

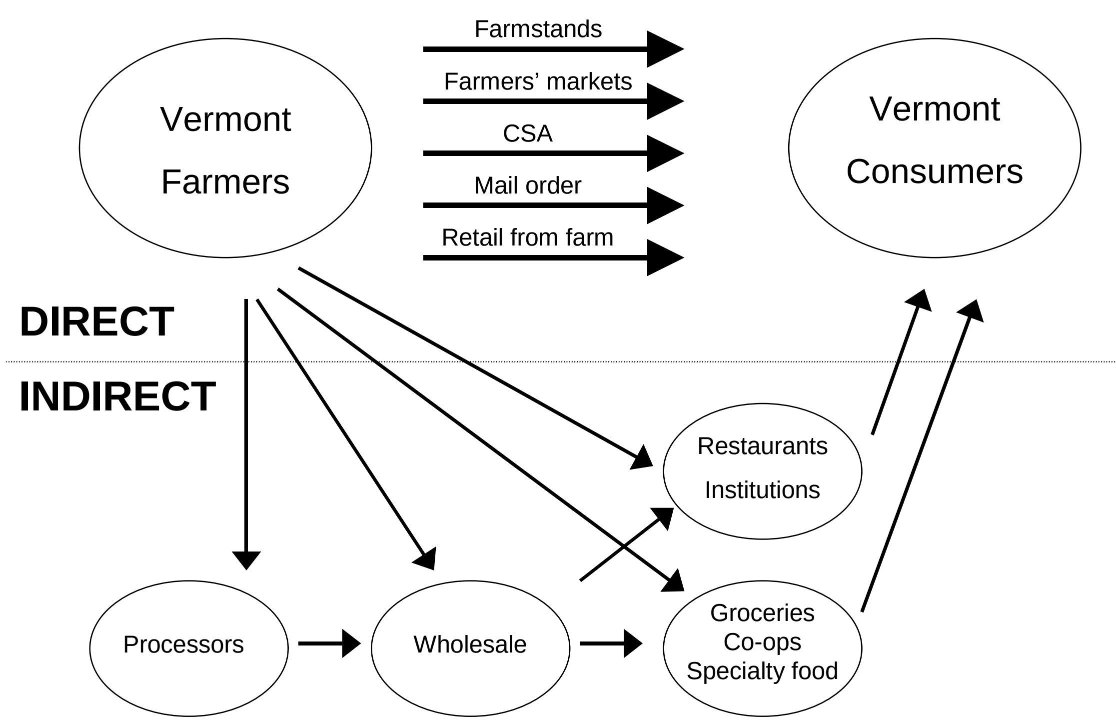
$$\frac{\text{(total weight of local ingredients – weight of water added locally)}}{\text{(total weight of product – weight of water added)}}$$

Ingredients are measured by weight, since this is the main determinant of transportation energy required. Added water weight is subtracted to exclude from the local definition products that are merely mixed locally (e.g. soda might fall under a local definition if an imported syrup was mixed with local water and the proportions calculated by weight including water).

While this study focuses on Vermont local food, the same definitions might be applied to other states or other political regions, data availability being the main constraint on studying sub-state areas. USDA production data are in fact available to the county level, but confidentiality requirements do not allow data to be disclosed when information from individual farms might be ascertained. In Vermont, for example, the agricultural census reveals that Addison County produced 153,559 bushels of corn for grain, but does not disclose how many bushels of corn for grain were grown in Windham county, since Windham did not meet the disclosure-requirement threshold for protecting confidentiality (U.S. Department of Agriculture, 2004). Thus county-level comparisons are often thwarted by non-disclosed data, a problem that is less common at the state level, where there are more producers.

Figure 1 characterizes the channels by which Vermont local food reaches consumers. Of particular interest is direct-marketed food (above the dotted line), which is expanding quickly in Vermont. On a per-capita basis, Vermont is a national leader in direct sales (US Department of Agriculture, 2004).

Figure 1. Vermont food marketing



1.3 Objectives

The overall goal of this thesis research is to develop tools to quantify local food use in the United States, and six specific objectives have been developed to attain this overall goal.

1. to review past and current interest in local foods, and theoretical reasons that food production might or might not be local.
2. to review past methods of calculating how much food in an area is locally produced.
3. to propose a method that can be used by policy makers and local food organizers to measure local food status and potential, with emphasis on low-cost and replicable measurement methods.
4. to explain how direct sales of farm products vary around the United States, and factors associated with that variation.
5. to provide benchmarks for assessing direct sales at state and county levels.
6. to derive recommendations for future local food research

1.4 Thesis Organization

This thesis is organized into five major chapters. Following this introduction, chapter 2 presents a general review of literature on Vermont local food, covers previous studies of New England food self-sufficiency, examines agricultural location theory for indications about what agriculture might be expected in an area, describes current local food research, and finally summarizes studies on consumer perceptions of local food.

Chapter 3 addresses the question of how much of Vermont's food might be local, presents detailed calculation methods and results, and compares the situation in Vermont to that in other states. Chapter 4 focuses on direct marketing of local food, using linear regression models to understand differences in direct marketing across the United States. Chapter 5 provides general conclusions and recommendations.

2. General Literature Review

"Local food" is currently the most common term used to describe the extent of a region's production of its own food. Yet much historical literature relevant to local food has fallen under somewhat different titles, e.g. "food self-sufficiency" and "agricultural location theory." This chapter reviews such material from the past, as well as more recent literature, and studies on consumer local food demand. Additional literature specific to food measurement and direct sales is reviewed in chapters 3 and 4 respectively.

2.1 Self-Sufficiency Studies

The oil embargo of 1973 and resulting spike in oil prices raised concern about the extent to which the U.S. food system relied on oil for moving food around the country. This sparked a number of studies on feasibility of state and local food self-sufficiency; much literature about what is now called "local food" dates from that time. Many authors of 70s and early 80s felt that oil depletion was a near-term certainty, and analyzed the extent to which regional self-sufficiency then existed or was possible. This work gives indications about the possible extent of a local food economy.

In Vermont, Burrill and Nolfi (1976) studied the state's potential for producing its own food, approaching the question in two different ways:

1) They reviewed the long and diverse history of Vermont agriculture, from self-sufficient homesteading in the 18th century, to commodity production for northeast population centers in the early 19th century, and the 20th century transition to dairy that still dominates Vermont agriculture. From historical production it is clear that Vermont is

physically capable of producing much of its own food. Wheat production, for example, peaked in 1850 at 536,000 bushels per year. Had Vermont raised that much wheat in 2002, and used it for flour, the state would have been 38% self-sufficient in wheat flour, instead of the 3% possible self-sufficiency provided by actual 2002 production (calculation by the author, not Burrill and Nolfi). Many other historically important crops have disappeared from or are greatly reduced in modern Vermont, including beans, oats, barley, potatoes, pork, chickens and eggs, pears, and various berry crops. Burrill and Nolfi note it "likely that present agriculture is related only slightly to physical production potential, and more related to what slice of the economic pie Vermont agriculture can carve out."

2) Burrill and Nolfi also calculated the approximate acreage needed to provide the typical 1974 diet, including primary production of feed grains and pasture needed for finished meat and dairy products. Production acres needed were based on USDA figures for Addison county, assumed to be representative of the state. Burrill and Nolfi found that producing the typical 1974 diet for the population at that time would require 478,706 acres, or 22 % of the 2,225,523 acres of Vermont "class I and class II" farmland, the land classification being from an earlier study by Sykes (1964). Burrill and Nolfi also modeled requirements for less meat-intensive diets, which require much less land.

Burrill and Nolfi's diet and production figures suggest that the 2002 population would require 646,961 acres of farmland (estimate may be high, since yields of many crops are higher than in 1974) or 29% of the farmland figure used in 1974. But even in 1974 the class I and II farmland figures from Sykes were dated, the original data having been gathered in 1935. While soil and topography are essentially static, development has removed much farmland from production since 1935. It would be more appropriate to express the 646,961 acres needed in 2002 as 91% of the 710,853 acres of total cropland, pastureland, and pastured woodland in use in 2002 (US Department of Agriculture, 2004), or as 48% the 1,342,857 acres of prime farmland and farmland of state importance identified by the Natural Resources Conservation Service (US Department of Agriculture, 2003) from its 1985 data. Based on Burrill and Nolfi's figures, it appears likely that Vermont could today produce most of its diet, but this would require most of the farmland currently in use, and self-sufficiency capability would decline with population increase and farmland loss.

Burrill and Nolfi limited their study to potential self-sufficiency in Vermont based on production capability, and did not attempt to calculate actual food local food consumed in the state at that time. Several other studies have attempted to quantify Vermont potential food self-sufficiency, and found figures ranging from 27% to 123%, depending on definitions used, assumptions made, and methodologies. These studies are described in detail below in chapter 3.

2.2 Classical Agricultural Location Theory

To ask whether food is local is first to ask whether food production is present in a given area, and why. For clues we turn to agricultural location theory.

Agriculture is everywhere subject to natural constraints. Heady (1952) identifies the main categories of production constraint as climate, soil, and biological factors (presence of absence of pests and diseases). These constraints may be common across broad regions or vary down to the farm level. Production constraints are not necessarily absolute, but may impose costs or restrict yields in ways that affect relative profitability of different crops. Based on climate, soils, and geography, a crop like wheat *can* be grown in Vermont (and was), but can be grown less expensively in Kansas. Natural constraints are the first determinant of local production and its cost.

Yet a study of production constraints alone reveals little about actual production in an area; some areas suitable for agricultural production remain unused, while elsewhere crops are grown despite marginal natural conditions. In addition to production possibilities, we must know something about location of markets.

Johann Heinrich von Thünen was an early developer of agricultural location theory, first publishing his book The Isolated State in 1826 (Hall, 1966). Thünen developed an idealized city model to analyze the role of transportation in agricultural development:

> "Imagine a very large town, at the centre of a fertile plain which is crossed by no navigable river or canal. Throughout the plain the soil is capable of cultivation and of the same fertility. Far from the town the plain turns into an uncultivated wilderness which cuts off all communication between this State and the outside world.
>
> There are no other towns on the plain. The central town must therefore supply the rural areas with all manufactured products, and in return it will obtain all its provisions from the surrounding countryside."

By analyzing a solitary city on an unbroken and uniformly fertile plain, Thünen removes from the analysis agricultural constraints as well as the possibility for food imports or exports. In this imaginary setting the role of transportation, based on distance from the city, can be isolated and studied:

> "The problem we want to solve is this: what pattern of cultivation will take shape in these conditions?; and how will the farming system of the various districts be affected by their distance from the Town? We assume throughout that farming is conducted absolutely rationally.
>
> It is on the whole obvious that near the Town will be grown those products which are heavy or bulky in relation to their value and which are consequently so expensive to transport that the remoter districts are unable to supply them. Here also we find the highly perishable products, which must be used very quickly. With increasing distance from the Town, the land will progressively be given up to products cheap to transport in relation to their value.
>
> For this reason alone, fairly sharply differentiated concentric rings or belts will form around the Town, each with its own particular staple product."

From this premise, Thünen develops production theories and formulae. These assume fixed commodity prices in the town, and farmgate values that decrease as a function of distance from town, given transportation cost. At the distance where the farmgate value of a particular commodity equals its production cost, where marginal cost equals marginal benefit, cultivation of that crop would in theory cease.

Thünen explains composition of the agricultural landscape through land rents: at every location where market price exceeds production cost, a surplus is generated. Thünen calls this surplus land rent. Rational farmers maximize land rent: closest to town, they grow crops with the highest value per acre (lowest land use) and/or most advantage from reduced transportation (highest transportation cost). Crops providing the highest rent displace all others in a given area. Adjacent to the town we should find vegetable crops, which have high yields per acre and high transport costs. Furthest out we should find products like wool, with low yields per acre and low transportation cost. Grains should occupy intermediate locations.

Thünen also allows for another possibility:

> "From ring to ring the staple product, and with it the entire farming system, will change; and in the various rings we shall find completely different farming systems."

Thus besides the crop selection changing with distance from town, Hall (1966) notes that this point about farming *systems* changing suggests different cultivation methods for the same crop in different places, of crops "produced by an intensive system in one place, and an extensive system in another." Intensive production can be profitable closer to consumers, given the savings on transportation. This point is of interest in analyzing local food systems; for example in the northeast, off-season tomatoes might be grown either intensively in greenhouses near a city, or extensively as field crops in Florida or California.

While some historical evidence suggests that land around ancient cities may have resembled Thünen's description, Hall points out that even in Thünen's time the predicted concentric rings were not often apparent. Transportation by water, and later by rail, violated the assumption of equal transportation cost from equidistant points, the assumption of uniform fertility was not the norm, and agricultural trade between cities had deep historical roots. But while Thünen's landscape description may have lacked accuracy, it served to model the role of transportation cost in the spatial organization of agriculture.

Dunn (1954) further developed and proved many of Thünen's ideas, continuing the emphasis on distance from markets as a deciding factor in agricultural location. Garrison and Marble (1957) followed Dunn and Thünen's approach, but without the simplifying assumptions of an unbroken and uniformly fertile plain feeding a single urban area. Their model allowed for variations soil productivity, multiple markets, and differing means of transportation. Garrison and Marble proved that an optimum set of crop and production-intensity choices exists for every distance from a market, confirming in a more rigorous way existing location theory.

Heady (1952) states that "the price [of a commodity] at any particular point tends...to vary directly with distance from the central market or consuming center. Under competitive conditions the price to the producer would be the central market price less the cost of transportation services between the production center and consuming location." Heady goes on to note that in practice, topography and transportation infrastructure distort what would otherwise be circular price bands (or transportation iso-cost lines) around a market, and that iso-cost lines for different markets usually overlap. Relative price of production factors also impacts production possibilities. Beyond transportation and production expenses, price ratios between different crops (also partly a result of transportation), and varying marginal rates of substitution between crops, all interact to create the agricultural landscape in a particular area.

While Thünen's ideas about the centrality of transportation expense for the agricultural landscape still hold, the actual cost of transportation has changed radically, and with it feasible distance from markets. Based on his own data farming in Germany from 1810, Thünen concluded, “grain cannot be brought [to market] from a distance of more than 50 miles, because the horses and their drivers would consume the entire load, or its equivalent value, on the journey. Hence even if it were possible to produce grain free of cost, tillage would have to cease at 50 miles from the Town” (Hall, 1966). But transportation improvements would soon shift market boundaries. Britain, which had historically been self-sufficient in grain, imported much of its grain from Germany by 1840, then from southeast Europe by 1870, and then from Argentina and Canada by 1913 (Hall, 1966). Thünen’s rings expanded dramatically, and for many products went global.

Thus the spatial composition of agriculture is driven primarily by 1) production constraints that largely determine cost of production; 2) transportation costs that effectively set farmgate prices. And transportation costs, in real terms, have declined remarkably since the industrial revolution. Chisholm (1962) concludes that there has been a “substantial decline in ‘real’ transportation costs in the last few decades,” citing several examples, e.g. that ocean freight rates declined 56% from 1876 to 1955. Chisholm cites three reasons for the decline of transportation cost relative to the value of goods:

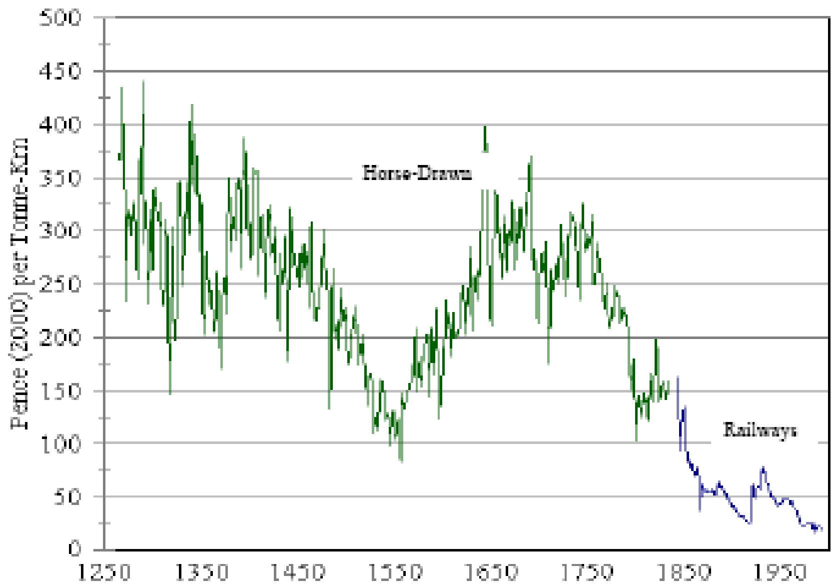
a. Substitution of improved means of transport for more rudimentary methods;

b. Improvements within individual transport media;

c. Greater degree of processing undergone by products and changes in the type of product towards more valuable ones.

Fouquet and Pearson (2003) compiled overland transportation time and cost data for the UK for years 1250 to 2000, showing a steep decline over that time, as shown in Figure 2. Occasionally deteriorating road conditions are blamed for cost increases.

Figure 2. Historic overland transportation costs in the UK



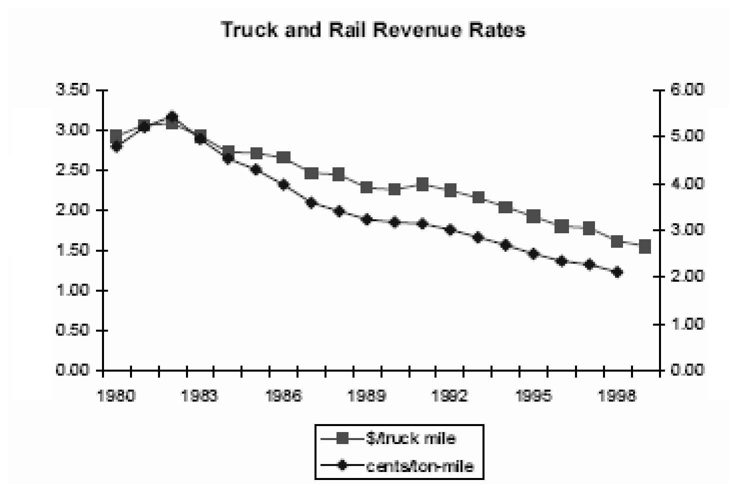
Source: Fouquet (2003)

More recently, a report commissioned by the U.S. Department of Transportation shows that U.S. land transportation costs continued to decline through the 1990s, as shown in Figure 3 (ICF Consulting and HLB Decision -Economics, 2002) . The decline is attributed at least in part to deregulation of transportation rates.

Declining transportation costs increasingly give agricultural price advantage to places with lowest production expenses, irrespective of where those places are in relation to markets. This stokes trends toward a global food supply, specialization and monocropping in the most advantaged growing areas, and loss of local agricultural diversity throughout the food system.

Figure 3. US overland freight costs

$ per truck mile (1996 $)



Rail cents per ton-mile

Source: ICF Consulting (2002)

But will transportation costs continue to decline, and what are the total costs of the transportation system? In Thünen's time, the cost (in grain) of transportation was clear: when a horse consumed all the grain to be transported, grain could be transported no further. In the current fossil-fuel based transportation system, externalities like oil spills and global warming are not counted as transportation costs. Glickman (2001) presents eight different authors' calculations on the external costs of gasoline, including costs like car accidents and time lost to congestion, as well as environmental damage. The average additional cost per gallon from the eight studies is $4.54 per gallon, which added to a market price of $2.50 per gallon would result in a real gasoline cost of $7.04 per gallon. Pricing gasoline at its true cost would undoubtedly change the complexion of the agricultural landscape.

2.3 Recent Interest in Local Food: Multiple Benefits

Current interest in local food still relates to oil-depletion concerns, as it did in the 1970s, but scholars today have many additional questions. Besides running out of oil, another concern is build up of CO_2 and other pollutants from oil combustion. Atmospheric pollution "sinks" may fill before fossil-fuel sources are actually exhausted (Meadows, et al., 1992).

Pirog (2001) has conducted several studies of food transportation logistics in and around Iowa, using a weighted average source distance (WASD) method to calculate distance from grower to consumer. Comparing local food projects in Iowa with conventional distribution coming through the Chicago terminal market, Pirog found the Iowa system to have a WASD of 44 miles, or 2.9% of the 1,546 miles estimated for conventional distribution. The study also analyzed several local distribution models designed to provide 10% of Iowa's produce, and found CO_2 emissions reductions ranging from 6.7 to 7.9 million pounds per year over conventional distribution, depending on the local system used.

Kloppenburg (1996) argues that "how we eat is a major determinant of how natural resources are used and misused," and proposes the concept of a "foodshed," borrowed from Getz (1991), to describe the source of an area's food supply. Unlike Getz, Kloppenburg also uses "foodshed" in a normative sense to refer to localized food systems, advocating that they replace the globalized food economy. He suggests using food policy councils, farmers' markets, etc. to develop local foodsheds. Kloppenburg also uses commodity chain analysis to trace individual products from point of production to consumption, analyzing not only transportation impacts, but other environmental impacts and social costs. A french fry, to use Kloppenberg's example, might be linked to groundwater pollution or exploitation of food workers. Thus foodshed development is seen as a means to multiple social ends.

For many authors, the social issues related to moving food around the world loom larger than energy and environmental impacts. Campbell (1997) describes "a new emphasis on homegrown, community-based approaches" to economic development, and believes sustainable agriculture should be one such approach. Lyson and Greene (1999) contend that increased local food production is a key to sustaining agriculture and economic prosperity in the northeast. These economic outcomes also have social ramifications: "The local food system...is part and parcel of community capitalism, which is grounded in theories of civil society and civic engagement." Buying from local farmers brings economic benefit to both farmer and consumer, but also weaves the social fabric of a rural community. The resulting social ties benefit communities in ways that go beyond economic performance, by enhancing cooperation and common interests in quality of life.

Feenstra (1997) defines local food systems as ones that "are rooted in particular places, aim to be ecologically viable for farmers and consumers, use ecologically sound production and distribution practices, and enhance social equity and democracy for all members." She outlines the broad contours of a U.S. local food movement, describing the historical roots of the movement, many of its current manifestations, and findings of studies on local food. Feenstra concludes that successful local food system development depends on leadership, collaboration, and “fostering the politics of civic renewal.”

A few authors are cautious about tenets of the local food movement. Hinrichs (2003) notes that while local food “has recently emerged as a banner under which people attempt to counteract trends of economic concentration, social disempowerment, and environmental degradation in the food and agricultural landscape, ” in practice local food production may or may not have all of these attributes. Hinrichs also contrasts “defensive” localization, an isolationist tendency to avoid interaction with outsiders, with a more positive “diversity receptive” localization, which accepts positive features from both one’s own locality, and from others. Bellows and Hamm (2000) caution that “there is no certainty that local food systems will produce local autonomy and sustainable development,” and propose that local food systems be judged on their actual performance in developing “fair labor trade, equity and democracy, and environmental stewardship.” And Tippins, Rassuli, and Hollander (2002) survey trends in local food use but conclude that “barring any unforeseen disasters that may befall the US and other western industrial economies, farm-to-table seems confined to a very supplementary role.”

At a minimum, local food can reduce food transportation with associated oil depletion and pollution. Many believe local food can also develop communities and improve rural society. But given current availability of relatively cheap transportation, what would cause food to be locally grown? Consumer choice may be the only answer.

2.4 Consumer Demand for Local Food

Individual consumers can choose to assign higher personal values to transportation than does the market, recognizing that market prices do not reflect real costs to society. Satisfaction may be derived from knowing that personal buying decisions can help to preserve local farms or the environment. Consumers can also choose to assign value to supporting a local economy and to the increased freshness that they may receive from local foods.

One measure of local food interest is the increase in direct marketing across the United States. Direct marketing includes farm products by farmers to consumers at roadside farmstands, farmers' markets, CSA, etc., as described above. Direct marketing is increasing: nationally, the 2002 Census of Agriculture found that total direct sales grew to $812 million in 2002, a real increase of 23% from the 1997 census (after adjusting for inflation). The number of U.S. farmers' markets increased 63% from 1994 to 2000, with a reported 915,774 customers per week. CSA grew from only two operations in 1986 to over 1,000 in 1999 (Lass, et al., 2003). Clearly there is consumer interest in local foods; but what motivates consumers to buy local?

A 2002 study of 1,600 consumers in four different regions of the United States that all had buy-local campaigns found it important to 58% of those polled that food comes from farms and ranches in their area, and 84% thought it important that food come from the U.S. (Greenberg Quinlan Rosner Research Inc., 2002). Reasons given to buy local are shown in Table 1.

Responses indicate that supporting the local economy and freshness/quality were the "most convincing" reasons to buy local, while environmental protection scored much lower. But it is not clear that consumers understood the environmental impacts of transporting non-local food; among those who consider buying local important, researchers found that 76 percent pay close attention to local environmental issues. Researchers also found a number of inconsistencies; for example, only 11 percent said that price was a reason to not buy local, though 46 percent said that it was very important to find food at the lowest possible price. Consumer attitudes may not be fully formed, or inconsistent answers may reflect conflicts between behaviors consumers aspire to and ones they exhibit.

A study in Iowa (Pirog, 2003) asked some questions similar to the Greenburg, Quinlan, Rosner study; results from that survey are also shown in Table 1. The data are from 424 Midwest consumers[3], and while the study surveyed only the Midwest and used a different methodology than Greenburg, many response levels are similar, with notable exceptions: the Iowa group was much more likely to cite freshness or quality as the primary reason to buy local, and much less likely to cite helping the local economy. Environmental concern ranked even lower than the Greenburg survey, with just one respondent citing environment as a primary motivator. But note that for both studies, the researchers were asking for priority reasons to buy local; a low score for a particular reason did not necessarily indicate that people disagreed with that reason, only that it was

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[3] Data used are from the control group for a larger study that also gauged consumer response to different eco-labeling schemes (data used are from consumers who did not view any eco-labels).

not a top priority. And the Greenburg poll was of areas that already had buy local campaigns, which may have influenced responses.

Table 1. Reasons to buy local.

Reason to buy (Greenburg/Leopold)	Greenburg n = 1600	Leopold n = 424
supports local economy/helps local economy	29%	4%
fresher or better quality	27%	56%
supports family farmers/local farms	21%	20%
healthier/safer	7%	3%
protects the environment/environmental concerns	7%	0%
safer from terrorists/food security	3%	1%
price	na*	15%
other	6%	1%

***not included in the survey**
sources: Greenberg, Quinlan, Rosner (2002), and Leopold Center (2003)

In a second group of surveys, Pirog (2004) found “local” labels more appealing to consumers than designations of “organic” or “pesticide free.” Pirog also found that as many as 18% of consumers surveyed would pay an additional 30% or more for products that “combine the attributes of locally grown with environmental and community stewardship,” and added that “locally-grown” appeared to be the most important attribute. At the University of Vermont, a poll of students about possible improvements in dining services ranked local food ahead of organic and vegetarian options, but behind such options as “lower prices” and “better tasting foods”(Jordan, 2006). “Supporting small-scale farmers” was the most frequent reason giving for local food preference.

2.5 Summary of Literature Review

Historical records and land capability analysis both reveal that Vermont is capable of producing much of its own food, likely much more than it currently produces. Declining local food production can be attributed mainly to long-term decreasing transportation costs, and thus to relatively higher comparative advantage to producing food in other areas. Internalizing transportation's external costs would tend to favor more local food production. And despite Vermont's (or any region's) disadvantage in producing the lowest-cost food, surveys indicate that some consumers still favor local food, and are willing to pay somewhat higher prices for it. Reasons given by consumers for interest in local food vary, but appear to center mainly on freshness and helping the local farm economy. Consumer preference for "local" may rank higher than for "organic."

3. Article I: Measuring Local Food

Article 1 deals with a central question of this thesis, how local food use might be quantified, and proposes several possible measurement methods.

3.1 Introduction

In many regions of the United States there is increased interest in local foods, as seen in the renaissance of farmers' markets and other once-common forms of direct sales. Nationally, real direct sales increased 28 percent between the 1992 and 1997 agricultural censuses, and by the 2002 census increased an additional 23 percent (after adjusting for inflation) to over $812 million annually (U.S. Department of Agriculture, 1994, 2004). Hundreds of initiatives and projects around the country promote local food (Feenstra, 1997). Yet little is known about how much of the food supply is actually sourced locally in any given place. This paper reviews past methods of measuring local food consumption, proposes an updated and modified version of one of those methods, and presents indicators of in-state food consumption for the fifty United States.

A number of authors describe benefits associated with local food systems and direct marketing. Lyson and Greene (1999) "believe that the development of food marketing systems which more effectively link farmers with the vast population of consumers in the region may be the most effective way to sustain agriculture and communities." Lezberg and Kloppenburg (1996) "subscribe to a view that might be called the 'proximity principle'—that the food supply of a region should come from proximate locales rather than from distant places where the production practices remain invisible to the eaters. Regional food self-reliance...entails the restructuring of food economies for the benefit of communities and labor, rather than corporations and stockholders." And according to Feenstra (1997), "the way food is grown, distributed and eaten also profoundly affects the environmental, social, spiritual, and economic well-being of a community."

The growing interest in local food has not escaped the notice of state governments. In the northeast, every state department of agriculture has a buy-local campaign or a website to encourage consumers to buy foods from its state (Table 2). In Vermont, for example, the "Buy Local, it's just that simple" campaign encourages consumers to shift 10% of their food purchases to local providers, and estimates the potential economic impact of doing so at $100 million. The website also provides listings of Vermont farmstands, farmers' markets, and producers of various agricultural products.

Table 2. State buy-local programs

State	Program	Program Website
Connecticut	(links to local food listings)	http://www.ct.gov/doag/cwp/view.asp?a=1368&q=259140
Maine	Get Real, Get Maine	http://www.getrealmaine.com/
Massachusetts	Massgrown	http://www.mass.gov/agr/massgrown/index.htm
New Hampshire	New Hampshire's Own	http://www.nhstories.org/
New Jersey	Jersey Fresh	http://www.state.nj.us/jerseyfresh/
New York	Pride of New York	http://www.agmkt.state.ny.us/GROWNY/pny.html
Pennsylvania	Pennsylvania Preferred	http://www.agriculture.state.pa.us/agriculture/cwp/view.asp?a=3&q=129328
Rhode Island	(links to local food listings)	http://www.dem.ri.gov/topics/agricult.htm
Vermont	Buy Local, it's just that simple	http://www.vermontagriculture.com/buyvermont2.htm

Such initiatives at state and local levels would benefit from more and better data about local food sources. Like any development project, a buy-local campaign should have baseline data about how much food is local before the campaign starts, goals for change, and data to reflect actual campaign results. Judging efficacy and improving performance of buy-local initiatives depends on having such data. Feenstra (1997) notes that "more studies that ask questions about regional food self-reliance are needed... A first step will be to identify meaningful indicators and measurement methods." Yet local food data are not readily available. While the Economic Census' Commodity Flow Survey does track interstate food shipments, this has significant limitations for assessing local food (discussed below). The United States has no system for tracking food self-reliance at the state (or any sub-national) level. Yet from available data, several useful indicators of local food activity can be derived.

For supporting local food initiatives, such indicators should have several qualities: 1) indicators should be sensitive to actual local food activities, i.e. if consumers redirect food dollars to local providers, an indicator should above all reflect this change in activity. 2) To the extent possible, indicators should be transparent to local users, that is, users should be able to understand not only how much of their food may be local, but also major features and deficiencies of their local food systems. Such information is a basis for planning and policy design. 3) Indicators should be useful at different scales; in different contexts, "local" may be defined as a region, state, city, or county. 4) Finally, to be useful, local food indicators must be relatively low cost and replicable across time and space. One can fully understand a food system today only in relation to its past, and in relation to possibilities demonstrated by food systems in other places.

While definitions of "local" vary, this study focuses chiefly on food indicators at the state level, using Vermont as an example. But the procedures described can be used at any sub-national U.S. scale for which production data are available. Such production data are generally available at the county level from national studies. County data can also be aggregated to study multi-county regions or Metropolitan Statistical Areas (MSAs).

3.2 Literature Review

3.21 Transportation Data

The U.S. Commodity Flow Survey (CFS) is conducted every five years, as part of the Economic Census (U.S. Census Bureau, et al., 2004). Data on value and weight of goods transported within the United States are collected and aggregated under NAICS codes, which include several food codes. Published data list shipments by NAICS code from every state to every other state, and allow total food imports and exports to be calculated at the state level. While this gives an approximation of gross U.S. food movements, several characteristics of the CFS severely limit its utility for quantifying local food: 1) Goods shipped can represent anything from raw commodities (e.g. corn) to partially processed products (corn meal) to finished foods (corn flakes), and thus their values vary considerably. It is not possible to calculate values of goods in terms of either original farmgate value or final retail price, thus precluding comparison with either production or consumption data. 2) Shipment origins and destinations do not necessarily reflect either places of production or final locations of consumption. For Vermont, for example, many food shipments originate in New York and Massachusetts. This is not because these states are major food suppliers to Vermont, but because they are major transportation hubs for the state. Similarly, goods shipped to Vermont are not necessarily consumed there, but may be in transit to other states. 3) Transportation from farms to distribution points is specifically excluded from the CFS. Though the amount of food movement excluded is likely small (e.g. trucking from farms to grain elevators), it cannot be quantified, and may be important in some cases.

3.22 IMPLAN

The Minnesota IMPLAN Group (MIG) publishes software for input-output modeling. One factor used for such models is the Regional Purchasing Coefficient (RPC), defined as "the proportion of local supply that satisfies local demand" (Lindall, et al., 2005). Applied to food products, RPCs can be used to calculate food sourced at the county level, by dollar value. A new national trade-flows model developed jointly by IMPLAN and the U.S Forest Service will soon be used to calculate these RPCs. This model uses various data sources for consumption and production at the county level (e.g. USDA Census of Agriculture), total U.S. transportation data from the CFS, and county-level data on available transportation modes, distances, and costs, from the Oak Ridge National Labs (Lindall, et al., 2005). The model projects transportation by commodity for each county, and is constrained so that county projections sum to actual national totals, i.e. the model accounts for all U.S. production, consumption, and commodity transportation.

For local food analysis, these projections from IMPLAN RPCs (while not direct observations) are likely the most accurate estimates of local food consumption, and thus represent important data on local food. Yet relying exclusively on IMPLAN RPCs for local food information is limiting. Compared to the criteria for local food indicators presented above, IMPLAN RPCs have the advantages of scalability, relatively low cost, and replicability, but are only moderately sensitive and transparent. For example, the models will not necessarily reflect regional variation in consumer preferences for local food, particularly if such preferences should be successfully altered through buy-local campaigns. And given the variety of data sources and mathematical methods needed for a national economic model, most local users cannot hope to understand what the model results actually mean for their particular areas. Additional measures discussed below can improve local food system analysis.

3.23 Self-Sufficiency Studies

A number of studies on state and regional food self-sufficiency were conducted during the 1970s and 1980s. The main concern at that time appears to have been the extent to which areas studied were *capable* of producing their own food (as opposed to how much of their own food they actually produced and consumed). Several calculation methods and manuals were published. All of these methods in some way compared local production to local consumption, assuming that all local products did (or could) stay within a region until local needs were satisfied, at which point surplus could be exported or deficits made up with imports. This assumption ignores cross-transportation of similar goods; in Vermont, for example, apples are clearly both exported *and* imported. Cross transportation reduces actual local food consumption from its hypothetical maximum, and the extent of cross transportation cannot be ascertained from the consumption-production models used in the 1970s and 80s. Yet these models still provide an accessible starting point for understanding local food systems. Results of such models suggest an upper bound on local food consumption, based on current production.

Bahn and Christensen (1979) calculated potential food self-sufficiency in the New England states, comparing consumption, based on 1975 national per-capita consumer expenditures, to production data from the Census of Agriculture. In making this comparison they aggregated food products into seven categories. Crop production value for each group was converted to retail value by multiplying by a farm-retail price-spread factor. Total production was then compared to total consumption, derived from national per-capita consumption multiplied by population. Holm (2000) updated this study, and used the same calculation method to assure comparability with Bahn and Christensen. A limitation of this method is that farm-retail price spreads do not include food eaten away from home (Elitzak, 1999), so such food must be assumed to have the same price spread as that bought in stores and prepared at home. Farm-restaurant price spreads undoubtedly exceed farm-grocery spreads, so use of the farm-retail figure has the effect of understating final value of food consumed, and thus understates the possible food self-sufficiency of a region.

The studies found Vermont to be more than self-sufficient in food production, with production at 123 percent of consumption in 1975 and at 111 percent of consumption for the 1997 update. These figures represent the general productive capacity of farmers to provide enough food for the state, i.e. with 111 percent self-sufficiency Vermont in general has a large enough farm economy to support its population. But the 111 percent figure bears little resemblance to the actual amount of food produced and consumed in the state, since the calculation method allows surpluses in one category to increase the total self-sufficiency estimate. For Vermont in 1997, for example, there was a large surplus of dairy products (with production at 830 percent of consumption). If one instead understood self-sufficiency to mean that 100 percent were the maximum attainable local food consumption (since producing more than consumption would in fact lead to exports, not more local consumption), each of the production categories would be capped at 100 percent of consumption. Using this method, Vermont's 1997 maximum local food would have been 31 percent.

The Cornucopia Project (1982) of the Rodale Institute published a manual about calculating food self-sufficiency at the state level, and encouraged people around the country to assess their own states. Cornucopia's method was similar to Bahn and Christenson's, recommending that self-sufficiency be calculated either as Bahn and Christensen did, by adjusting production to retail value and comparing to consumption, or by comparing actual quantities of farm products (e.g. bushels of wheat) to local consumption (consumption again based on national per-capita estimates). Production in excess of consumption was assumed to be exported, and not counted toward food self-sufficiency.

Compared to other methods, Cornucopia's calculations were made at a relatively detailed level. For the Pennsylvania example used in the manual, Cornucopia calculated possible self-sufficiency of 118 different food products. The authors note the difficulty of obtaining production figures at this level of detail, and suggest a number of possible data sources. Given this lack of standardization in data collection, results from different states may not be completely comparable. The Cornucopia study estimated Pennsylvania's food self-sufficiency to be 29%. Tarlov (1984) used Cornucopia's method for a study of Vermont, and found self-sufficiency to be 27%. In Massachusetts, another Cornucopia study by Engel (1983) determined food self-sufficiency to be 7%. The Cornucopia manual also suggested that studies evaluate land requirements for total self-sufficiency, and address pressing agricultural issues like soil erosion. The manual lists 13 state-level projects, three county projects, and seven municipal ones that had been completed when the manual was published.

Gingrich and Madden (1979) also published a study of possible food self-sufficiency in the northeast, but used a somewhat different calculation method. Instead of comparing regional production to consumption, they divided the region's share of national production by the region's share of national population, which is the same as dividing regional per-capita production by national per-capita production. By avoiding the use of consumption data, the need to adjust production values to the retail level is eliminated. Gingrich and Madden, writing in 1979, ignored national imports and exports, assuming that United States was (or could be) essentially self-sufficient in food (that assumption may be less valid today). Like Bahn and Christenson, Gingrich and Madden allowed for more than 100% self-sufficiency (e.g. in 1975 the northeast was 107 percent self-sufficient in apples), but did not sum food categories to arrive at a figure for total possible food self-sufficiency.

This paper follows Gingrich and Madden, comparing local per-capita production to national per-capita production, to arrive at an upper bound for local food production and consumption. But this study also introduces several modifications and additional steps: 1) the U.S. production benchmark is adjusted for imports and exports, to reflect production needed for national food self-sufficiency. 2) Broader aggregations of food products are used (e.g. "poultry" instead of "chickens", "turkey", and "broilers"), based on the USDA Census of Agriculture categories. Using the USDA categories allows calculations to reflect the entire food system, including all intermediate products (e.g. fodder for dairy production). Aggregations also allow for more substitutions in regional diets (e.g. a region could eat more chicken than average, but less turkey, without affecting the self-sufficiency calculation for poultry). And aggregating is necessary for the import-export adjustments. 3) Potential self-sufficiency in each category is capped at 100%, so that 4) a maximum or upper bound on local food consumption can be calculated. 5) A similar process is used to evaluate the extent of regional food processing, which is used as an additional constraint or second possible upper bound on local food consumption, and 6) the calculations for two possible minimum bounds on local food are presented and discussed. The minimum bound is likely more significant for policy makers than the maximum.

3.3 Methodology

3.31 USDA Production Data

Maximum and minimum bounds on local food consumption can be calculated from publicly available data, using a method similar to that of Gingrich and Madden. National production data are obtained from the USDA Census of Agriculture, in this case from the 2002 Census (U.S. Department of Agriculture, 2004). The Census aggregates agricultural production into 16 categories. Five categories that represent primarily non-food are excluded: 1) tobacco, 2) cotton and cottonseed, and 3) nursery, greenhouse, floriculture, and sod, 4) cut Christmas trees and short rotation woody crops, and 5) horses, ponies, mules, burros, and donkeys. In addition, three red meat categories are combined into one, to facilitate the import-export adjustment (below). Thus nine food-product categories are used in the analysis, as shown in Table 3.

Note that the categories used do not perfectly measure products used in the U.S. food system. The excluded "nursery, greenhouse, floriculture, and sod," category, for example, does include greenhouse vegetables. But vegetables account for only 4.9% of the space under glass (U.S. Department of Agriculture, 2004), and value of the greenhouse vegetable crop is not provided in the Census, so the category is excluded. Thus the categories used represent the best available measure of U.S. food production, though small amounts of food-related products are excluded and small amounts of non-food are included.

Fish landed in particular place may or may not originate from the vicinity of the port; fish can be caught thousands of miles away from their home ports. Thus for the purpose of measuring local food, this study (like Gingrich and Madden's) excludes fish and seafood products other than those from aquaculture.

Table 3. USDA production categories

	USDA Category	Status
1.	grains, oilseeds, dry beans, and dry peas	used
2.	tobacco	not used
3.	cotton and cottonseed	not used
4.	vegetables, melons, potatoes, & sweet potatoes	used
5.	fruits, tree nuts, and berries	used
6.	nursery, greenhouse, floriculture, & sod	not used
7.	cut Christmas trees & short rotation woody crops	not used
8.	other crops and hay	used
9.	poultry and eggs	used
10.	cattle and calves	combined with categories 12 & 13
11.	milk and other dairy products from cows	used
12.	hogs and pigs	combined with category 10
13.	sheep, goats, and their products	combined with category 10
14.	horses, ponies, mules, burrows, and donkeys	not used
15.	aquaculture	used
16.	other animals and other animal products	used

Non-disclosed data items are assumed to be zero; this occurs when there are not enough producers in a region to meet census standards for protecting confidentiality. Since at the state level, non-disclosure means there are only a few producers in the entire state, the zero-value assumption is more accurate than at the county level, where non-disclosed data are more likely to be significant. For many regions this makes food analysis at the county level problematic.

3.32 Import-Export Adjustment

U.S. agriculture totals are adjusted for imports and exports. This improves the accuracy of the benchmark against which state food self-sufficiency is measured. For example, the United States is a net exporter of wheat. Not adjusting for wheat exports would inflate the amount of wheat production needed for state-level self-sufficiency. Food disappearance data from the USDA's Economic Research Service (ERS) are used for the import-export adjustment. "Supply and use" spreadsheets provide total weight or volume of domestic production, imports, and exports by commodity (USDA Economic Research Service, 2002). Net export factors are then calculated, and applied to U.S. production (Table 4).

The ERS data describe the food supply by weight or volume, while Census of Agriculture provides dollar value of goods. This is a source of some inaccuracy, more for adjustments to some commodities than to others. For wheat, a relatively homogenous commodity, applying the net export percentage (calculated in bushels) to the production value (in dollars) is likely quite accurate, since most bushels of wheat have a similar price. But the export adjustment for fruit is clearly less accurate, since the price per pound of different fruits varies significantly. Thus the import-export adjustment can be considered only an approximation, but an approximation superior to a failure to adjust for imports and exports.

Table 4. Import-export adjustments

		2002 market value ($k)	net exports	adjusted market value ($k)
1.	grains, oilseeds, dry beans, and dry peas	$39,957,698	21%	$31,442,659
2.	vegetables, melons, and potatoes	12,785,898	-3%	13,191,098
3.	fruits, tree nuts, and berries	13,770,603	-25%	17,273,959
4.	other crops and hay	7,929,618	0%*	7,929,618
5.	poultry and eggs	23,972,333	11%	21,253,203
6.	beef, pork, and other red meat production	58,057,906	-1%	58,527,966
7.	milk and other dairy products	20,281,166	-2%	20,703,329
8.	aquaculture	1,132,524	0%*	1,132,524
9.	other animals and other animal products	721,738	0%*	721,738
	TOTAL U.S.	$178,609,484		$172,176,094

***no adjustment made to this category**

source: USDA (2004)

3.33 Maximum 1: Production

From the adjusted U.S. production figures and 2002 population (U.S. Census Bureau, 2002), U.S. per capita production is calculated. Per capita production is then calculated for the state level. The sum of the minima of state per capita production or U.S. per capita production for each category is then divided by total U.S. per capita production (Equation 1). Selecting the minimum of state or national per capita production caps the potential local food contribution from any one category at the national level, i.e. more than 100% self-sufficient in any commodity group does not contribute to local food, since surplus must be exported. The result provides one upper bound on local food at the state level. This is the amount of food produced in a state that could be consumed in a state, if no cross shipment of like goods occurred. The same equation can be used to calculate an upper bound for local food at the county level.

$$\text{LF}_{\max 1} = \frac{\sum_{n=1}^{9} \min\left[\left(\frac{STprod_n}{STpop}\right),\left(\frac{USprod_n}{USpop}\right)\right]}{\sum_{n=1}^{9}\left(\frac{USprod_n}{USpop}\right)} \tag{1}$$

where:
$\text{LF}_{\max 1}$ = first upper bound on local food production
STprod = state production commodity group
STpop = state population
USprod = U.S. production commodity group
USpop = U.S. population

A state for which the per capita production matched or exceeded U.S. production in every category would have a maximum_1 of 100% (though for 2002, there were no such states). Thus the local food maximum is based both on total productive capacity of a state, and the extent to which the diversity of production matches national diversity. This reflects the fact that diets are diverse, and that more state production could be consumed in state if production diversity matched diet diversity.

3.34 Maximum 2: Processing

A second potential upper bound is provided by state capacity to process foods. Most U.S. food consumption is of foods that are processed in some way, and food cannot remain in the area where it is produced unless processing facilities are also present. Food processing data are taken from the U.S. Census Bureau's Economic Census 2002. NAICS codes and descriptions for the seven categories used are shown in Table 5.

Comparable data are not available to adjust food-processing totals for imports and exports, so no adjustment is made to U.S. processing totals. The same procedure used to calculate the local food production $maximum_1$ is used to calculate a processing $maximum_2$ (Equation 2). The smaller of the two maximums then becomes the upper limit on in-state food consumption (Equation 3), i.e. either food production or food processing can be a constraint on local food availability.

Table 5. U.S. food processing

NAICS Code	Description		U.S. 2002 value ($k)
3112	Grain & oilseed milling		47,141,000
3113	Sugar & confectionery product mfg		18,219,398
3114	Fruit & vegetable preserving & specialty food mfg		53,289,114
3115	Dairy product mfg		65,648,723
3116	Animal slaughtering & processing		123,016,631
3118	Bakeries & tortilla mfg		48,204,999
3119	Other food mfg		56,968,464
		TOTAL	412,488,329

Source: Economic Census 2002

$$LF_{max2} = \frac{\sum_{n=1}^{7} \min\left[\left(\frac{STproc_n}{STpop}\right),\left(\frac{USproc_n}{USpop}\right)\right]}{\sum_{n=1}^{7}\left(\frac{USproc_n}{USpop}\right)} \quad (2)$$

where:
LF_{max2} = second upper bound on local food production
STproc = state food processing commodity group
USproc = U.S. food processing commodity group

and,

$$LF_{max} = \min(LF_{max1}, LF_{max2}) \quad (3)$$

3.35 Minimum 1: Portion of National Production

There are two possible minima for local food. One is provided by the portion of national production from a state; i.e., if there were no transportation cost and all food supplies in the United States were thoroughly mixed, the minimum amount of local food consumed in a state would be its own contribution to national production (Equation 4):

$$LF_{\min 1} = \frac{\sum_{n=1}^{9}\left(\frac{STprod_n}{USpop}\right)}{\sum_{n=1}^{9}\left(\frac{USprod_n}{USpop}\right)} \qquad (4)$$

where:
$LF_{\min 1}$ = first lower bound on local food production

For small producer states like Vermont, this minimum_1 bound is close to zero (0.3%), since Vermont contributes only a small amount of the total national food supply. But the bound is higher in larger agricultural states like Iowa (7.1%), and would also be higher for regional calculations (e.g. the New England minimum_1 bound instead of Vermont's).

3.36 Minimum 2: Direct Sales

A second, and more important, possible minimum is provided by the portion of consumer food expenditures in a state supplied by direct sales from farmers. Direct sales by state (and by county) are available from USDA Census of Agriculture, and reflect sales at farmstands, farmers' markets, etc. An assumption can be made that these sales mostly represent food consumed in the state where produced (though this is not entirely true; e.g. a farmer could sell at an out-of-state farmer's market, or sell to a tourist who transports the food out of state). An interesting feature of the direct-sales data is that they represent both farmgate values and retail values, since there is no intermediate mark up between farmer and consumer. But since direct sales values are closer to retail values than typical farmgate values, for the local food calculation it is more appropriate to divide direct sales by consumer food expenditures instead of agricultural production value (Equation 5). Consumer expenditures by region are available from the U.S. Department of Labor's Bureau of Labor Statistics (2002). Data for food at home are used, since a restaurant-food purchase is by definition not a direct sale from farmer to consumer. At-home food consumption by state is derived from food expenditure by consumer unit by region, divided by the number of consumers per consumer unit, multiplied by state population.

$$LF_{min2} = \frac{STdir}{\left(\frac{RG\exp}{RGcons/unit}\right) * STpop} \qquad (5)$$

where:
LF_{min2} = second lower bound on local food production
STdir = state direct sales from farmers to consumers
RGexp = at-home consumer food expenditure by region
RGcons/unit = number of consumers per consumer unit by region

The minimum bound of state local food consumption is then the greater of the national-contribution minimum or the direct-sales minimum:

$$LF_{min} = \max(LF_{min1}, LF_{min2}) \qquad (6)$$

3.4 Results

State local food maxima and minima are shown in Table 6. Upper bounds on local food range from 88.3% (Minnesota) to 0.0% (Wyoming at 0.0%, with no disclosed food processing data). The mean local food upper bound is 46%. Thirty-three states are constrained by production, and 17 by lack of food processing industries. Food production and processing maxima are correlated ($\rho = 0.66$, $p<.001$), suggesting that in general food production and processing tend to occur in the same places.

Lower bounds on local food range from 12.6% (California) to 0.1% (Alaska), with the mean lower bound being 2.1%. For 42 states the minimum is established by the state's contribution to national production. Direct sales set the lower bound in eight states: Alaska, Hawaii, and the six New England states.

The range between state mean upper and lower bounds is a rather-broad 2.1 to 45.9%; these numbers thus provide only an imprecise answer to the question of how much food is local in each state. But the numbers can be used to provide additional insights. All four of the calculated upper and lower bounds can be monitored over time to detect changes in local food patterns. The $minimum_2$ bound (based on percentage of food supplied by direct sales) should be of particular interest as an indicator of local food activity. Since direct sales currently make up only a small percentage of consumer food expenditures (mean is 0.3%), and buy-local campaigns typically promote direct sales from farmstands, farmers' markets, etc., this number should be sensitive to changes induced by buy-local efforts. Policy makers could assume that any success in promoting direct-marketed food also yields increases in sales of local products that are not direct marketed, e.g. sales of local food in restaurants (though effects are more difficult to detect for non-direct-marketed products).

Returning to the Vermont example, the state has the highest $minimum_2$ bound (from direct sales), at 1.2%. Vermont apparently has consumers who are interested in local food, and has established direct-marketing channels (though other factors like tourism may also play a role). Yet Vermont's upper bound of 37.8% local food ranks only 36 out of the fifty states. A closer look at Vermont's production numbers tells the story (Table 7).

Per capita production in Vermont exceeds U.S. production in 3 categories, most significantly for dairy products. Vermonters are capable of providing all of their milk. But production in other major categories is low, notably for grains, vegetables, fruit, poultry, and meat, in none of which Vermont production surpasses 40% of that needed for self-sufficiency. Policy makers might encourage more local production in any of these areas, with the aim of increasing total local food use. Targets of opportunity would be products for which a state is best suited or for which infrastructure exists, e.g. beef in Vermont, given that the state already has a viable bovine industry. Questions include how much consumers might value local products, and the cost of providing such goods.

3.5 Conclusions

If promoting local food is a policy goal, as appears to be the case in the northeast (based on the universality of state buy-local efforts), then measurement of local food is needed; without measurement no assessment of program impact or progress can be made.

Table 6. State local food maxima and minima

State	$LFmax_1$ production	$LFmax_2$ processing	$LFmin_1$ percent nat'l	$LFmin_2$ direct sales
Alabama	**37.4%**	70.1%	**1.7%**	0.2%
Alaska	3.7%	**2.0%**	0.0%	**0.1%**
Arizona	38.2%	**34.4%**	**1.0%**	0.1%
Arkansas	**73.2%**	87.1%	**2.6%**	0.2%
California	**51.1%**	73.1%	**12.6%**	0.3%
Colorado	78.0%	**57.4%**	**2.5%**	0.3%
Connecticut	**8.8%**	42.8%	0.1%	**0.4%**
Delaware	**41.6%**	45.9%	**0.3%**	0.3%
Florida	**33.8%**	35.4%	**2.5%**	0.1%
Georgia	**39.3%**	69.9%	**2.4%**	0.1%
Hawaii	**34.5%**	40.0%	0.2%	**0.4%**
Idaho	81.4%	**80.1%**	**2.2%**	0.3%
Illinois	**44.3%**	86.7%	**4.2%**	0.1%
Indiana	**70.2%**	86.6%	**2.6%**	0.2%
Iowa	**83.1%**	92.0%	**7.1%**	0.3%
Kansas	**70.1%**	76.8%	**5.0%**	0.3%
Kentucky	**71.9%**	86.6%	**1.2%**	0.2%
Louisiana	**42.8%**	52.0%	**0.9%**	0.1%
Maine	**39.4%**	44.5%	0.2%	**0.7%**
Maryland	**27.5%**	45.0%	**0.6%**	0.2%
Massachusetts	**4.0%**	46.5%	0.1%	**0.4%**
Michigan	**51.4%**	65.8%	**1.8%**	0.3%
Minnesota	90.0%	**88.3%**	**4.8%**	0.4%
Mississippi	58.0%	**52.2%**	**1.5%**	0.2%
Missouri	**79.9%**	93.6%	**2.7%**	0.2%
Montana	72.8%	**31.1%**	**1.1%**	0.4%
Nebraska	87.6%	88.1%	**5.6%**	0.2%
Nevada	29.3%	**22.2%**	**0.2%**	0.1%
New Hampshire	5.8%	**5.7%**	0.0%	**0.6%**
New Jersey	**7.2%**	60.1%	**0.2%**	0.2%
New Mexico	71.8%	**35.5%**	**0.9%**	0.3%
New York	**22.4%**	46.6%	**1.6%**	0.2%
North Carolina	**64.4%**	77.9%	**3.3%**	0.2%
North Dakota	82.9%	**62.2%**	**1.9%**	0.2%
Ohio	**50.5%**	76.2%	**2.2%**	0.3%
Oklahoma	79.1%	**63.2%**	**2.4%**	0.1%
Oregon	73.5%	**64.7%**	**1.3%**	0.5%
Pennsylvania	**39.7%**	82.3%	**2.0%**	0.3%
Rhode Island	**2.6%**	16.5%	0.0%	**0.3%**
South Carolina	**29.5%**	61.7%	**0.6%**	0.2%
South Dakota	82.8%	**68.7%**	**2.1%**	0.4%
Tennessee	**45.0%**	89.3%	**0.9%**	0.2%
Texas	**64.3%**	74.6%	**7.1%**	0.1%
Utah	**61.2%**	79.6%	**0.6%**	0.2%
Vermont	**37.8%**	49.2%	0.3%	**1.2%**
Virginia	**40.1%**	75.0%	**1.1%**	0.2%
Washington	75.3%	**69.3%**	**2.8%**	0.4%
West Virginia	30.6%	**22.2%**	**0.3%**	0.2%
Wisconsin	**81.2%**	91.5%	**3.1%**	0.5%
Wyoming	58.0%	**0.0%**	**0.5%**	0.4%

Governing bounds (lower maximum and upper minimum) shown in bold.

Table 7. Vermont local food maximum (based on production)

		VT per capita production	Potential VT local food	U.S. per capita production	VT % of U.S.
1.	grains, oilseeds, dry beans, and dry peas	**4.49**	**4.49**	109.04	4.1%
2.	vegetables, melons, and potatoes	**16.45**	**16.45**	45.74	36.0%
3.	fruits, tree nuts, and berries	**15.03**	**15.03**	59.90	25.1%
4.	other crops and hay	39.30	**27.50**	**27.50**	100.0%
5.	poultry and eggs	**9.53**	**9.53**	73.70	12.9%
6.	beef, pork, and other red meat production	**76.32**	**76.32**	202.96	37.6%
7.	milk and other dairy products	555.38	**71.79**	**71.79**	100.0%
8.	aquaculture	**2.15**	**2.15**	3.93	54.7%
9.	other animals and other animal products	3.13	**2.50**	**2.50**	100.0%
	TOTAL		225.77	597.07	37.8%

IMPLAN's Regional Purchasing Coefficients (RPCs) provide a point estimate of local food production and consumption, but this has limitations as a local food indicator.

This study proposes a methodology for calculating local food minima and maxima as measures of local food. These bounds provide several advantages over a point estimate: 1) The calculated range more accurately reflects possibilities in a given area. Actual local food consumption depends on local consumer preference, which is better indicated by local direct sales than by models like IMPLAN's. 2) The data used to calculate the minima and maxima are publicly available (mostly from USDA); anyone with internet access and a calculator can determine the possible local food supply (http://www.nass.usda.gov/Census_of_Agriculture/index.asp). 3) Results are transparent, and may indicate production gaps that represent possibilities for farmers or that policy makers can address.

These measures likely represent the best information about local food that can be obtained from existing national data. A remaining question is whether better measures might be developed at either local or national levels, and whether the cost of such measures would be warranted by their possible improvements in accuracy.

This study proposes direct sales as a percentage of consumer expenditures (the $minimum_2$ bound) as the single best local food indicator. It meets all the proposed criteria of sensitivity, transparency, scalability, replicability, and low cost. While direct sales do not include all local food, they are currently the best indicator of its presence, absence, or change.

3.6 Article I References

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4. Article II: Understanding Direct Food Sales in the United States

Since direct sales and are an important indicator of local food interest and activity, it is useful to understand more about how and why direct food sales may vary across the United States. Thus this thesis research includes a study of variables associated with direct sales, and uses results to suggest possible policy targets for direct sales in Vermont.

4.1 Introduction

Around the United States, there is growing interest in local foods, and a corresponding growth in food sales through farmers' markets, farmstands, community supported agriculture (CSA), etc. Between 1992 and 2002, U.S. direct sales increased more than 50% in real (inflation-adjusted) terms (USDA, 1994, 2004). While such direct sales from farmers to consumers still represent only 0.4% of total U.S. agricultural sales, the prevalence of direct sales varies widely across the country. In some regions direct sales are very important: in Massachusetts, for example, direct sales represent 8.1% of all agricultural sales, a significant part of the agricultural economy (USDA, 2004).

Consumer purchases of foods directly from farmers may also be the best indicator of consumer interest in local foods in general. A number of authors identify possible benefits associated with local food production and consumption (Dahlberg, 1999, Feenstra, 1997, Kloppenburg and Lezberg, 1996), what Lyson (2004) calls a new civic agriculture: "a locally-based agricultural and food production system that is tightly linked to a community's social and economic development." Characteristics of this civic agriculture include: 1) farm production aimed at local consumption rather than export, 2) valuing agriculture for underpinning rural communities as well as producing commodities, 3) more emphasis on product quality and less concern for minimizing production costs, 4) smaller, more labor-intensive farming than is typical in commodity production, 5) reliance on local, site-specific practices rather than uniform production standards, and 6) direct marketing links between producers and consumers (Lyson and Green, 1999). Thus an area's direct sales may reveal something of the structures of both agriculture and rural society.

The quintennial Census of Agriculture first measured direct sales in 1978, and again in 1982. The direct-sales questions were then omitted from the 1987 census, but appeared again in 1992, 1997, and 2002. These USDA direct-sales data represent one of the few ways to measure differences and trends in local food activity across the United States. This study uses econometric methods to identify four major factors associated with the presence of direct sales, and develops a model that predicts typical sales levels based on those four factors. This information can assist farmers and policy makers in understanding the extent of and potential for direct sales in their own areas.

4.2 Literature Review

4.21 Direct Sales Definition

Direct sales of food products have no doubt occurred since there was agriculture and currency, yet the definition of direct sales is surprisingly elusive. The USDA Census of Agriculture (2004) question to farmers on direct sales reads "During 2002, did you grow or raise any crops, livestock, poultry, or their products that were sold DIRECTLY to individual consumers for HUMAN CONSUMPTION (roadside stands, farmers' markets, pick your own, door to door, etc.)?" If yes, farmers are asked for the gross value of these sales. The Census instructs farmers to "EXCLUDE crops, livestock, poultry, or other products which you bought and sold within 30 days. EXCLUDE processed products such as hams, sausage, or jellies. EXCLUDE 'craft items' such as bird houses, woodwork, etc." The definitions further note that "sales of agricultural products by vertically integrated operations through their own processing and marketing operations [are] excluded" (USDA, 2004). While the intent is reasonably clear, in practice there are several problems with gathering data around this definition.

4.22 Limitations of Direct Sales Data

Since direct sales are reported by farmers, the data reflect sales of farms in a particular place, which is not necessarily the same place where the products were sold. Farmers may travel significant distances to the larger farmers' markets. For example, the USDA direct sales data would not clearly indicate total direct sales taking place in Boston, since Boston farmers' markets draw farmers from a distance, and those sales are only reported in the farmers' home counties. Thus multi-county or state-level data aggregations are often more useful than individual county totals.

For small growers, Tippins, Rassuli, and Hollander (2002) note that "the informal rudimentary nature of many of the [direct sales] operations tends to result in poor record-keeping and the general absence of consistent data." This may cause some farmstand operators to report sales of non-food items (e.g., flowers), processed foods, and crafts in their totals. Such sales could only be excluded if the growers themselves track such sales separately, which may be unlikely in smaller operations. This would have the effect of inflating direct-sales figures, though the effect may be small, if the problem is confined to the smallest sellers.

At the other end of the scale, reporting by larger operators may be understated due to the structure of their businesses. Bills (2001) observes that the Census only counts sales from entities defined as “farms”; larger operators may have separate business entities for farm stores that carry products from their farms and sometimes other groceries, gasoline, etc. But since the products are sold by the store entity, not the farm entity, they are not counted as direct sales, though food products may indeed have been raised and sold directly to the public by an individual farm operator. This is likely a larger problem, since it involves the largest operators. It has the effect of understating direct sales.

There is also some evidence of systematic underreporting of direct sales. Mueller and Edmondson (1988) suggest that direct marketing is part of the “underground economy,” and that sellers may underreport income from direct sales. In Iowa, Otto and Varner (2005) used both vendor surveys and consumer surveys to estimate statewide farmers’ market sales, and found that consumer surveys yielded a figure roughly double that from vendor surveys. It was not clear which figure was more accurate (though Otto and Varner used the consumer number); while sellers may underreport for perceived tax avoidance, buyers may also overestimate the amount they actually spend at farmers’ markets. But one assumes there is at least some underreporting of direct sales by vendors, and this could significantly impact the data, if it happens systematically.

Since the factors influencing underreporting are likely of a larger scale than those influencing overreporting, the USDA direct sales figure is likely a low estimate of actual direct sales in the United States. Brown (2002) concurs that "information collected by the Census on direct marketing is felt by many to underestimate returns." And direct sales are only one portion of what might be called "local food"; by definition, direct sales do not include food purchased through grocery stores, co-ops, or restaurants, or any processed food. Yet the USDA direct sales figures are the best ones that exist. The Census of Agriculture is conducted regularly and uniformly across the United States, and reports data to the county level. No other data source provides greater accuracy or insight about direct food sales, or indeed about local food in general.

4.23 Previous Studies of Direct Sales

Much of the interest in direct sales relates to farmers' markets. Brown (2002) reported that U.S. farmers' markets numbered only about 340 in 1970, but grew to over 3,000 by 2001, aided in part by the 1976 Farmer-to-Consumer Direct Marketing Act. Despite the growth in this area, Brown found a dearth of solid quantitative studies that would reliably indicate the size or impacts of farmers' markets.

Gale (1997) found direct sales to be higher in areas where vegetables and fruits are grown, and near urban areas. Small farms were more than twice as likely to use direct sales as larger farms. Gale further noted that regions where direct marketing was concentrated in 1992 included the Northeast, Florida, the Great Lakes region, the West Coast, and Hawaii. Based on 1992 Census of Agriculture data, California and Pennsylvania were the leading states in total direct sales, followed by New York, Ohio, and Florida.

Lyson and Guptill (2004) used econometric methods to understand where "civic" and "commodity" styles of agriculture occur, using the number of farms selling directly to the public (not amount of sales, as used in this study) to represent prevalence of civic agriculture. They found the number of direct-selling farms increased in and near metropolitan areas, varied by region with highest number of farms in the northeast, increased with the prevalence of fruit and vegetable farming, and increased in counties with higher incomes. Lyson and Guptill concluded, "as long as civic agriculture has the potential to nurture local economic development, maintain diversity and quality in products and provide forums where producers and consumers can come together as food citizens to solidify bonds of community, it merits increased attention by both researchers and policy makers."

Goetz, Dunn, and Lego (2001) also found direct sales to be more common near cities, and in states with vegetable and fruit production. They suggested that direct selling may be one strategy that farmers in high-land-value areas use to remain viable, and since the Northeast has relatively high land values, noted that concentration of direct marketing in the Northeast is not surprising. Evaluating state direct sales on the basis of average direct sales per farm, Goetz et al. also found eight of the ten states where direct selling was most important to be in the Northeast. But direct sales per farm only reveal the relative importance of direct marketing compared to conventional marketing; high direct sales per farm could be an indication of either high value of direct sales or the absence of conventional farming.

Several measures of direct sales are possible. In the 2002 Census of Agriculture state-level total direct sales ranged from $114,000,000 in California to $829,000 in Alaska. On a per-capita basis, i.e. measuring the extent to which direct sales impact consumers, sales ranged from $15.52 in Vermont to $0.72 in Arizona. This study focuses on direct sales per unit of area, i.e. the productivity of land in term of direct sales. In 2002 direct sales per square mile of state land area ranged from $3,994 in Massachusetts to $1 in Alaska. From the sales per square mile figure, total sales, sales per capita, and sales per farm can easily be calculated.

4.3 Data and Methods

A state-level regression model was developed to determine what factors are most closely associated with direct sales. Those variables were then used in a county-level regression model, which can be used to assess direct sales differences across counties, as explained below. Agricultural data used were from the 2002 USDA Census of Agriculture. Land area came from the U.S. Census Bureau, and population data from the Census Bureau's 2002 Population Estimates program. Four variables to explain direct sales per square mile were included in the model:

4.31 Farm size

Average farm size is strongly and negatively associated with direct sales, i.e. the presence of smaller farms is correlated to higher direct sales. This could indicate either that smaller farms are forced into direct marketing, as suggested by Gale (1997), or that farmers who choose direct marketing as a strategy find that smaller farms optimize results. In either case, the association between small farms and direct sales is indisputable.

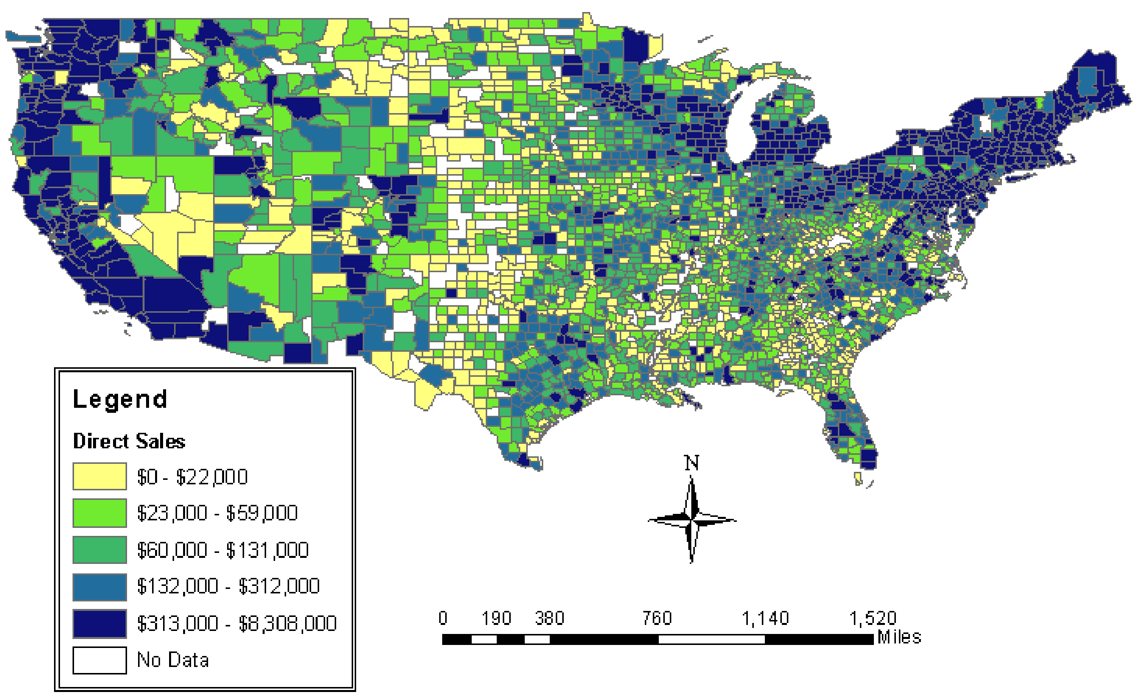
4.32 Population

The density of population in an area is also associated with direct sales. As noted by others, most direct sales occur in and near cities (Goetz, et al., 2001, Lapping, 1999, Lyson and Guptill, 2004), for the simple reasons that most consumers are there, and that direct sales by their nature tend to occur locally. While total direct sales and direct sales per square mile increase with population density, this study also found that per-capita direct sales decline with population density: while average farmers have higher direct sales near cities, average consumers in rural areas buy more products directly from farms. A separate study of metropolitan statistical areas also found that direct sales ultimately decline in the most densely populated areas, i.e. urbanization increases direct selling to a point, but can ultimately crowd it out.

4.33 Geographical area

The nine U.S. Census divisions were used to represent geographical areas of the country, and divisional influences were found to be a significant indicator of direct sales[4], as is evident from the map showing concentration of direct sales across the United States (figure 4). New England has the highest direct sales per square mile, and location in any other division has a negative influence on direct sales, though differences between New England and the Middle Atlantic, Mountain, and Pacific divisions were not found to be statistically significant. Divisional differences could represent many things: variations in

Figure 4. Geographic distribution of direct sales quintiles



Source: USDA Census of Agriculture, 2002

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[4] Eight dummy variables were used for census divisions, with New England as the reference region.

income, diets, food marketing channels, or just cultural differences in where people shop for food. Reasons for direct sales differences are not clear, though divisional variations are significant.

4.34 Available farmland

The total amount of farmland in a state as a percentage of state land area was used to represent available farmland. This farmland percentage indicates the general suitability of an area for farming, which could be due to differences in soils, climate, or urban development in otherwise arable lands. Direct sales increase with farmland percentage.

Previous studies and agricultural theory also suggest that other variables might influence direct sales. Several such variable were tested, but rejected when found to be statistically insignificant:

4.35 Income

Higher income may be associated with elevated direct sales, as found by Lyson and Guptill (2004), if sales venues like farmers' markets are mostly shopping venues for the affluent. In this study, income as a variable was found to be insignificant when census division was included as a variable. With census division omitted, income was significant, but had less explanatory power than census division. This suggests that income may in fact play a role in direct sales, but that the role is just one part of a more complex set of regional differences across the United States.

4.36 Vegetable farming

The percentage of vegetable farms was calculated as the number of farms reporting some vegetable sales, divided by the total number of farms. This has been suggested as determinant of direct sales (Gale, 1997, Goetz, et al., 2001, Lyson and Guptill, 2004), and has been found to be significant in similar studies, but was not significant in the state and county models used in this study.

4.37 Climate

Length of growing season is theoretically a determinant of production. All else equal, one would expect higher direct sales in areas with longer growing seasons, since there are more weeks per year for farmers' markets, farmstands, etc. to remain open with produce for sale. But in a previous model of metropolitan statistical areas, a variable for length of growing was introduced, thoroughly tested, and found to be insignificant in all cases. A casual look at the U.S. map of direct sales (Figure 4) also shows that high-direct-sales areas are heavily (though not exclusively) located in northern areas with shorter growing seasons. Regional differences in direct marketing apparently outweigh the natural advantages of longer growing seasons. The length of growing season variable was not used in this study, due to the difficulty of calculating it for the larger (state) areas.

4.38 Tourism

The presence of a non-local population may also influence direct sales; while population density only counts year-round residents of an area, part-time residents contribute to direct sales, especially if part-time residents are present in the summer. Two variables that would capture this effect were tested: 1) accommodation sales, from the Economic Census, and 2) percentage of homes vacant due to seasonal use, from the decennial Population Census. Neither variable was found to be significant. Again, a glance at the data suggests explanations: areas like Las Vegas have high levels of tourism and accommodation sales, but are not particularly known for the quality of their rural experiences or their numbers of farmstands. Similarly, coastal areas have large numbers of seasonal homes, but may be ill suited to agriculture. Thus there is likely no overall relationship between tourism and direct sales, though tourism in particular areas or of particular kinds (e.g. agritourism) clearly does contribute to direct sales. Some tourism effects may also be captured in the divisional variables.

4.4 Results

The state model predicting direct sales, using the four variables described above, predicts actual sales with about 92% accuracy[5]. This is a very high level of accuracy given the nature of the data used, and suggests that the four variables jointly predict almost all of the variation in state-level direct sales across the fifty United States[6]. The

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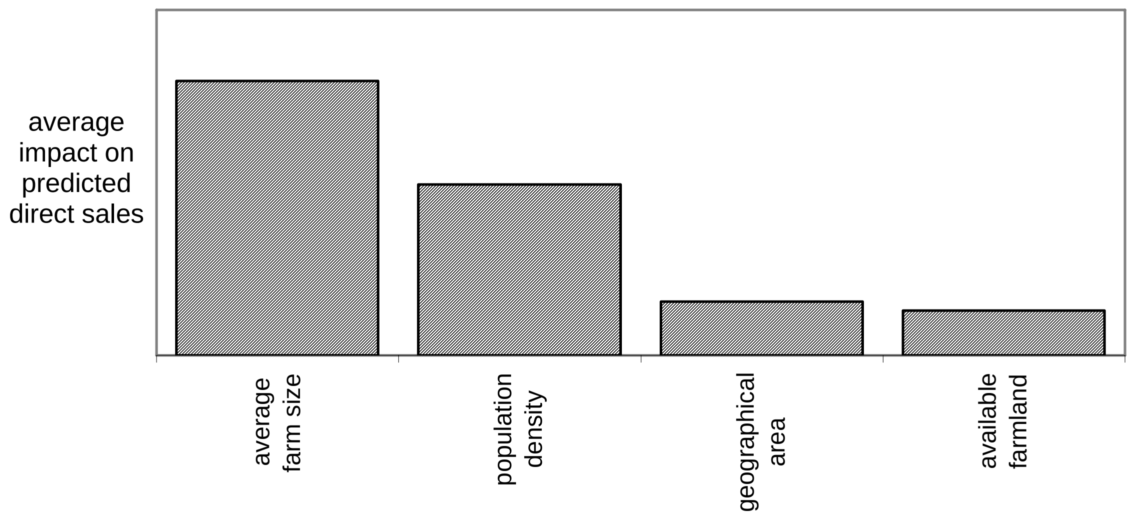
[5] Adjusted $R^2 = 0.923$

[6] State regression model: ln(direct_sales/mi^2) = 7.374 – 0.815[ln(average_farm_size)] + 0.672[ln(population/mi^2)] + 1.895(farmland_percentage) – 0.667(middle_atlantic_division) – 1.136(midwest_divison) – 1.349(west_north_central_division) – 1.288(south_division) – 1.630(east_south_central_division) – 1.960(west_south_central_division) – 0.161(mountain_division) – 0.246(pacific_division)

All coefficients significant at p<.01 except for the middle altantic, mountain, and pacific divisions.

Figure 5. Average impact on direct sales of four significant variables

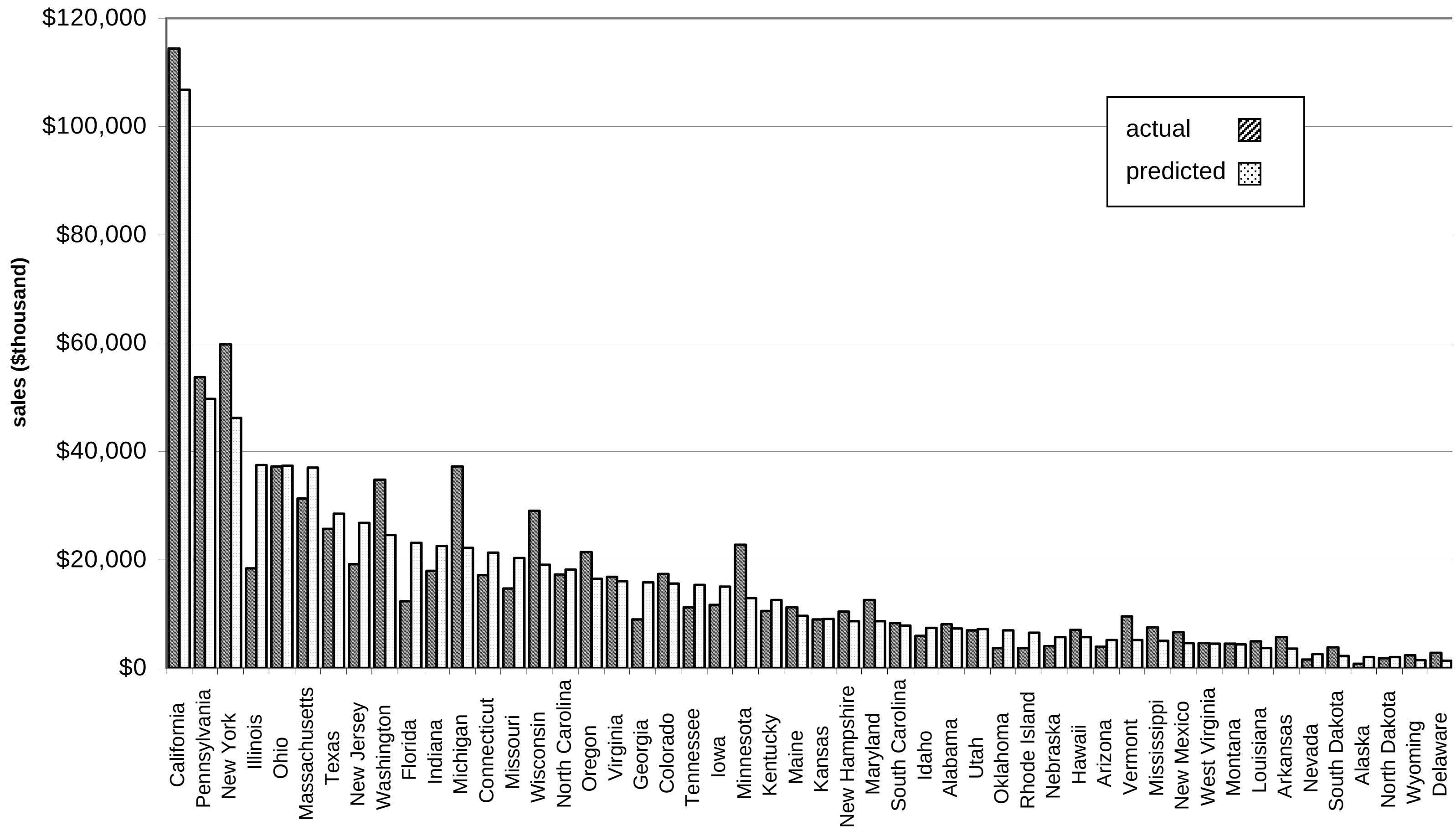


relative average impact on predicted sales of the four variables is illustrated in Figure 5[7]. Farm size and population density are the strongest predictors of direct sales, followed by geographical area and available farmland.

One purpose of the model is simply to learn what factors are associated with variations in direct sales. A second purpose is to identify targeted opportunities. Figure 6 shows the predicted values and actual values of direct sales for the fifty states. Most actual state values are close to the predicted values, not surprising given the high accuracy of the model. Exceptions, though, are of interest. Florida's actual sales, for example, are only 53% of sales predicted by Florida's average farm size, population density, census division, and farmland percentage. Florida policy makers might assess

[7] Bars represent absolute values of betas multiplied by mean values of the three continuous variables, and the mean value of nine census division betas (using zero as the value for the New England reference division).

Figure 6. Actual and predicted direct sales by state



Source for actuals: USDA Census of Agriculture 2002

whether increased promotion of direct marketing in the state might yield results similar to those found in other states. Similarly, actual direct sales in Michigan already exceed predicted sales by 67%. This might reflect successful direct-marketing promotion in Michigan, or simply reflect Michigan consumer preferences. But based on national averages, the current status does indicate that additional gains in Michigan direct sales may be harder to achieve.

Using the same four explanatory variables, a second model predicts sales at the county level, using data for 3,073 U.S. counties (data for Alaska counties and some other U.S. counties are missing)[8]. The county model predicts with much lower accuracy than the state model, explaining only about 62% of the variation in the data[9]. This is expected, since there is more variation at county level than state, and because of the inherent border-crossing problems associated with the data (described above). But variations are again of interest.

Figure 7 shows an example of results at the county level for the state of Vermont. Five of the 14 Vermont counties have lower direct sales than predicted by the model, i.e., based on the characteristics of these counties and typical performance based on national data, we would expect these counties to have higher direct sales. Three of these counties are adjacent along the Canadian border, one county is in the north central region, and the

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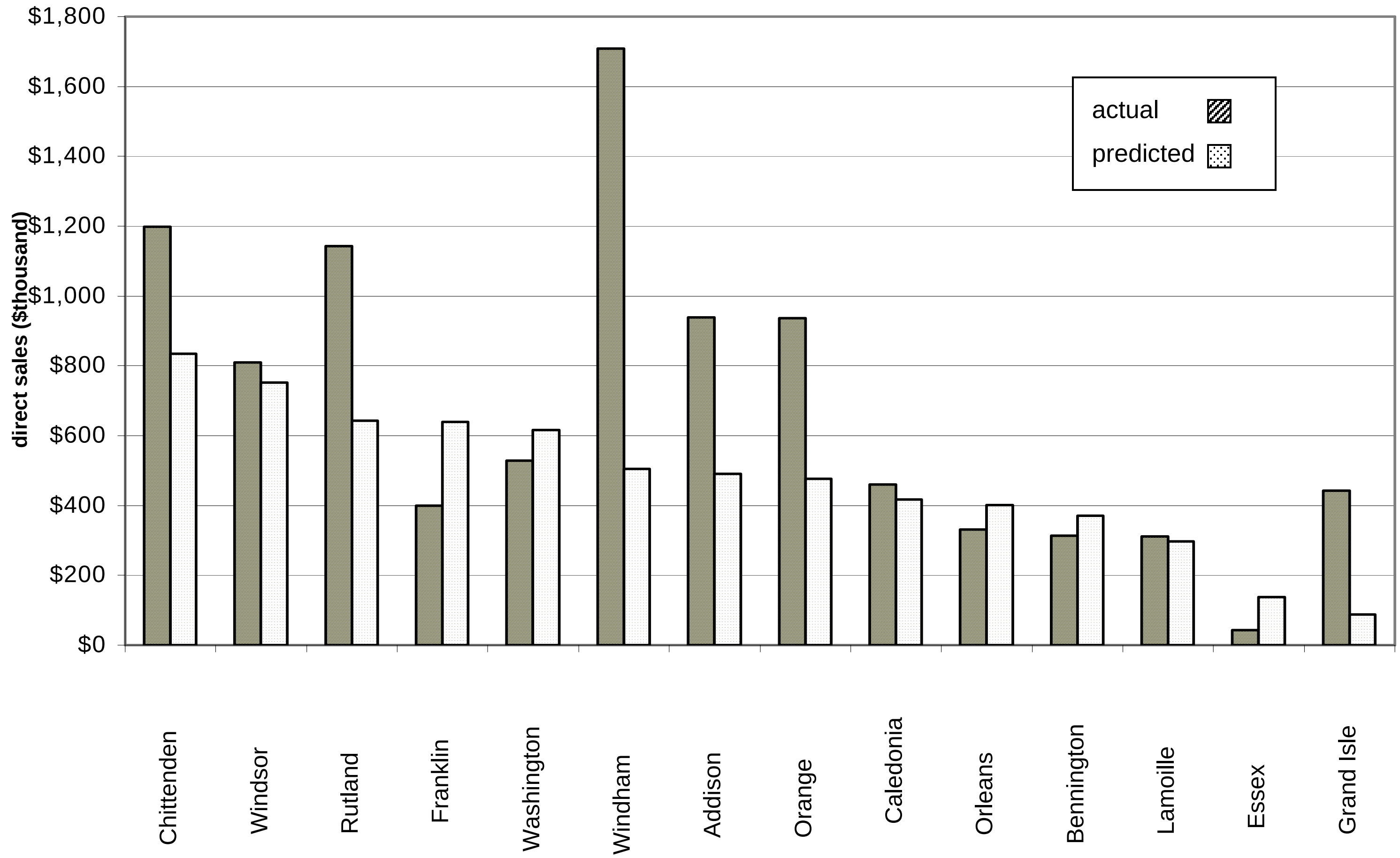
[8] County regression model: $\ln(\text{direct\_sales/mi}^2) = 7.935 - 0.705[\ln(\text{average\_farm\_size})] + .460[\ln(\text{population/mi}^2)] + 1.893(\text{farmland\_percentage}) - 0.458(\text{middle\_atlantic\_division}) - 1.458(\text{midwest\_region}) - 2.062(\text{west\_north\_central\_division}) - 1.974(\text{south\_division}) - 2.282(\text{east\_south\_central\_division}) - 2.467(\text{west\_south\_central\_division}) - 1.359(\text{mountain\_division}) - 0.619(\text{pacific\_division})$

All coefficients significant at $p<.01$.

[9] Adjusted $R^2 = 0.624$

Figure 7. Vermont actual and predicted direct sales by county



Source for actuals: USDA Census of Agriculture 2002

fifth is in the southwest corner of the state. Vermont policy makers might target these counties or regions for increased attention or support to direct sales. Bringing the five lower counties up to typical U.S. performance would increase overall Vermont direct sales by 6%. Windham County is another interesting case, exceeding the predicted sales by 239%. Windham County is not near any urban area that might influence its sales, does not have an unusually large concentration of summer homes, or have any other obvious factor that might explain its high direct sales: the culture of farmers' markets and farmstands simply appears to be very strong in Windham County (author lives in Windham County). Policy makers might view Windham's performance as a possible target for all Vermont counties; if all counties exceeded typical performance by the same margin as Windham, total direct sales in the state would increase by 66%. This might be viewed by policy makers as a long-term state direct-sales goal that is ambitious but achievable (given that a successful example exists). Similar analysis could be conducted for any state.

A final observation is that regional differences in direct sales, while significant, are not likely inherent. No papers reviewed for this study identified inherent limitations (e.g., soils, climate) to direct sales in the regions where sales are lower. This suggests that the lower-selling regions have at least the potential to achieve the sales of the higher-selling regions, should there be suitable agricultural production, marketing channels, and consumer preference.

4.5 Summary

As measured by the USDA's Census of Agriculture, direct sales likely represent a low estimate of actual sales at farmers' markets, farmstands, etc., and definitely represent only a portion of the agricultural production that might contribute to local food or be described as civic agriculture. Yet direct sales are likely the best indicator of local, civic-oriented agriculture. This study identified four factors associated with variations in farmer direct sales: average farm size, population density, geographical area, and available farmland. Together these factors account for 92% of the variation in direct sales at the state level, and 62% of county-level variation, establishing a statistically valid correlation between factors like farm size and direct sales.

The regression models can be used to calculate expected or typical values for direct sales, based on the characteristics of a state or county. This information can in turn be used to help in assessing current performance of and future potential for direct food sales, local food, and civic agriculture in U.S. states and counties. In the case of Vermont, for example, while the state is already the U.S. leader in per-capita direct sales, the county-level model suggests the possibility of still higher direct sales in the state.

The correlation of the explanatory factors with direct sales does not necessarily imply causation, i.e., smaller farms do not necessarily *cause* direct sales to be higher. More research is needed on the actual linkages between the variables identified and observed direct sales. Is farm size, for example, a cause or effect of direct selling, and to what extent is farm size associated with profitability in direct selling? Of particular interest are the regional differences in direct sales, and the extent to which reported differences in direct sales reflect actual differences in local food use; low direct sales could also indicate greater prevalence of home gardening, for example, or non-direct but still short and local marketing chains. While this study cannot answer such questions, it does clearly establish some lines of questioning. Direct sales are but the most visible aspect of a growing interest in local foods, and warrant additional attention and study.

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5. General Conclusions and Recommendations

5.1 Summary

Interest in local food is on the rise in many areas of the United States, as demonstrated by the many initiatives underway to promote local food, and the increase in direct sales of food products. Many authors describe the possible benefits of increasingly local food economies. In Vermont, historical evidence suggests that the state is physically capable of producing much of its own food, and the same is likely true in other locales. Yet to date there has been relatively little attention given to the question of how much food is actually local in any particular place, and how this might be measured. If food system localization is a goal, then methods to assess programs and evaluate progress are needed.

5.2 Major Findings

This thesis proposes a method to develop local food indicators from publicly available data, using an upper-bound, lower-bound approach that establishes a range of possible local food. Possible upper bounds can be calculated for both food production and food processing, and possible lower bounds are based on local contribution to the national food supply and on direct sales of farm products to consumers. The four bounds together represent available measures of local food use and trends that could be employed anywhere in the United States. The direct-sales lower bound is likely the single best indicator of success in promoting local food consumption. A remaining question is whether more accurate and timely measures might be developed, at what cost, and whether any possible gains in accuracy from such measures would be warranted by the cost.

This thesis also explores differences in direct sales across the United States, and using econometric methods, finds four variables associated with most variation in direct sales: average farm size, population density, geographic region of the country, and available farmland. From the values of these four variables, direct sales in states and counties can be predicted with reasonable accuracy. These predicted or expected values indicate typical direct sales for similarly situated areas, and thus can be used to evaluate direct-sales performance in a particular area. Remaining questions include what the specific links between the four variables and direct sales might be, and under what circumstances direct selling is most profitable for farmers.

For the case of Vermont, four major conclusions can be drawn: a) Local food currently accounts for a minimum of 1.2% of all food consumption (based on direct sales), and a maximum of 38% of consumption (based on production). b) For local food to increase beyond 38%, more production diversity is needed: production diversity does not match diet diversity. c) Direct sales, a significant channel for local food, can be expanded still further, based on evidence from the best-performing counties in the state. d) Agricultural location theory suggests that we not expect most local Vermont food products to be the least expensive available. Yet price still matters; with lower local food prices, we could expect higher local food consumption. Policies that help Vermont farmers and food processors to be cost competitive are likely to increase local food use in the state. Similar conclusions could likely be drawn for many other parts of the United States.

5.3 Future Research

Agricultural location theory suggests that transportation cost is a major determinant of local food use, that lower transportation cost in general leads to less local food. History appears to bear out this theory. Yet the full social costs of transportation are not necessarily reflected in its market price, e.g. the cost of global warming is not reflected in the price of diesel fuel. Future fuel prices may rise due to either higher market prices for energy, or to internalizing currently externalized social costs. And while higher energy or transportation prices could be expected to increase local food use, an additional research question is how much a change in transportation cost would impact local production, and for which food products.

Beyond transportation cost, consumer demand is increasingly seen as a determinant of local food production. Consumer research indicates that freshness is likely the most important reason for buying local, though other reasons including support for local farms are also important to consumers. Assuming (based on agricultural location theory) that local food will often not be the least expensive alternative, a key question for farmers and policy makers is what premium consumers will pay for food that is local, and how this varies by product and by region.

Finally, while this thesis reports on possible benefits ascribed to local food from a number of sources, it finds few rigorous studies of such benefits. Though benefits clearly exist (e.g. from reducing environmental impacts of transportation), these should be weighed against costs, for example from more expensive food, or from reduced dietary variety. There may also be regional economic opportunity costs from spurning the conventional specialization-and-trade model of development. Welfare can only be maximized when all benefits and costs of an activity like local food production are clearly recognized and counted. Local food holds promise for increasing social welfare and sustainability, and deserves additional, rigorous study of its potential and dynamics.

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