Does Local Production Improve Environmental and Health Outcomes?

by Steven Sexton

Some critics of industrial agriculture propose the "relocalization" of food production to reduce environmental damage and improve health outcomes. This article considers the welfare effects of locavorism along these dimensions.

Modern agriculture is increasingly under attack by critics who blame the industry's specialization and concentration for a number of societal problems, from global warming to rising health care costs. The critics contend that today's industrial agriculture is too dependent on fossil fuel, and too eager to ply consumers with cheap but nutritionally bankrupt calories. Among the critics, locavores, like best-selling author of *The Omnivore's Dilemma* Michael Pollan, and famed chef Alice Waters, advocate a community-based food production system in which consumers buy goods that have travelled less than 150 miles from farm to fork.

The rise of modern farming would seem to be one of the great successes of the last century. Propelled by the Green Revolution, agricultural productivity in the United States grew at an average 1.9% per year from 1948 to 1998, exceeding the rate of growth in the U.S. manufacturing sector. Similar productivity gains were achieved elsewhere around the world. A doubling of food production in the second half of the 20th century saved the world from mass starvation as its population doubled to six billion. Because of modern agriculture, farmers were able to produce more food per person for more people—without expanding farmland or farm labor demand. In fact, 50 million acres of land were released from farming in the United States over the last half-century, and the percentage of the national workforce employed in agriculture fell from 16% to less than 2%. Norman Borlaug, considered the father of the Green Revolution, credits science with saving from conversion to farming an area of land equal to the U.S. east of the Mississippi River.

Critics of our current food system don't deny these achievements. But they blame the transition to industrial farming for simultaneous increases in the amount of energy embedded in food products and heightened rates of obesity among the American public. The case against industrial agriculture has been articulated in major box-office draws like "Food, Inc.," and "Supersize Me," featured in cover stories for *Time* and the *New York Times Magazine*, and detailed in *New York Times* bestsellers by Pollan.

Amid growing concern about climate change and health care costs, it has become almost conventional wisdom that the federal government's farm program has created a food production and marketing system that poorly serves societal interests and that new policy is needed to coordinate a return to our agricultural roots. Economic theory and empirical evidence suggest, however, that this new conventional wisdom may be quite wrong. This article considers whether a food system based on local production would improve outcomes in the key areas its proponents assert the current system lets us down: human health and environmental preservation.

Climate Change and the Environment

As recently as the 1930s and 1940s, when horses and mules still provided the bulk of power on American farms, food output contained twice the energy consumed in production. But today, ten times more energy is consumed in production than is yielded in food output. Energy has become an important input at every step of the supply chain, from the production of chemical inputs upstream from the farm to the processing of raw material into finished food products downstream. And on the farm, 4.3 million fossil fuel-powered tractors have replaced the 21.6 million work animals that occupied farms in 1900.

As farms became increasingly specialized, reducing the average number of commodities produced per farm from about 5 in 1900 to about 1.5 today, demands for soil enhancements and damage-control agents grew. Specialization and trade also increased demand for energy to transport crops and food products to buyers. It is estimated that today's fresh produce travels an average 1,500 miles from the farm to the consumer. As a consequence of the energy demands throughout the supply chain, agriculture consumes 14% of the national energy budget. Transportation of food products alone consumes 5%.

Locavores argue that to accomplish environmental objectives, the food production system must be transformed to one characterized by small farms growing multiple crops and marketing them directly to consumers or local retailers. The "relocalization" of the food system demands a farming landscape that resembles our agricultural past. Farming in the 1930s, in fact, looks a lot like what the critics of industrial agriculture hope to achieve today: 5.7 million farms averaging 147 acres in size and growing an average 5.1 different crops.

Implicit in the locavore assertion that local farming is environmentally friendly relative to industrial agriculture is an assumption that altering the scale and location of agricultural production does not alter its efficiency. Holding all else constant, a reduction in food transportation miles and an increase in biological control of pests and soil fertility, necessarily reduces the carbon intensity of food production. However, all else is not likely to be constant under such a transformation.

Locavores presume that we can return to a historical form of agriculture without also returning to historical farm yields. The average farmer produced 13 bushels of wheat per acre in 1930 and 20 bushels of corn. In contrast, today's farms, which number only 2.2 million and occupy an average 414 acres, are able to produce an average 44 bushels of wheat and 164.2 bushels of corn per acre.

While it is surely true that a small, diverse farm today can improve upon the yields of the early to mid-20th century by employing modern seed varieties and other scale-neutral innovations, it is certainly also true that high yields today reflect modern agriculture's exploitation of two basic principles of economic efficiency that the locavores either ignore or discount: comparative advantage and economies of scale. It is the inability of a local food system to exploit these forces that could render it a net contributor to global warming and environmental damage rather than a net reducer.

Specialization and Trade: Economists have long recognized the welfare gains from specialization and trade. The case for specialization is perhaps nowhere stronger than in agriculture, where the costs of production depend on natural resource endowments such as temperature, rainfall, and sunlight, as well as soil quality, pestilence, and land costs. Because ideal growing conditions and crop sensitivity to deviations from optimal conditions vary by crop, different regions enjoy comparative advantage in different crops. As a consequence, California, with its relatively mild winters, warm summers, and fertile soil is the leading producer of high-value crops, producing all U.S.-grown almonds and 80% of U.S. grapes and strawberries. Iowa, in contrast, with a less ideal agronomic resource endowment, specializes in corn and soybeans, providing nearly 20% of all U.S. production of these less-valuable crops.

Table 1. Psuedo-Locavore Effects on Input Costs

Change in Millions	Corn	Soybeans	Oats	Change in Millions	Milk
Acres	22.06	13.82	0.95	Head of Cattle	0.64
	26.91%	18.26%	37.36%		7.58%
Fertilizer Costs	$39.01	$30.69	$86.10	Purchased Feed Costs	$-420.26
	35.07%	54.90%	61.88%		0.03%
Chemical Costs	$45.66	$61.64	$-0.46	Homegrown Feed Costs	$7.32
	23.07%	20.04%	-8.71%		0.11%
				Grazed Feed Costs	$33.04
					22.60%
Fuel Costs	$88.60	$32.60	$14.95	Fuel Costs	$25.16
	22.80%	33.92%	27.24%		1.72%
Total Input Costs	$71.62	$35.47	$12.73	Total Input Costs	$-257.74
	29.45%	29.54%	44.77%		-0.93%

The dramatic change in land-use and input-demand induced by a "relocalization" of the food supply is demonstrated using USDA region-level production cost and return data and state-level data on production, land allocations, and yield. To derive a first-order approximation of locavore effects on production costs and input demands, assume that a local food system must maintain existing levels of per capita production for each crop. Further, assume that each state must produce all the food for its residents. These assumptions reallocate production so that each state produces an average "diet" for each if its residents. Because of data limitations, production is reallocated in this analysis for each crop only over those states for which a complete set of data exists. For instance, yield data for a given crop do not exist for states that are not currently producing that crop, so it is impossible to determine input demands.

Using the regional mean production costs and state-level data on yield, the input-demand under this "proportional" or "pseudo-locavore" production system is determined. This analysis is carried out for four major crops—corn, soybeans, oats, and milk. Results are reported in Table 1. Proportional corn production among current corn producers results in a 22 million acre (26%) increase in area planted to corn, a 35% increase in fertilizer costs, a 23% increase in fuel costs, and a 29% increase in total input costs. Similar results are reported for the other two field crops considered in this analysis. Notably, however, results for milk suggest that production costs decrease under the "pseudo-locavore" scenario, and purchased feed is substituted for grazing and feed produced in the dairy farm. The changes in feed consumption suggest carbon savings relative to the status quo, but the increased number of cows would induce more carbon emissions. Because of the way data for milk are reported, the change in head of cattle accounts for efficiency differences across states, where as input costs do not.

If a national price for inputs is assumed, these input cost changes can be interpreted as changes in input demand,

Table 2. Change in Cropland by State	
State	Thousand Acres
Top 5 Growth States	
California	40,000
Texas	34,600
Florida	26,000
Iowa	22,100
North Dakota	19,900
Bottom 5 Growth States	
New Hampshire	0.54
Vermont	0.65
Connecticut	1.42
Rhode Island	6.99
Oregon	4.68

so that, for instance, fertilizer use in corn grows 35%. Therefore, this analysis suggests that, in general, a transition to a pseudo-locavore production system leads to considerable growth in the use of carbon-intensive inputs, which would lead to increasing carbon emissions and pollution of natural ecosystems.

Availability of cost and return data limits analysis of input cost effects for a broader set of crops. It is possible, though, to estimate the land-use impacts of pseudo-locavore production using state-level production and yield data. Assuming yields are maintained as additional land is brought into production, the increase in demand for land for each crop associated with the pseudo-locavore rule is determined by multiplying the percentage change in state-level production by the state-level area planted. With 500 state-crop observations, covering 40 major field crops and vegetables, it is estimated that localization would require a 60 million-acre increase in land devoted to producing these crops in producing regions—a 23% increase. Table 2 reports the states that gain the most farmland under local production and those that lose the most, in absolute terms. Extrapolating this change across the 2.26 billion acres of farmland in the United States, the agricultural land base would grow by 214.8 million acres—an area twice the size of California.

Increased demand for energy-intensive inputs and the expansion of farmland cause carbon emissions that reduce, and may overwhelm, the carbon emissions reductions associated with less transportation and monocropping in "relocalized" food systems. Extrapolating the percentage change in fertilizer and chemical demand from reapportioning corn production among corn producers to all U.S. corn production, for instance, suggests pseudo-locavorism would cause a 2.7 million ton increase in fertilizer applications and a 50 million pound increase in chemical use per year. Conversion of natural land to agricultural uses jeopardizes biodiversity and causes an increase in atmospheric carbon. There are immediate emissions from land-use change as biomass is cleared to make room for crops. And, because natural land sequesters more carbon than cropland, there are emissions associated with foregone annual and ongoing sequestration.

Many of the assumptions made in this simple model will tend to produce a conservative estimate of the carbon costs of locavorism. For instance, this analysis is constrained to consider the reallocation of production to states that are already producing a given crop. Locavores would also reallocate production to states that are not already producers in order to meet the 150-mile constraint on food travel. States that are not among current producers should, on average, be relatively costly producers of a given crop because they would otherwise be growing the crop today. Also, in assuming the persistence of existing yields as land-use expands, this analysis ignores any decline in yields that may result from expansion to marginal lands. Further evidence of the conservatism of this approach is the fact that it shows a net reduction in input costs from localized milk production. Were localized production actually more efficient, we would not be seeing increasing average herd sizes and consolidated production.

Because of data limitations, per capita production in producing regions is reallocated among states under the "pseudo-locavore" scenario. This will tend to bias upward extrapolations out of sample, producing larger effects.

Economies of Scale: A local food production system would upend long-term trends of growing farm size and increasing concentration in food processing and marketing. Ending the food market dominance of big agribusiness—large monocrop farms and integrated food processors—is a secondary motive of locavorism, which generally views big business as an insincere steward of the environment and a principal cause of the obesity problem in the United States.

Local food production would largely eliminate scale economies by dividing a national market for food into local "foodsheds" that can only support smaller farms and food-processing operations. To the extent scale economies exist in farming, food processing, and marketing, they permit larger firms to more efficiently convert inputs to outputs. By forsaking these efficiencies, locavorism causes an increase in the quantity of inputs demanded, which increases carbon intensity, and an increase in the price of commodities and food products.

Large monocropped farms are more dependent than small polycrop farms on synthetic fertilizers and tilling operations to restore soil nutrients. They also face heightened pest pressure because they provide a consistent environment for breeding of crop-specific pests. Higher pest pressure increases demand for chemical damage control agents. Disposal of farm residues, like animal waste, also becomes a significant environmental challenge on industrial farms. The direct environmental costs of large-scale agriculture are clearly non-trivial. What is unclear, however, is whether the environmental benefits of small, poly-cropped farms outweigh the loss of efficiencies that are equally well-documented to accompany the increasing scale of production.

Recent work presents convincing evidence that economies do exist and that small farms are relatively inefficient. Catherine Morrison Paul and colleagues analyzed farm-level surveys from 1996–2000 and concluded the presence of "significant" scale economies in modern agriculture. They report that small farms are less efficient in both the scale of their operations and the technical aspects of production. They are "high cost" farms that have unexploited scale economies and consequently cannot compete with large farms.

Human Health

Locavores allege that modern agriculture is responsible, in part, for growing rates of obesity and obesity-related illness among Americans. They argue that flawed public policy has fueled the industrialization of agriculture and produced a glut of cheap but nutrient-deficient calories by subsidizing the major commodities like corn and wheat. Locavores are also critics of processed foods and fast food, coining the phrase "slow foods" to encapsulate their ideal of home production of fresh, raw, and unprocessed commodities. Better policy, they argue, would yield better health outcomes.

This argument, however, is also based on a series of assumptions that seem to belie accepted fact. For instance, agricultural economists have rejected the notion that farm policy is to blame for the obesity epidemic in America. While policy has made grains relatively cheap, it has also made sugar more expensive. Prices for many fruits and vegetables, such as apples, strawberries, tomatoes, and broccoli, have declined over the past 25 or more years, which should increase access to nutrient-dense foods. Where prices for fruits and vegetables have trended upwards, the increases can be attributed to quality improvements, extended availability, and other value-added attributes in processing, such as enhanced product packaging. No identifiable pattern has been found in the price of unhealthy foods relative to healthy foods. Economists have also largely attributed the obesity epidemic to technological innovation that makes labor less strenuous and food products cheaper, meaning people are eating more but burning fewer calories.

Would a local food system improve American diets? In two key respects, the likely answer is no. First, as this analysis has shown, a local food system would greatly increase the costs of food production by imposing constraints on the efficient allocation of resources. The monetary costs of increased input demands from forsaken gains from trade and scale economies will directly bear on consumer welfare by increasing the costs of food. Research shows that as incomes rise, fresh produce as a share of diets increases. Therefore, given that locavorism would effectively make consumers poorer by increasing the cost of food, it is hard to see how local production improves diets or health outcomes.

While it may be beneficial from a health policy perspective to increase the relative cost of grains to reduce the surfeit of cheap calories, it is not clear that locavorism would accomplish this unless cost increases were biased toward grains. Instead the inefficiencies of reallocating food production are likely to be greater for high-value crops like fruits and vegetables so that, if anything, local food production will disproportionately raise the prices of the very foods that should become cheaper from a health policy perspective.

Second, taken literally, locavorism would block access to fresh produce for millions of Americans who live in climates that cannot, for many months per year, grow fruits and vegetables outside climate-controlled greenhouses. Greenhouse production is clearly energy-intensive and would impede environmental objectives. Blocking access to fresh produce would impede health objectives.

Conclusion

Some critics of modern agriculture have articulated an alternative that they assert would improve environmental and health outcomes. It is unlikely the benefits of locavorism are as substantial as has been asserted, and it is possible they are dwarfed by the costs of less efficient production and reduced access to nutritious foods. With the global population expected to grow to more than nine billion by 2050, today we face a challenge to feed the world, much as we did 60 years ago. The sources of tremendous productivity growth in the past, however, are largely exhausted, at least in the developed world, and the rate of productivity growth has begun to decline. If mass starvation is to be avoided in the current century, then we must either forsake natural land, including tropical forests, or renew our commitment to crop science. The debate about the future of agriculture must weigh the uncertain potential for environmental improvements under local production with the more certain risk to vulnerable populations, if food production doesn't increase, or to precious habitat if productivity doesn't increase.

Steven Sexton is a Ph.D. student in the Department of Agricultural and Resource Economics at UC Berkeley. He can be contacted by e-mail at ssexton@berkeley.edu.

For further information, the author recommends:

Morrison Paul, C.J. and R. Nehring. "Scale, Diversification and Economic Performance of Agricultural Producers." *ARE Update* 6(4) (Mar/Apr 2003): 5-8.

Gray, A.W. and M.D. Boehlje. "The Industrialization of Agriculture: Implications for Future Policy," Purdue University, (2007), Working Paper 07-10.

Alston, J.M., D.A. Sumner, and S.A. Vosti. "Farm Subsidies and Obesity in the United States." *ARE Update* 11(2) (Nov/Dec 2007): 1-4.